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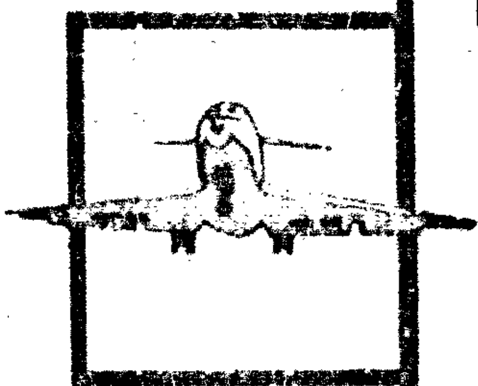

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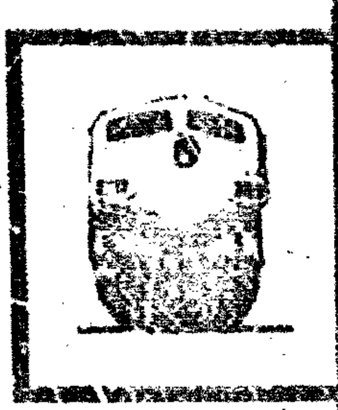

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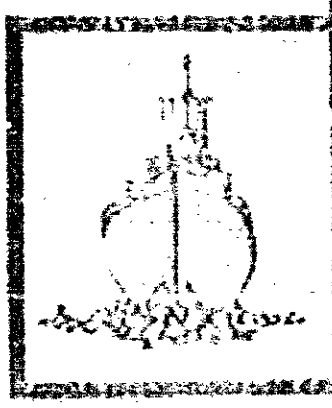
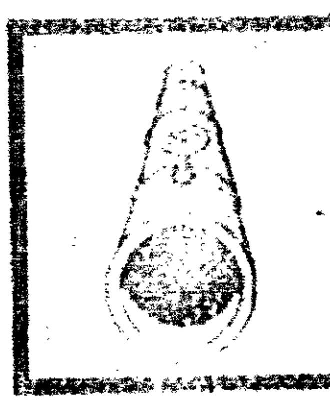


HIGHWAY ACCIDENT REPORT

TRUCK ENGINE FUEL TANK PUNCTURE BY BRIDGE REPAIR PLATE, DIESEL SPILL, AND MULTIPLE VEHICLE SKIDDING COLLISIONS
INTERSTATE ROUTE 10
LAKE CHARLES, LOUISIANA
AUGUST 27, 1981



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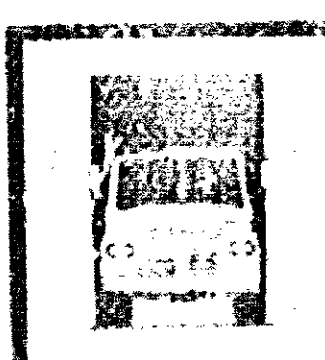

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16. Abstract About 10:25 p.m. on August 27, 1981, a tractor-semitrailer loaded with steel pipe was traveling eastbound across the Calcasieu River Bridge, a 1 1/4-mile long, four-lane divided highway bridge on Interstate 10 at the city limits of Lake Charles, Louisiana. As the truck was descending the east side of the bridge, the tractor's left side fuel tank was struck and penetrated by a dislodged bridge repair plate that had been used to cover a hole in a pavement expansion joint. As a result of about 75 gallons of diesel fuel leaking onto a 1/2-mile section of the bridge, 26 vehicles were involved in a series of skidding collisions. Three persons were killed, and 18 persons were injured; there were no fires.

The National Transportation Safety Board determines that the probable cause of this accident was the loss of vehicle control on a slippery highway surface, produced by a diesel fuel spill from a truck fuel tank punctured by a dislodged steel plate used as a temporary repair of a bridge expansion joint. Contributing to the accident was the failure of the Louisiana Department of Transportation and Development to make a permanent repair at that joint.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

HIGHWAY ACCIDENT REPORT

Adopted: July 15, 1982

TRUCK ENGINE FUEL TANK PUNCTURE BY BRIDGE REPAIR PLATE, DIESEL SPILL, AND MULTIPLE VEHICLE SKIDDING COLLISIONS INTERSTATE ROUTE 10 LAKE CHARLES, LOUISIANA AUGUST 27, 1981

SYNOPSIS

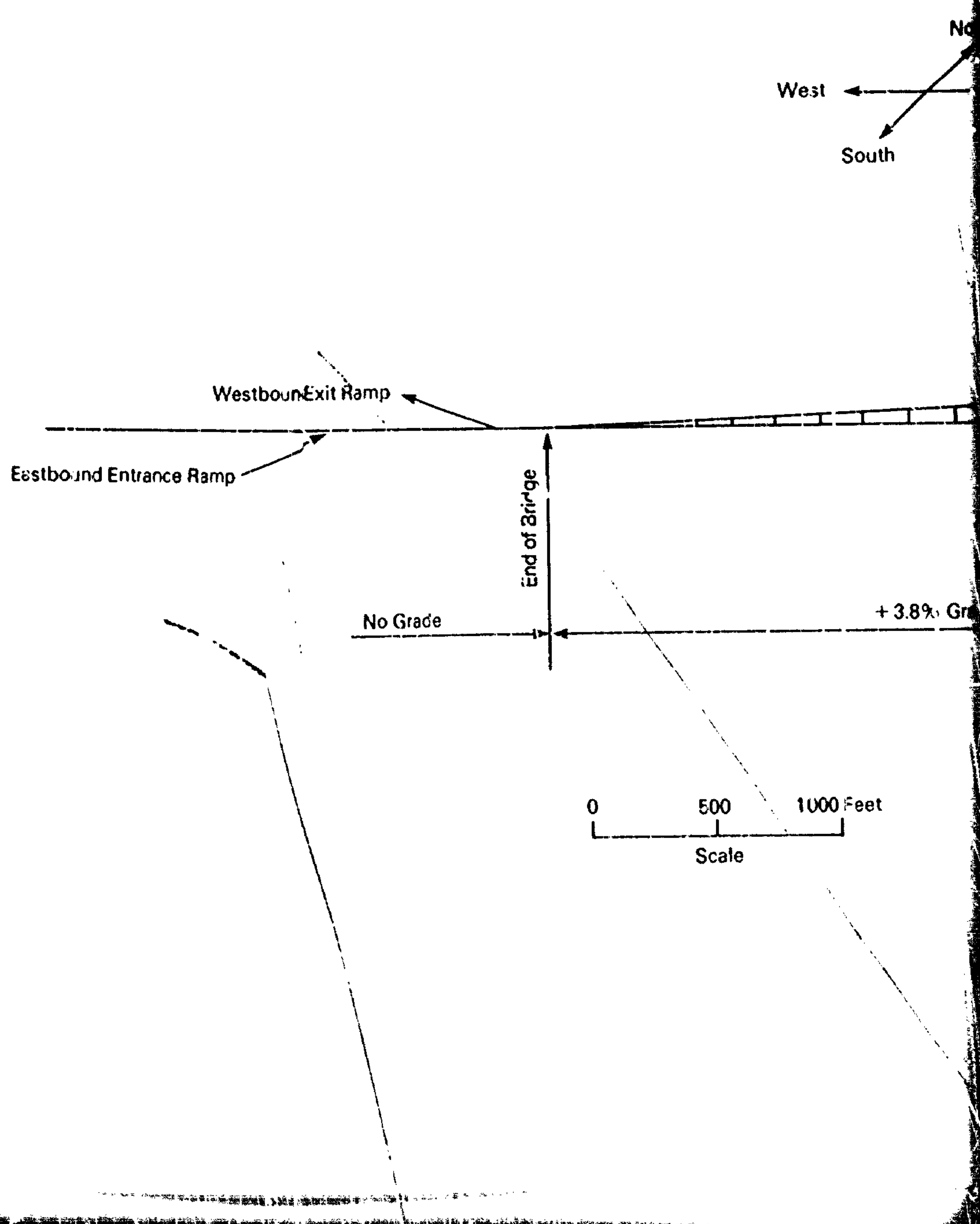
About 10:25 p.m. on August 27, 1981, a tractor-semitrailer loaded with steel pipe was traveling eastbound across the Calcasieu River Bridge, a 1 1/4-mile long, four-lane divided highway bridge on Interstate 10 at the city limits of Lake Charles, Louisiana. As the truck was descending the east side of the bridge, the tractor's left side fuel tank was struck and penetrated by a dislodged bridge repair plate that had been used to cover a hole in a pavement expansion joint. As a result of about 75 gallons of diesel fuel leaking onto a 1/2-mile section of the bridge, 26 vehicles were involved in a series of skidding collisions. Three persons were killed, and 18 persons were injured; there were no fires.

The National Transportation Safety Board determines that the probable cause of this accident was the loss of vehicle control on a slippery highway surface, produced by a diesel fuel spill from a truck fuel tank punctured by a dislodged steel plate used as a temporary repair of a bridge expansion joint. Contributing to the accident was the failure of the Louisiana Department of Transportation and Development to make a permanent repair at that joint.

INVESTIGATION

The Accident

Diesel Spill.--About 10:25 p.m. on August 27, 1981, a tractor-semitrailer loaded with steel pipe was traveling eastbound across the Calcasieu River Bridge on Interstate 10 at the city limits of Lake Charles, Louisiana. (See figure 1.) As the truck was descending the east side of the bridge in the curb lane, a dislodged 15 1/4-inch-square steel plate struck and penetrated the tractor's left side fuel tank. (See figure 2.) This plate had been used to repair a hole in a pavement expansion joint near the crest of the bridge about 4 months earlier. The truckdriver did not hear any unusual noise associated with the fuel tank puncture and continued to travel down the bridge. When the truck was about halfway down the east side of the bridge, the truckdriver glanced into his left outside rearview mirror, saw a "misty-looking fog or cloud" at the rear of the tractor cab, and slowed down. At this time, he smelled diesel fuel. He pulled over and parked on the shoulder area just beyond the end of the bridge, found the leaking left fuel tank, and shut off the right fuel tank so it would not drain through the crossover fuel line system between the two fuel tanks. He then began broadcasting over his citizens band (C.B.) radio (channels 19 and 9) that the fuel spill had occurred.



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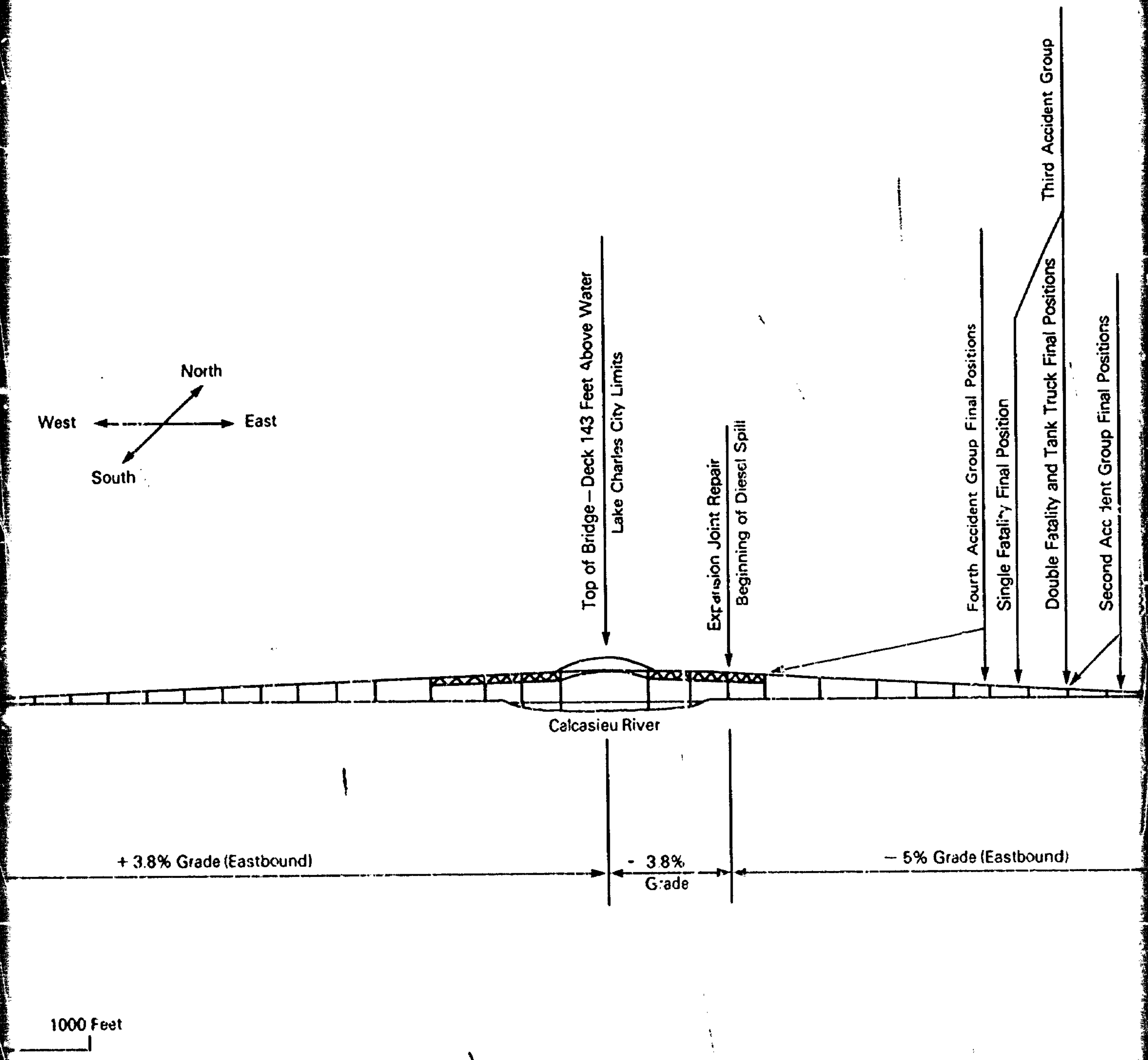

Figure 1. Interstate 10, Calca
Lake Charles, Louis
Profile of Bridge--

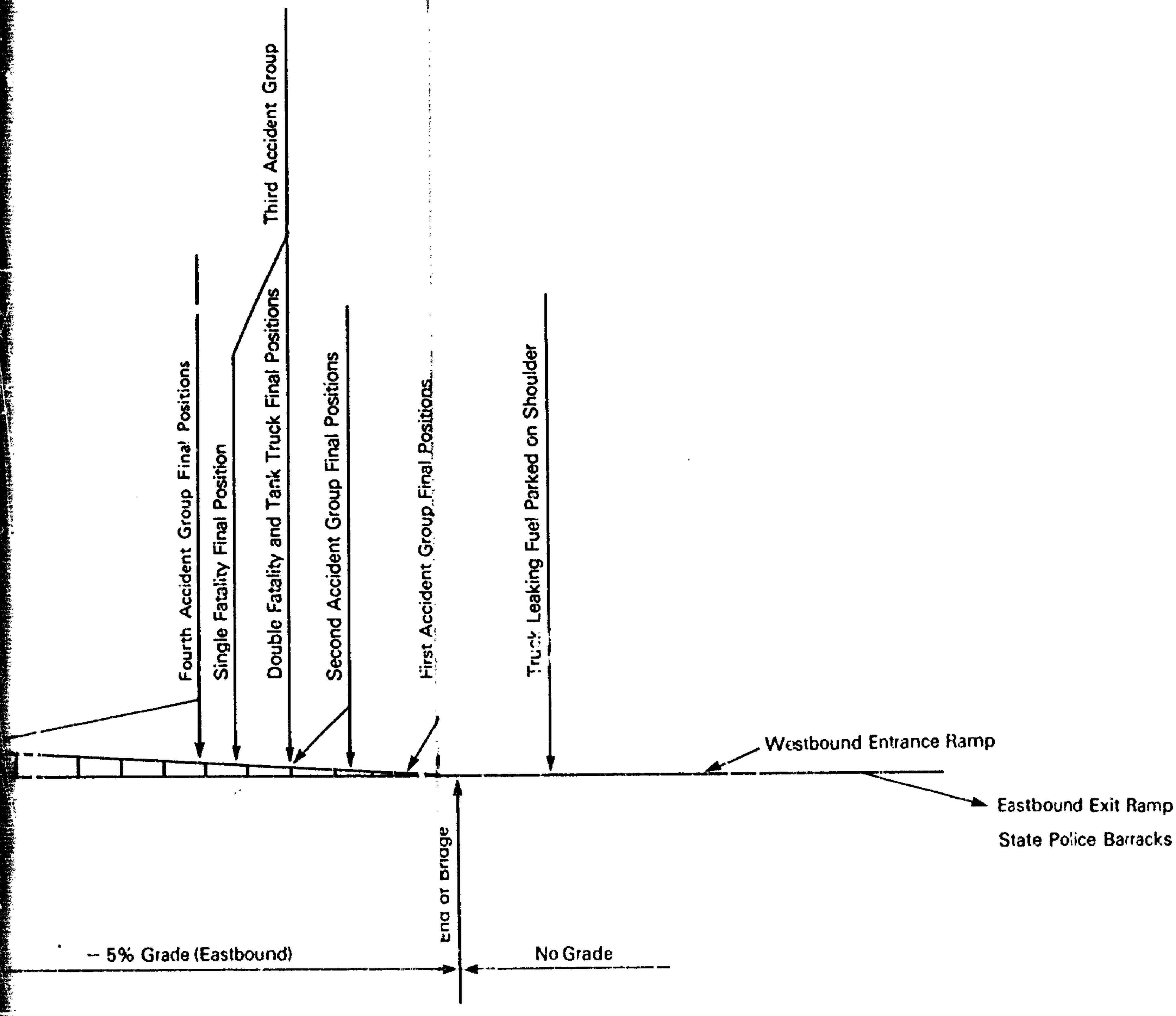

Figure 1. Interstate 10, Calcasieu River Bridge
Lake Charles, Louisiana
Profile of Bridge—Accident Events

Figure 2.--Steel repair plate and part of expansion joint finger embedded in tractor fuel tank.

First Accident Group.--About 10:30 p.m., a 1979 Chevrolet Chevette entered eastbound Interstate 10 at the west side of the Calcasieu River Bridge. The driver reported that the large electronic, changeable message highway sign, located at the end of the bridge read "50 MPH SPEED LIMIT." He said that he was traveling about 35 mph in the curb lane as he reached the crest of the bridge and started down. He saw that both lanes ahead were wet but he did not smell any odor--his driver side window was down. He stated that he did not attempt to apply the brakes, change lanes, or take any other action, but his car started to skid and lose stability as soon as it traveled onto the wet area of pavement. The Chevette struck the right curb, traveled across both lanes, struck the median divider wall, and stopped sideways in the road, across both traffic lanes and about 150 feet from the east end of the bridge.

A tractor-semitrailer, loaded with steel pipe, was traveling about 500 to 600 yards behind the Chevette in the curb lane. The truckdriver said that he heard the truckdriver with the punctured fuel tank announce that there was diesel fuel on the bridge as he and the Chevette were traveling through the spill. According to the truckdriver, both he and the Chevette driver started to brake, the Chevette lost control, and in attempting to avoid the Chevette, his truck struck the automobile before he could stop, even though he had applied the brakes on all wheels firmly.

A second loaded tractor-semitrailer was traveling about 600 feet behind the first tractor-semitrailer in the passing lane. The driver of the tractor-semitrailer said that he saw the Chevette lose control and the collision ahead, and was able to stop without striking either vehicle. He then used his C.B. radio to broadcast a warning to a tractor-semitrailer which was following him.

A third truckdriver reported that he heard a conversation between two drivers over his C.B. radio as he started up the west side of the bridge. One driver was advising the other that there was diesel fuel on the road and that he should get in the left lane. Because the conversation did not mention which road the fuel was on, the truckdriver continued up the bridge in the curb lane. When he started down the bridge, he ran into the diesel fuel, switched into the left lane, and then saw taillights from vehicles in both lanes ahead. At first he thought the vehicles were moving slowly, but then he realized that they were stopped. At this point, he was a little more than halfway down the grade, or about 1,500 feet behind the stopped vehicles. He down-shifted a gear, lightly applied his brakes, and his unit began to slowly slide to the right as it traveled down the grade. He broadcast via his C.B. radio to the vehicles ahead to give him room to get through and about the same time, saw a police unit with its blue lights flashing and approaching on the westbound side of the bridge. He struck the left side of a pickup truck that was traveling in the curb lane between his unit and the truck ahead, and ran into the rear of the second tractor-semitrailer unit that had stopped in the passing lane. Four other vehicles, including a tractor-semitrailer, were able to stop before striking other vehicles; however, the lead car of that group slid against the curb while stopping. Nine vehicles comprised the first general accident group. (See figure 1.)

Second Accident Group.--The next driver approaching the accident scene stopped his vehicle about 280 feet behind the first accident group but was struck from behind by a following car. A series of relatively minor rear-end collisions involving six more cars, a pickup truck, and a large, single-unit utility truck followed. (The two occupants of the utility truck, which was not equipped with a C.B. radio, credited a company-sponsored driver training program with teaching them to look far ahead at the actions of traffic, which alerted them to the accident potential and allowed them to stop safely without a collision.) The collisions which comprised the second general accident group occurred within a relatively short time according to occupants who described intervals of 5 to 10 seconds between stopping and being struck. (See figure 1.)

Shortly afterward, the driver of the pickup truck and a passenger in the utility truck, both of whom were near the end of the second accident group, left their vehicles and met to survey the damage. Everyone else in the second accident group remained in their vehicles. The drivers in the second accident group agreed that no one thought about turning on four-way emergency flashers when they stopped.

Third Accident Group.--Three automobiles (a 1977 Lincoln Continental with two occupants, a 1978 Chevrolet Nova with only a driver, and a 1978 Honda station wagon with two occupants) and a tractor-cargo tank semitrailer loaded with hot asphalt approached the second accident group. The tractor-cargo tank semitrailer was not equipped with a C.B. radio. The truckdriver reported that he was traveling about 30 to 35 mph as he started down the bridge in the curb lane. He was aware of two automobiles traveling side-by-side about 125 to 150 feet in front of him. Other vehicles ahead of these two cars appeared to be traveling "straight-ahead, without trouble." He suddenly noticed that the roadway was wet, thought it had rained, but then realized that there was something other than water on the pavement because it was "shiny." He lightly applied his brakes, noticed his unit did not slow, realized the pavement was slick, immediately released his brakes, and decided not to brake his unit again while on the downgrade because he might jackknife. He thought that if everyone ahead of him kept moving without "hitting" their brakes, they would all get off the bridge downgrade without an accident.

The truckdriver continued to follow the two cars down the grade for "some short distance" until both cars appeared to simultaneously converge toward the centerline without braking, contacted each other, and began separating. The truckdriver said that as he attempted to steer between the two automobiles, he struck an automobile that was crosswise in the road and heard a crashing noise on the left side of his tractor. His unit also broadsided a second car, jackknifed, crashed into and slid along the median wall and into the rear of the second accident group. (See figures 3 through 5.) The Honda station wagon ended up wedged between the cargo tank semitrailer and the concrete median wall and the Continental was at the front of the tractor. The driver of the pickup truck and the passenger from the utility truck, who had gotten out of their vehicles after being involved in the second accident group, heard the asphalt truck brake just before the collisions, turned to run, but were struck by vehicles which were struck by the asphalt truck.

Fourth Accident Group.--Several individual vehicles struck the curb to stop and one automobile collided with the rear-end of a 40-foot-long semitrailer loaded with about 3,000 pounds of drilling equipment. The truckdriver of the semitrailer reported that he had been told by a westbound truckdriver via the C. B. radio that there had been a diesel fuel spill in the right-hand, eastbound lane, on the "downside" of the Calcasieu River Bridge and that the pavement was very slippery. The truckdriver estimated that he received the information when he was still 8 to 10 miles, or 12 to 13 minutes, west of the bridge. He began broadcasting a warning to other drivers and, when he was about 4 miles from the bridge, he talked to the truckdriver with the punctured fuel tank who told him that he did not know how much fuel he had spilled, but he was warning people to be careful when they came down the east side of the bridge.

The truckdriver changed into the passing lane and traveled up the west side of the bridge at about 40 mph, continuing to broadcast a warning to other drivers. Two automobiles and a pickup truck passed him on the right as they began to descend the east side of the bridge. He tried to warn them of the danger by blowing his horn and waving his hand. However, the automobiles' drivers appeared to ignore his warnings and collided with the median wall and curb, while the pickup driver looked his way, seemed to "back off on his speed," and struck the curb while stopping. Another automobile also "backed off" from a passing maneuver, struck the median wall, and collided with the rear of the semitrailer. Other vehicles were able to stop without incident. The truckdriver confirmed that the asphalt truck in the third accident group appeared to be maneuvering between vehicles before the collisions occurred.

Shortly after, a Lake Charles city police unit arrived at the beginning of the diesel spill near the top of the bridge and parked sideways across the bridge, preventing other vehicles from entering the spill area.

Emergency Response

Eastbound drivers, traveling behind the truck with the punctured fuel tank, drove to the Louisiana State Police station, located about three-fourths of a mile beyond the east end of the bridge. The drivers described the spill as beginning near the crest of the bridge, initially forming about a 2-foot-wide strip down the center of the eastbound lanes that widened over time, with spray over all four lanes of traffic. The drivers said that they had been able to travel through the spill area by not braking or making any sudden steering maneuvers. Two drivers and a passenger reported that the spill occurred about 10:15 p.m.; one driver estimated that the spill occurred between 10:25 and 10:30 p.m. The truckdriver with the punctured fuel tank estimated that about 3 to 5 minutes passed between the time the spill occurred and accidents began.

According to the Louisiana State Police, the diesel spill was first reported about 10:29 p.m. Both the desk sergeant and the shift supervisor said that the first person to report the spill did not appear to be excited when he stated that the truck was parked at the end of the bridge with a puddle of fuel underneath it and indicated the size of the puddle with his arms held in a circle.

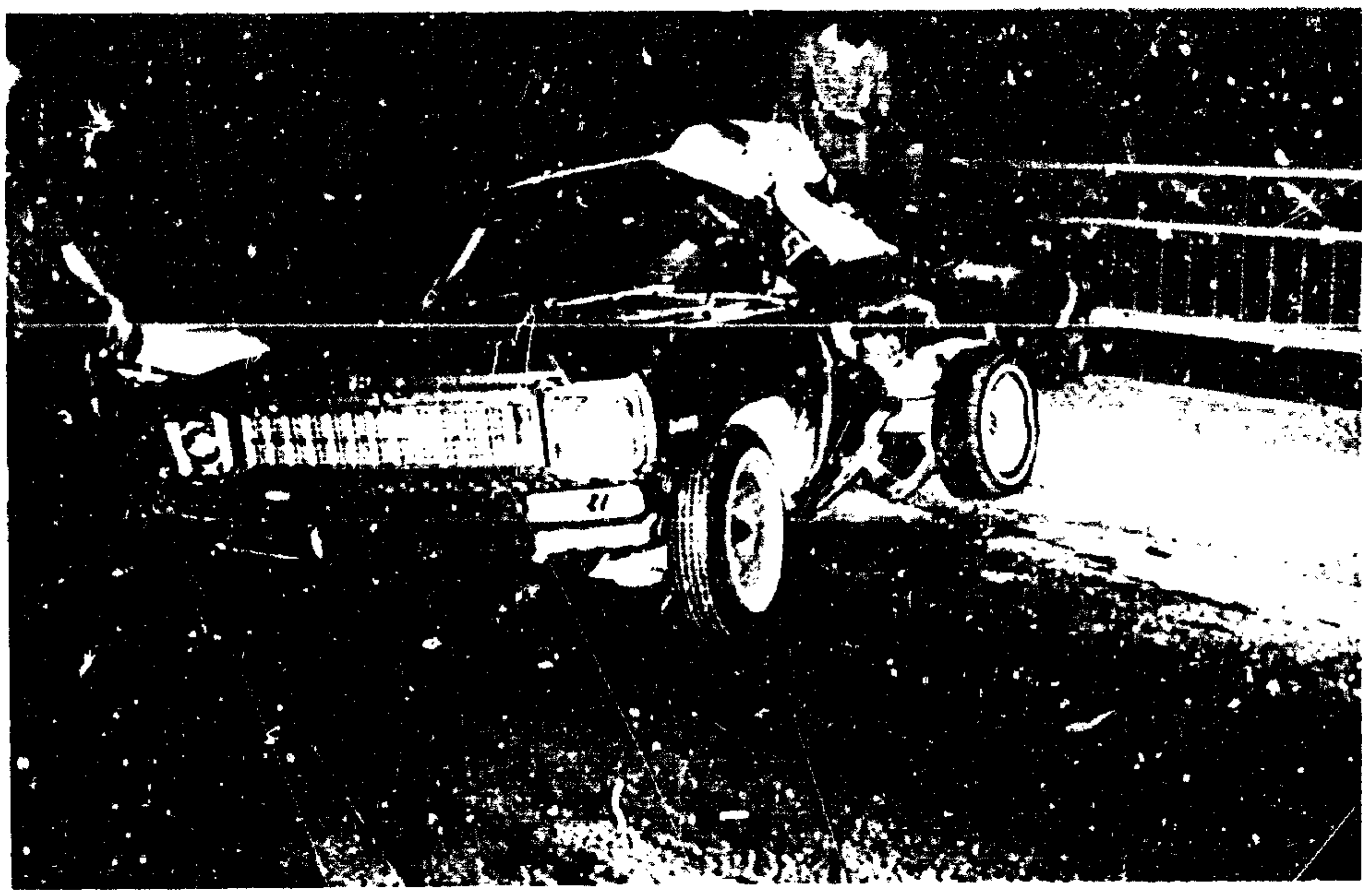

Figure 3.--1978 Chevrolet Nova.

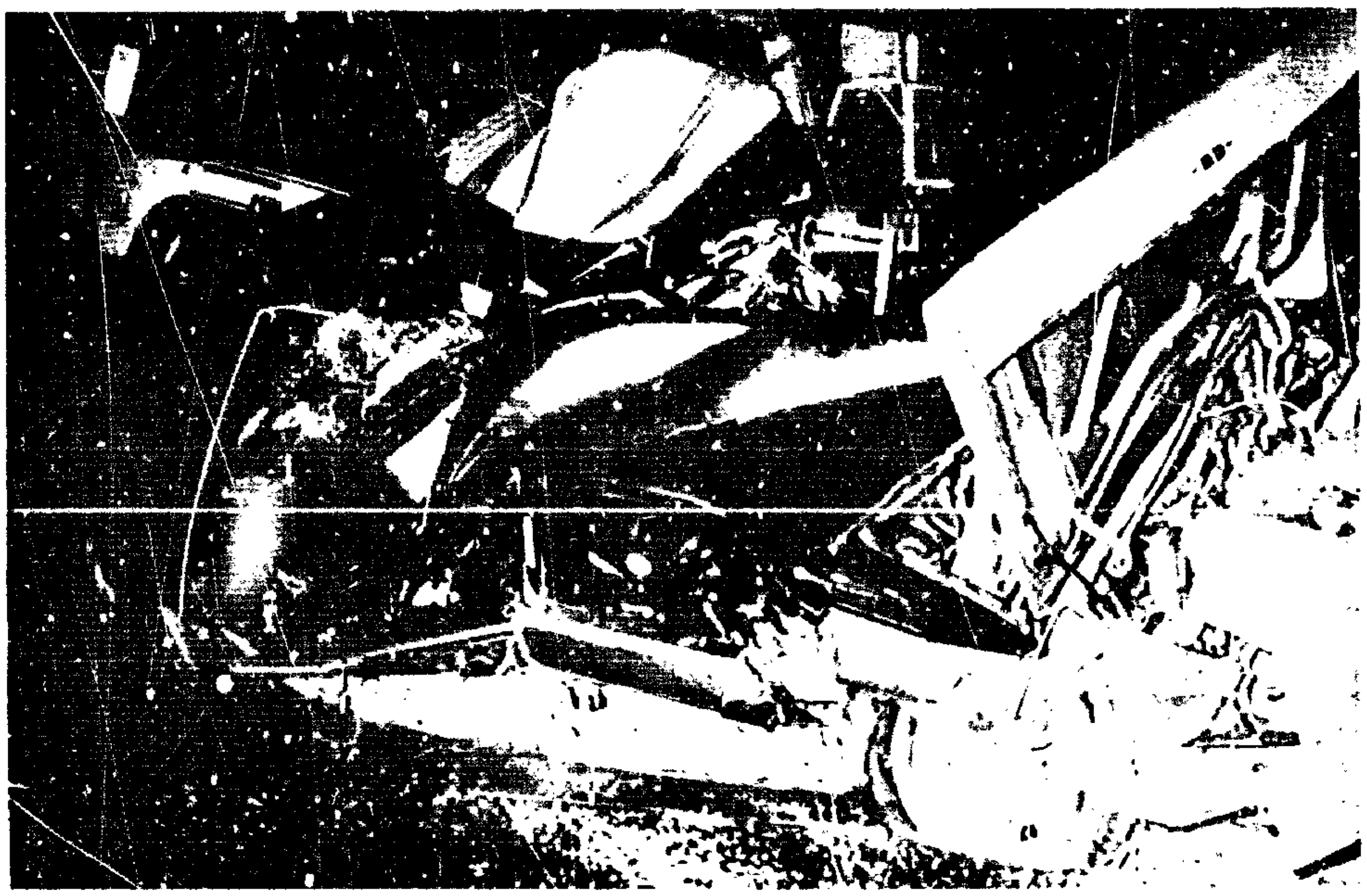

Figure 4.--1977 Lincoln Continental.

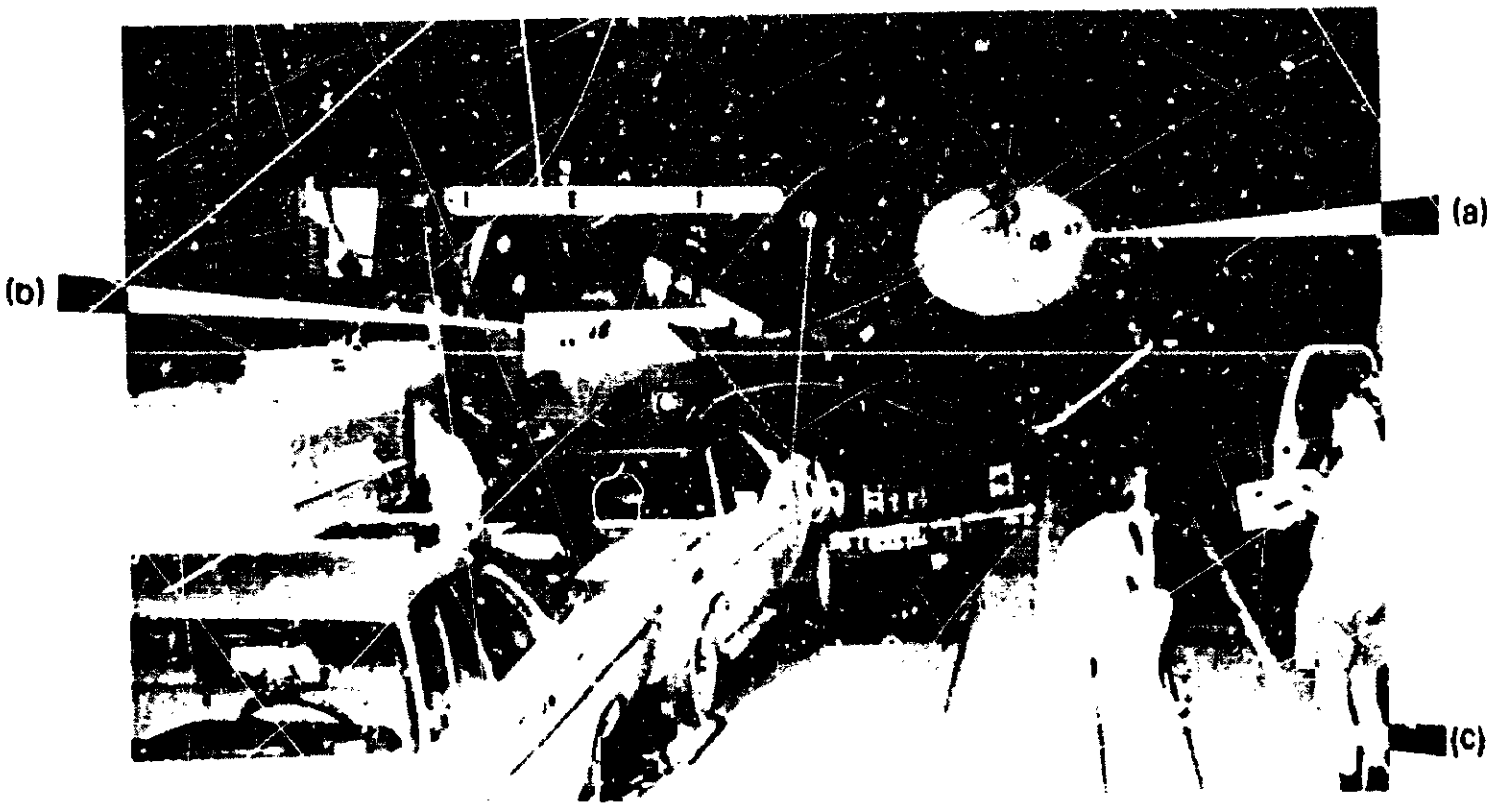

Figure 5.--Final position of the tractor-cargo tank semitrailer into the rear of the second accident group. Note tractor-cargo tank semitrailer (a), utility truck (b), and two-level concrete median wall (c).

The crest of the Calcasieu River Bridge is at the city limits of Lake Charles. According to an unwritten agreement that was established when the bridge was opened to traffic in 1951, the Lake Charles Police Department is responsible for responding to traffic problems that occur on the east side of the bridge, and the State Police is responsible for the west side. The State Police policy is to notify the Lake Charles Police if they receive a report of a "minor" incident, such as a stalled vehicle or debris, on the east side of the bridge and to notify the Lake Charles Police and dispatch a State Police unit for traffic control purposes if they receive a report of an accident/major traffic congestion on the east side that may affect the west side of the bridge.

Given the character of the first report, the desk sergeant treated the report as a minor incident and immediately notified the Lake Charles Police Department. The Lake Charles Police Department responded to a report of a "stalled 18-wheeler (tractor semi-trailer), eastbound, east side of the bridge . . . . a truckdriver having trouble securing his load." The first city police unit responded with no special emphasis on speed, no flashing light, and no siren. A second city unit that heard the transmission, but was not formally dispatched, also headed toward the bridge.

About the same time, a State Police officer, who was in the State Police station to refuel his car, also left for the bridge to check out the report, even though he and the desk sergeant had looked out the door and had seen the parked truck, but had seen no traffic congestion or anything unusual on the bridge. In order to reach the bridge, the officer had to circle underneath Interstate 10, about 1 mile away from the station, drive back 1-1/2 miles, and enter I-10 westbound near the end of the bridge. He responded with no special emphasis on speed.

More eastbound drivers stopped at the State Police station, each driver further emphasizing the severity of the spill and difficulty in maneuvering through it. One of the drivers reported that the desk sergeant had remarked that they (the State Police) thought the spill was at the end of the bridge and that it was only " a little spill." The Lake Charles Police Department received a second call from the State Police and advised the first city police unit responding to "step it up" because "traffic was backed up." This second dispatch occurred about 2 minutes after the first dispatch and both city police units began operating with flashing lights and speed.

At 10:33 p.m., the first city police unit reported that he arrived at the end of the second accident group while traveling westbound and slowed briefly to survey the scene and to report the accident. He decided that there was little or nothing he could do on foot to slow approaching traffic, and at the same time, he would be exposing himself to considerable danger. So he drove through the diesel fuel that had sprayed onto the westbound lanes to exit I-10 on the west side of the bridge, reenter eastbound, and stop traffic at the crest of the bridge. As he left the scene, he said that he saw a large amount of sparks in his rearview mirror.

The second city unit arrived on the westbound side of the bridge immediately after the driver of the pickup truck was struck by vehicles in the third accident group. The State Police officer, who had left for the bridge on his own, arrived shortly thereafter.

Shortly after the first city unit arrived at the scene, the State police received a request from the Lake Charles Police Department to change the electronic, changeable message highway signs by remote control to messages closing both sides of the bridge to traffic, using the signs located near each end of the bridge, and diverting I-10 traffic to I-210, using the signs located at the interchanges before the bridge. I-210 is an alternate interstate route that circles Lake Charles to the south. After a delay of up to 5 minutes due to either the dispatcher's inexperience in changing the signs or an equipment problem, the signs at the bridge were changed at 10:38 p.m. from "50 MPH SPEED LIMIT" to "BRIDGE CLOSED, ALL TRAFFIC STOP." State police units were dispatched to the interchanges and the bridge, and other neighboring police units were asked to assist at the interchanges in diverting traffic. Police representatives said that this action was taken because experience had shown that drivers do not totally comply with the electronic sign messages, and police have to be present to insure that drivers obey the sign messages.

Police officers at the scene reported that the diesel fuel was so slippery that several of them fell while trying to walk on the eastbound lanes. Sand was spread to absorb the fuel and to provide temporary traction. The bridge was closed until the next morning; no other traffic accidents occurred during the period that traffic was diverted.

Injuries to Persons

Injuries	Drivers	Passengers	Pedestrains	Totals
Fatal*	2	1	0	3
Nonfatal	11	5	2	18
None	12	12	0	24
Totals	25	18	2	45

* The drivers of the Nova and the Continental in the third accident group died at the scene. The passenger in the Continental was hospitalized and died 40 days later as a result of her injuries. None of these occupants were wearing seat or shoulder belts.

Vehicle Information

Twenty-six vehicles were involved in the series of collisions: 7 tractor-semitrailer combinations, 1 large utility company truck, 3 pickup trucks, and 15 automobiles. Vehicle inspection efforts were focused primarily on the tractor-semitrailer with the punctured fuel tank, the tractor-cargo tank semitrailer loaded with asphalt, the 1977 Lincoln Continental, and the 1978 Chevrolet Nova since these vehicles were the principal vehicles involved in the fuel spill and the severe injury consequences of the multivehicle accidents that followed.

The tractor-semitrailer with the punctured fuel tank was a 1971 White Freightliner tractor with a 1972 Lufkin flatbed, 2-axle semitrailer. One hundred-gallon diesel fuel "saddle" tanks were mounted on the right and left sides of the tractor, underneath the tractor cab. The bottoms of the tanks were originally 10 inches above the ground. The fuel tanks were made of 0.08-inch thick aluminum plate and were secured to the tractor frame by two aluminum straps, 6 inches wide and 0.06 inch thick. The forward aluminum strap was severed and the lower right front corner of the fuel tank was dented and torn open for a distance of 21 inches by the penetrating steel repair plate. The dent and tear were located at the 7 o'clock position, looking rearward, on the cylindrical tank. The tank remained attached to the tractor and did not sag to the pavement after the strap was severed.

According to distances traveled and fuel receipts, about 85 gallons of fuel was in each tank at the time the left fuel tank was punctured. The amount of fuel lost on the shoulder of the road could not be determined precisely; therefore, the amount of fuel lost on the pavement could only be roughly estimated as about 75 gallons.

The tractor-cargo tank semitrailer hauling asphalt was a 1977 International Fleetstar tractor with a 1968 Trailmobile 2-axle, cargo tank semitrailer. The weight of the vehicle with its cargo of not asphalt was 78,720 pounds. Both the tractor and the semitrailer were registered in the driver's family name. The tractor and cargo tank semitrailer remained attached as the unit struck several vehicles, jackknifed, and struck and partially overrode the concrete median barrier. The cargo tank was not punctured or ruptured. It was dented at the forward right side by the tractor when it jackknifed and the tank and fender were dented at the rear left side from contact with the Honda station wagon. There were also dents and creases in the tank at the forward left side and right rear corner, but these areas were damaged before the bridge accident. The tractor's front bumper suffered no apparent damage or deformation in the accident. Two shades of blue paint transfers across various bumper components were the only evidence of the collisions: the 1978 Chevrolet Nova and the 1977 Lincoln Continental were both painted blue.

Two of the 10 wheel brakes for the tractor-cargo tank semitrailer were not working. The brake push rod at the right rear tandem axle of the tractor, which must move to apply the brakes, was frozen. A kinked air hose prevented application of the left rear tandem axle brake of the trailer. Seven of the remaining eight wheel brakes were out of adjustment but not to their maximum limit.

The driver's side of the 1978 Chevrolet Nova was severely crushed inward from the windshield to the rear end of the automobile. Maximum penetration occurred just below the side window sills and an imprint from the asphalt tractor's front bumper was found in this area. A similar imprint from the asphalt tractor's front bumper was found along the right, passenger's side of the 1977 Lincoln Continental. Penetration and collapse of the Continental's passenger compartment was so severe that the driver's side door handles contacted and scraped the pavement. The clock on the instrument panel stopped at 10:34 plus 50 seconds.

Driver Information

The ages of the 26 drivers ranged from 18 to 61 years old. Twenty-two drivers were either from the Lake Charles area or were out-of-state truckdrivers who were familiar with the Calcasieu River Bridge. Four drivers were from out of state; they were not involved in the injury accidents. Those involved in the more serious accidents -- the asphalt truckdriver (age 61), the Chevrolet Nova driver (age 60), the Lincoln Continental driver (age 48), and the pickup driver/pedestrian (age 22) -- were all familiar with the Calcasieu River Bridge.

According to State of Louisiana traffic records, the asphalt truckdriver had been involved in an injury accident on July 21, 1980, and, according to the truckdriver, he had been involved in an accident several days before the Calcasieu River Bridge accident and another accident several days after. No alcohol or drug tests were administered to any of the involved drivers since the police reported that there was no preliminary evidence, such as odor, slurred speech, or liquor bottles, of such involvement.

Highway/Bridge Information

Interstate 10 is an east-west, coast-to-coast highway across the southern border States of the United States. It functions as an urban freeway and has a high proportion of local users in the vicinity of Lake Charles. The Calcasieu River Bridge was opened to traffic in 1951 as part of U.S. Route 90 and was incorporated into the Interstate 10 roadway system in 1964. The bridge is 1 1/4 miles (6,617 feet) long with a vertical clearance of 143 feet above low water level. The grade is 3.78 percent on the west side of the bridge; on the east side, the grade is 3.78 percent near the crest and changes to 5 percent about 600 feet from the crest. (See figure 1.) The repaired expansion joint was also located 600 feet from the crest. The bridge has two 26-foot wide roadways separated by a 4-foot wide, two-level concrete median wall. (See figure 6.) There are no shoulders or any openings in the median wall for emergency vehicles to cross the median and change directions on the bridge. Overhead lights are mounted at 180-foot intervals along both edges of the bridge. The bridge is maintained by the Louisiana Department of Transportation and Development (LADOTD) which is responsible for State highway construction and maintenance.

Four electronic, changeable message, highway signs are located near both ends of the Calcasieu River Bridge: one about 250 feet in front of the eastbound foot of the bridge, one about 1,950 feet in front of the westbound foot of the bridge, and one each at the two interchanges between I-10 and I-210. A limited number of electronic sign messages, such as closure of the bridge and warnings of traffic conditions, can be changed by a control panel at the State Police barracks. (See appendix B.) The control panel had been installed, tested, and put on line during January 1981.

Television cameras were tested on the bridge in 1979 and 1980 in an attempt to improve traffic surveillance. Some initial problems were encountered in obtaining adequate coverage and picture quality but the problems apparently have been resolved, and the project (LADOTD No. 450-91-15, Traffic Surveillance System) is tentatively scheduled for summer 1982, pending Federal Highway Administration (FHWA) approval of the specifications.

There are 100 expansion joints on the Calcasieu River Bridge, with 7 different expansion joint designs in use; these joints were constructed according to then existing design standards. Expansion joints are provided on bridges to permit sections of pavement and the supporting structure to expand and contract horizontally and vertically with changes in temperature. The repair plate that punctured the tractor fuel tank had been used to repair an LADOTD type-F expansion joint. The type-F expansion joint consists of a series of steel "fingers" that are constructed in 52-inch-long sections which are then attached to an L-shaped support backing plate and an end support beam for a length of concrete pavement bridge deck. (See figures 6 and 7.) The steel fingers are spaced so that the ends of the fingers from one length of bridge deck slide between the ends of the fingers of another length of bridge deck and form a "bridge" between the two lengths of bridge deck. The ends of the fingers are to rest on and slide back and forth across a 4-inch-wide center support beam as the bridge expands and contracts from changes in temperature. (See figure 7.) The center support beam is attached to the section of bridge deck on the downhill side of the expansion joint.

Pieces of steel, 7 inches long and 1/4-inch wider than the steel fingers are used to space the fingers apart. The steel pieces, referred to as spacers, are electric-arc-welded to the sides of each finger using 3/8-inch welds. An end cover plate, 52- by 6- by 1/2-inch, is welded across the top of the fingers and spacers using 3/8-inch welds. The thickness of the fingers and spacers is reduced by 1/2 inch in the area where the end cover plate is attached to provide a lower platform so the top of the end cover plate is at the same level as the top part of the fingers beyond the end cover plate. The thickness of each finger is also reduced by 1/4 inch where the fingers are "notched" to provide tire traction across the top of the fingers. (See figure 6.) The fabrication plans do not specify how the fingers are to be reduced in thickness or notched. A cutting torch was used on the repaired section of fingers where the steel plate dislodged.

A 1/2-inch-thick, curved rod is welded across the bottom of the fingers and spacers to provide a pivot point upon which each section of steel fingers can rotate up and down. (See figure 7.) The capability to rotate is necessary to insure that the fingers remain in contact with the center support beam, whose relative height and position can change with temperature changes, load variations, and other environmental conditions.

Three 1-inch-diameter steel bolts are used to attach each section of steel fingers to a support beam at the end of a length of bridge deck. (See figure 7.) A No. 4 gauge, heavy wire spring is partially compressed between the bottom of the support beam and the locking nuts of each bolt; this spring arrangement allows each section of fingers to rotate about the curved rod pivot point. Without the springs, a section of fingers cannot freely rotate, especially upward, as locked bolts would prevent such movement. The spring may also serve to "dampen" or soften any rebound vibration that could occur after a vehicle passes over the fingers.

Beginning in 1969, a number of expansion joints of various designs on the Calcasieu River Bridge began to experience a variety of problems. LADOTD maintenance personnel made a number of repairs and, between May 1979 and March 1980, an independent contractor rehabilitated some of the expansion joints on the bridge, in accordance with LADOTD design plans. At the type-F expansion joint involved in this accident, all bolts, springs, and nuts were replaced. Since the L-shaped support backing plate and center support beams were worn from contact with the pivot rods and fingers, 5/8-inch thick steel support pads were installed between these supports and the finger sections. (See figure 7.) Because installing the support pads raised the height of the finger sections, a 5-foot-wide pavement patch was installed on each side of the joint to raise the pavement height to match the new height of the finger sections.

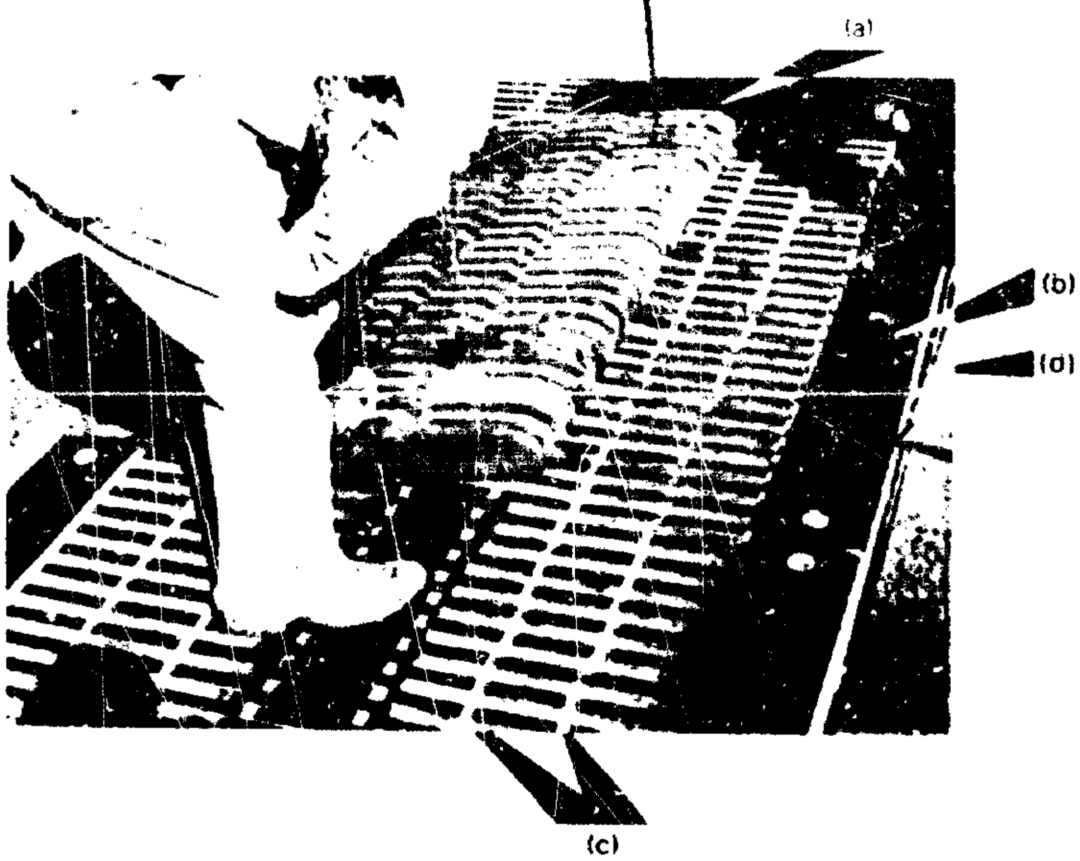

Figure 6.--A 52-inch-long section of steel fingers (a) being lowered and sliding between another section of steel fingers. Note end cover plate (b) and traction notches (c).

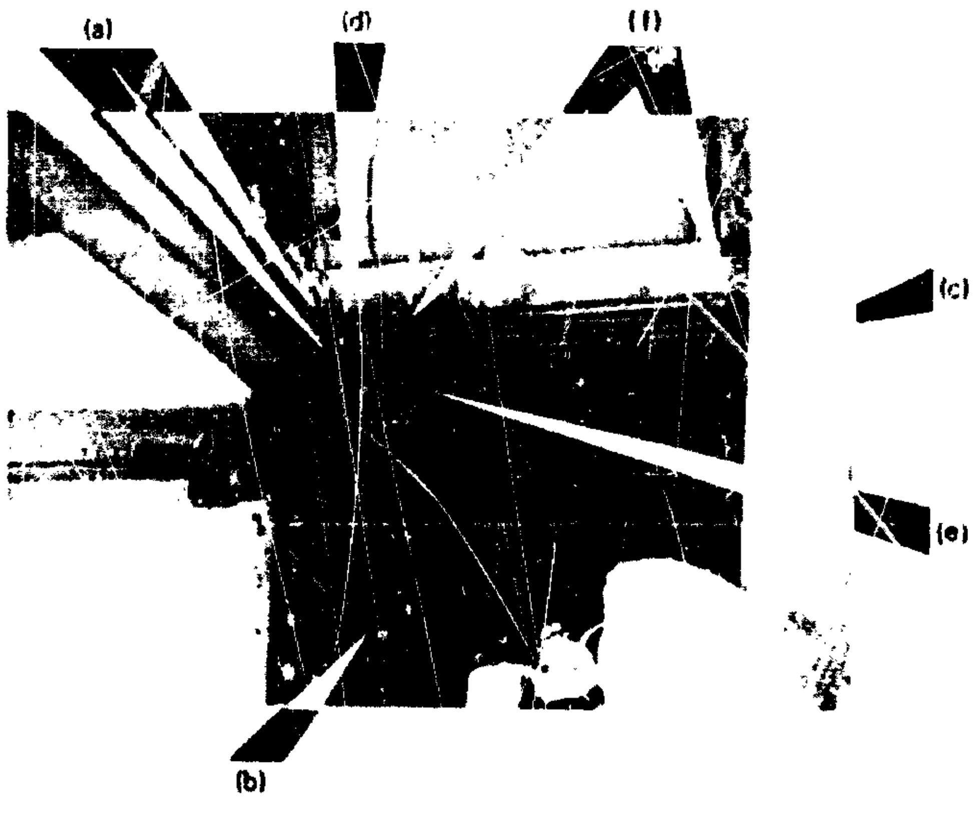

Figure 7.--Side and bottom view of expansion joint. Note L-shaped support backing plate (a), end support beam (b), center support beam (c), curved rod pivot point (d), bolt springs and locking nuts for bolts that attach a section of fingers to the support beam (e), and steel support pads (f).

LADOTD records indicated that on November 19, 1980, a 52-inch section of steel fingers at this same joint split into three pieces near the three bolts that were used to attach the section to the support backing plate and end support beam. The broken section was located in the left wheel path of traffic for the curb lane. Maintenance personnel recalled that at least one of the bolts sheared off but were unable to recall other details. A new section was fabricated by a local general machine shop and was installed by local LADOTD bridge maintenance forces on December 4, 1980.

By April 1981, about 4 months later, one finger in the new section had broken off near the center support beam, and three adjacent fingers had broken off near the edge of the steel end cover plate and near the forward edges of the steel spacers that were used to space the fingers apart. Local LADOTD bridge maintenance personnel placed a 15 1/4-inch square, "A-36" steel repair plate across the top of the hole that was produced by the missing fingers. A noncertified welder 1/ welded the edges of that 5/8-inch thick repair plate to finger 8, finger 16, the steel end cover plate, and the tops of fingers 8 through 10 and 14 through 16 near the center support beam. (See figures 8 and 9.) According to the LADOTD, the repair plate installation was "designed" at the repair site by the local bridge maintenance personnel. The problem of the broken fingers was reported to LADOTD district engineers, and a followup inspection was performed by maintenance personnel (date unknown), but no further repairs were scheduled.

After the accident, Safety Board investigators noted that fingers 14 and 16 to the left of the original hole had broken off at the edge of the steel end cover plate and near the forward edges of the steel spacers. (See figure 10.) The broken off piece of finger 16 had remained welded to the steel repair plate when that repair plate punctured the tractor's left fuel tank. (See figure 2.) The repair plate and attached finger weighed about 60 pounds. Finger 14 could not be found.

The day after the accident, local LADOTD maintenance personnel butt-welded pieces of fingers to the remaining stumps of the broken-off fingers and installed a new and wider repair plate across the fingers. The edges of the repair plate were welded again to the fingers and the end cover plate by the same welder and welding equipment. Two repair plates were placed across the bottom of the fingers and four bolts were used to connect the top and bottom plates together. (See figure 11.) Two days after the repair was completed, the thin welds between the edge of the top repair plate and the top of the fingers near the center support beam were cracked in several spots. On October 19, 1982, about 2 months after the accident, a new 52-inch long section of steel fingers was installed to replace the repaired section.

Meteorological Information

At the time of the accident, the sky had about 30 percent cloud cover, the temperature was 75°, and the wind speed was about 4 mph. Although there had been thunderstorms and rain showers in the late afternoon, area roads were dry at the time of the accident.

1/ Because of an inability to pay and keep certified welders on its maintenance forces, LADOTD does not require its maintenance personnel to be certified welders, and there are no Federal requirements that maintenance personnel for Federal-aid highways be certified. However, contract work for the State requires that welders be certified. Certification requires a welder to demonstrate his ability in various welding techniques.

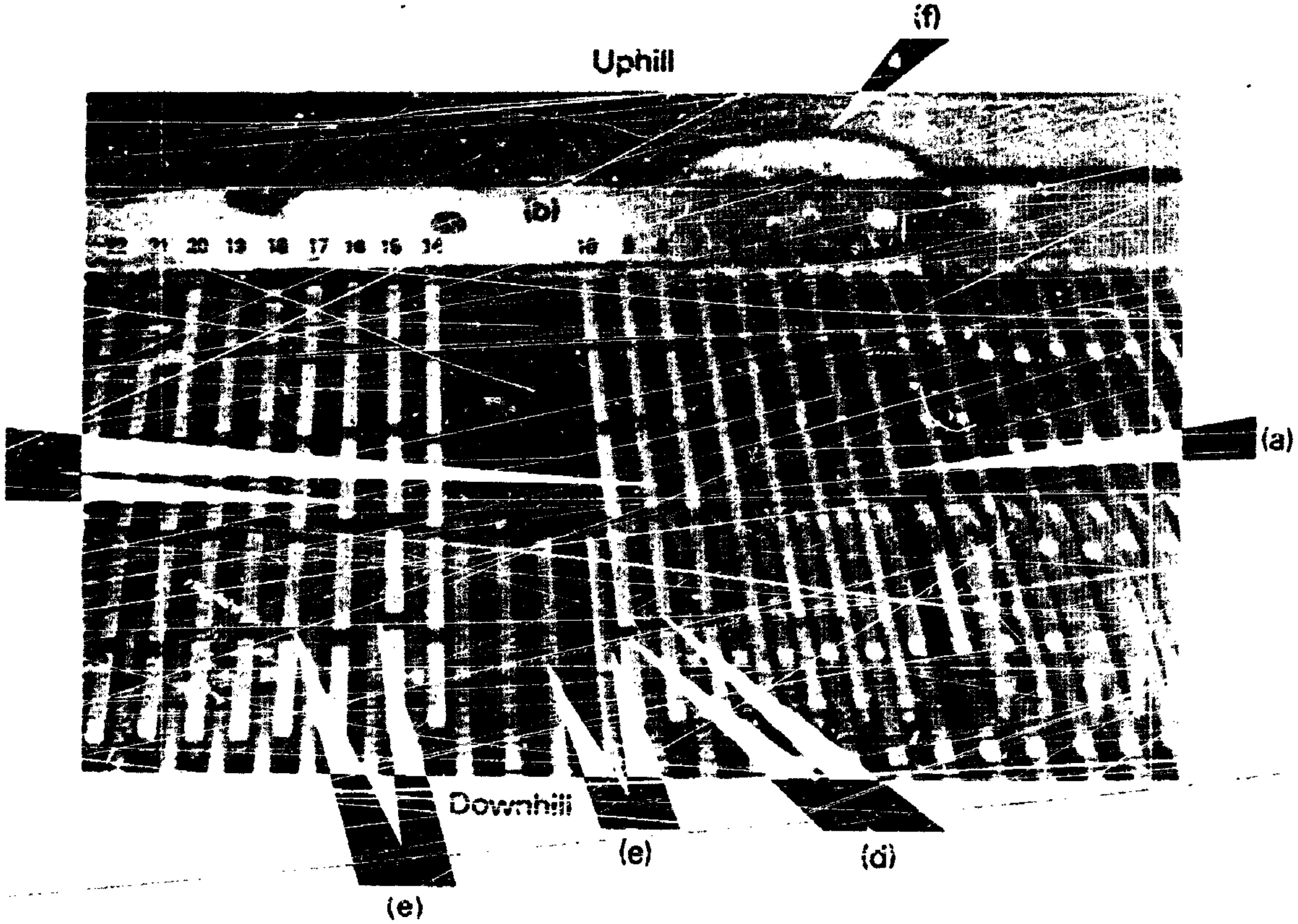

Figure 8.--April 29, 1961, photograph shows that a piece of finger 3 had broken off near the center support beam (a) and three steel fingers were missing from the type-F expansion joint. Edges of the steel repair plate were welded to fingers 3 and 16, the end cover plate (b), and across the tops of fingers 8-10 and 14-16 at a point just before the center support beam (c). Note the traction notches (d) in the steel fingers to the left and right of the hole are irregularly spaced, the tops of some uphill fingers are higher than downhill fingers where they overlap, the tops of some uphill fingers are higher than other uphill fingers, the spreading apart of downhill fingers (e), and the broken-up pavement patch (f).

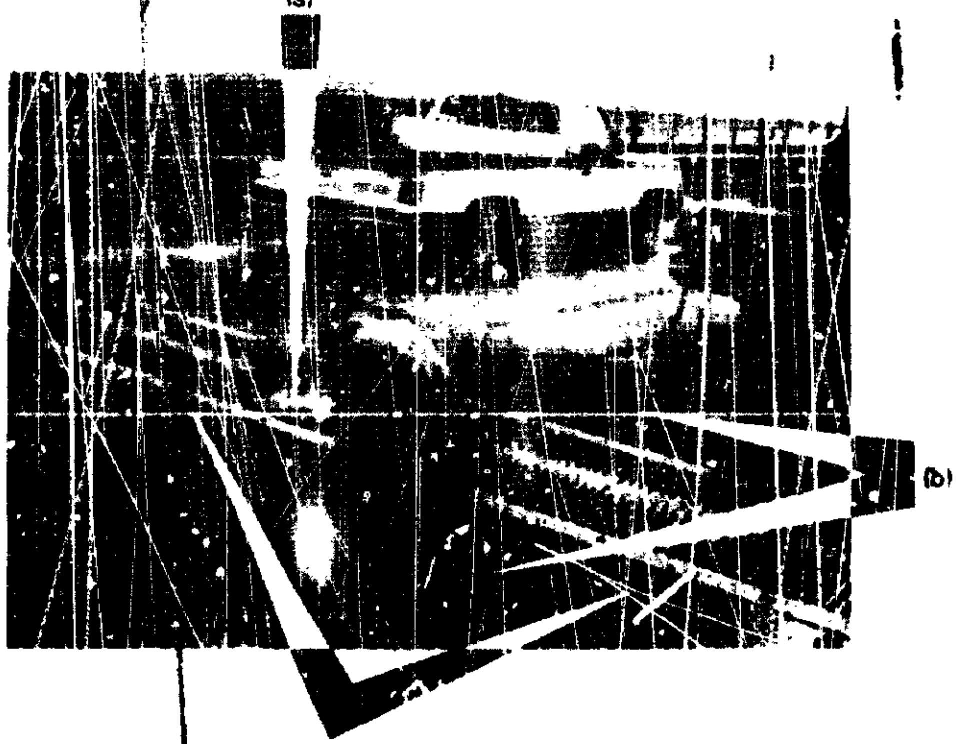

Figure 9.--Calcasieu River Bridge, Interstate 10, bridge pavement expansion joint. Photograph of steel plate (a) being installed on April 29, 1981, 4 months before the accident. This steel plate dislodged and penetrated the tractor's left fuel tank. Note the pavement patches on each side of the joint (b) and the breaking up of these patches (c). Note also that no clamps are being used to hold the repair plate in position and the repair plate is not flat against the end cover plate while it is being welded.

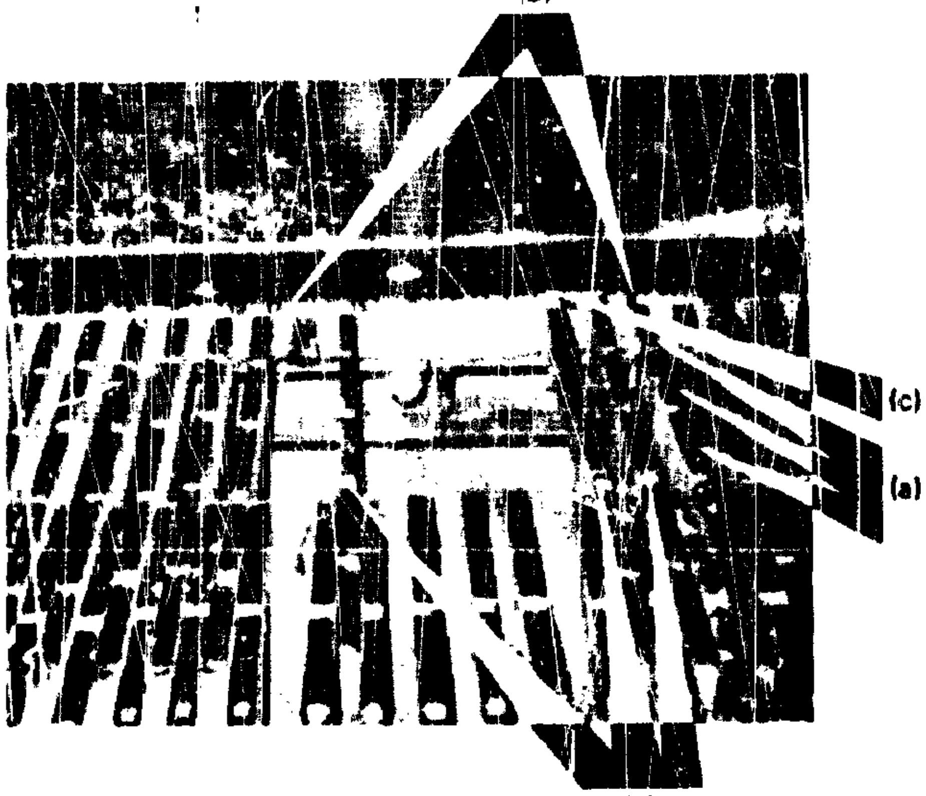

Figure 10.--Photograph made a few hours after the accident occurred. Note the thin lines of welding material on fingers 8, 9, 10, and 15 (a), the welding burn outline on the end cover plate (b) and the thin line of welding material along the edge of the end cover plate (c).

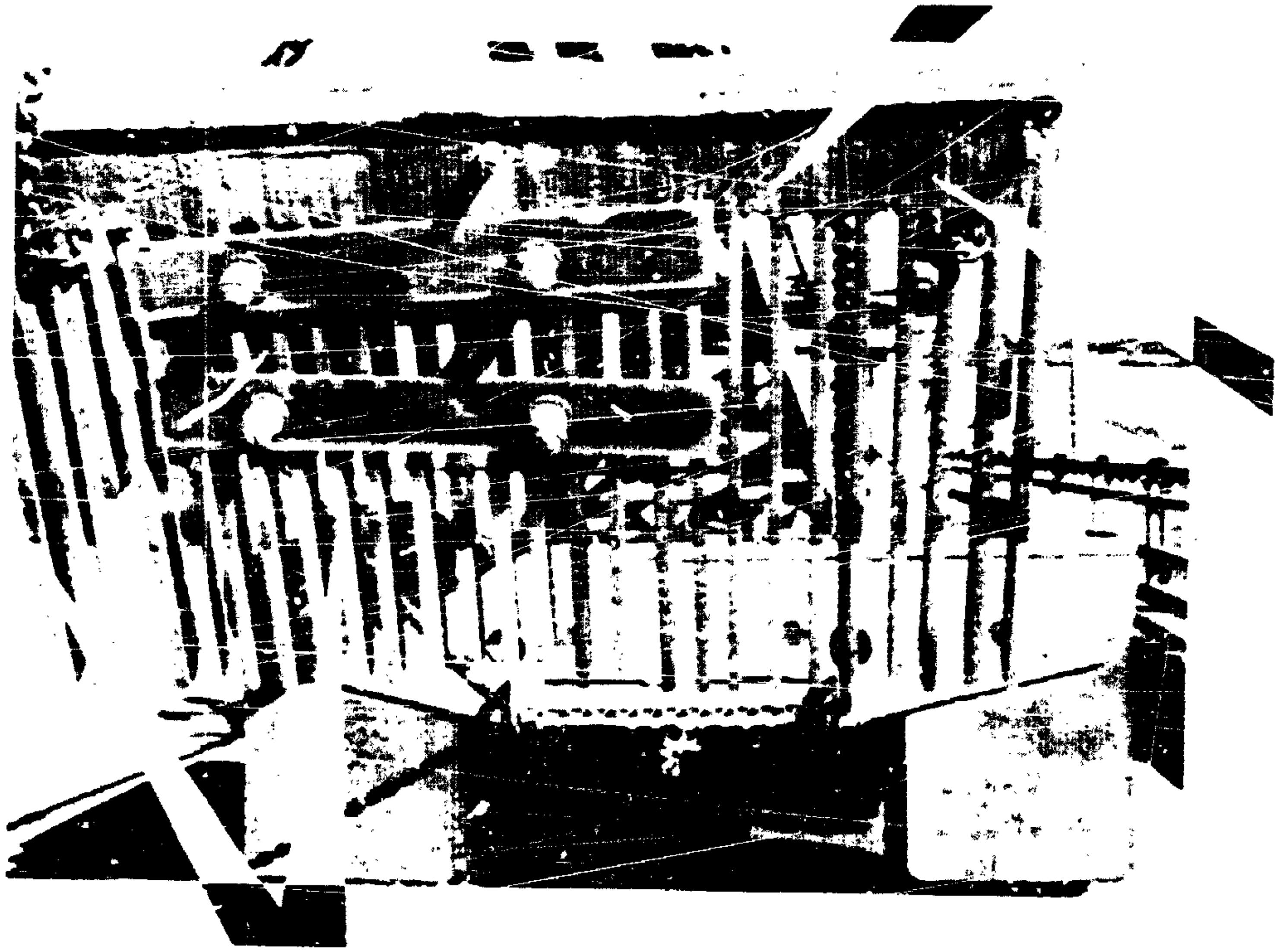

Figure 11.--View of the bottom of the repaired expansion joint section showing bottom plates and four bolts used to connect these bottom plates to the top repair plate. Note the two spacers between each finger (a) and the welds between the bottoms of the spacers and fingers (b). Original finger sections contained only one spacer and no welds of this type. Also note the irregular pattern of fresh wear marks on the bottom of the fingers from contact with the center support beam (c).

Medical and Pathological Information

The drivers of the 1977 Lincoln Continental and the 1978 Chevrolet Nova died at the scene; the passenger in the 1977 Lincoln Continental was hospitalized and died 40 days after the accident. All three victims had sustained severe, multiple internal injuries.

The passenger in the utility truck, who was struck by vehicles in the third accident group sustained abrasions, bruises, and sprains. The driver of the pickup truck, who also was struck by vehicles in the third accident group, sustained multiple leg fractures and internal injuries.

Survival Aspects

The second Lake Charles police officer, who arrived at the accident scene just after the most serious phase of the accident, was a trained emergency medical technician and was driving an emergency medical response unit. Ambulances, police emergency rescue units, and tow trucks arrived within minutes after the accidents. The 1977 Lincoln Continental passenger's blood pressure readings of 0/0 during rescue indicated that she was suffering from deep shock caused by injuries sustained and a loss of blood. Ambulance personnel, under two-way radio direction by a doctor at the hospital emergency room, applied a pair of "MAST 3" pressurized trousers. Upon arrival at the emergency room, her blood pressure reading was 68/0 and doctors credited the MAST 3 trousers for maintaining her life by sustaining a blood supply.

A review was made of the adequacy of on-scene emergency efforts by the Lake Charles police department sergeant in charge of emergency rescue and emergency medical response units. He reported that all aspects of on-scene efforts performed effectively. No problems, such as delayed treatment or additional accidents, were found by the Safety Board.

Tests and Research

Several expansion joint and repair irregularities were noted by Safety Board investigators through magnification of before and after repair photographs, accident photographs, during on-scene examinations of the expansion joint after the accident, and by a metallurgical examination of the repair plate and finger 16. In the replaced/repaired section of fingers, traction notches were irregularly spaced, the number of spacers were not according to original fabrication plans, additional welds were used to attach spacers and fingers, and fingers were 1/8-inch smaller in width than original fingers. (See figures 8 and 11.) These factors indicated that fabrication of the replaced/repaired section was not tightly controlled; also, the reduced amount of metal and the additional welds would reduce metal strength and resistance to fatigue, especially just beyond the welds and at the end cover plate where the fingers were breaking off.

Fingers in the replaced/repaired section were higher than those of adjoining and adjacent sections when the first repair plate was installed. (See figure 8.) Wear marks along the bottom of the fingers from contact with the center support beam varied from little or no apparent fresh contact near the hole and finger 3 to relatively full contact away from these items. (See figure 11.) This indicated that there was little, if any, contact with the center support beam from fingers near the hole and finger 3, even when vehicles were traveling across the fingers and applying full load to these fingers.

On the day after the accident, a large amount of debris from the broken-up pavement patch was visible between the repaired finger section and its support backing plate. (See figure 12.) The broken-up pavement patch was present in both the right and left wheel paths of traffic for the curb lane at the time the repair plate was being installed. (See figures 8 and 9.) Small stones and other pavement debris were found packed behind and under the repaired section in the left wheel path of traffic for the curb lane when it was again replaced on October 19.

A similiar problem of limited fresh contact between the bottom of the fingers and the center support beam was noted for part of the section of fingers in the right wheel path of traffic for the curb lane. Pavement debris was found between that finger section and its support backing plate at those areas where fingers were making limited contact. Although not required in the original design nor in the rehabilitation design drawings, some sections of fingers in this joint had pliable, fabric pads between the finger section and the support backing plate, apparently to permit movement of the finger section while preventing debris from entering at this point. No fabric pads were present at the repaired section or that part of the right wheel path section where debris was found and fingers were making limited contact.

Underneath the repaired section, the rivets that held the L-shaped support backing plate to the end support beam and the bolts attaching the finger section were loose, and there appeared to be a space between the back edge of the support backing plate and the edge of the original concrete bridge deck under the patch. (See figure 12.) This indicated that the support backing plate was pulling or being pulled away from the original concrete deck and debris was falling into and accumulating in the crack between the plate and the deck.

No springs were present between the bottom of the support beam and the locking nuts for the three bolts that attached the repaired section to the L-shaped support backing plate and end support beam. The LADOTD reported that the springs had been lost when the original section broke into three pieces in December 1980 and they could not replace them because they had had none in stock and no supplier would fill a request for only three springs. When the new section was installed after the accident, springs were obtained as part of the new, larger section order. Springs were present in the right wheel path section for the curb lane.

Photographs showed that when the first repair plate was being installed, clamps or other devices apparently were not being used to hold the repair plate in position while it was being welded to the finger section. The repair plate was not flat against the end cover plate while it was being welded to finger 16, and it did not appear that "spot" welds were being used to maintain the position of the plate before final welding. (See figure 9.) Finger 8 appeared to be lower than both fingers that were between it and the hole when the repair plate was installed. (See figure 8.) These factors would hinder maintaining proper position of the plate and butting the repair plate firmly to the pieces being welded.

There was also evidence of some potential problem with finger 16 to which the repair plate was to be welded. The first fingers on each side of finger 16 were spread apart, possibly by excess side-to-side movement by finger 16. A similar spreading of adjacent fingers was visible at a missing finger. (See figure 8.) These two items were perhaps a signal that the finger being welded was already failing.

After the accident, thin "lines" of welding material, estimated from photographs to be about 1/8-inch wide, remained attached to the tops of the fingers near the center support beam and along the center of finger 8. (See figure 10.) An outline of the weld for

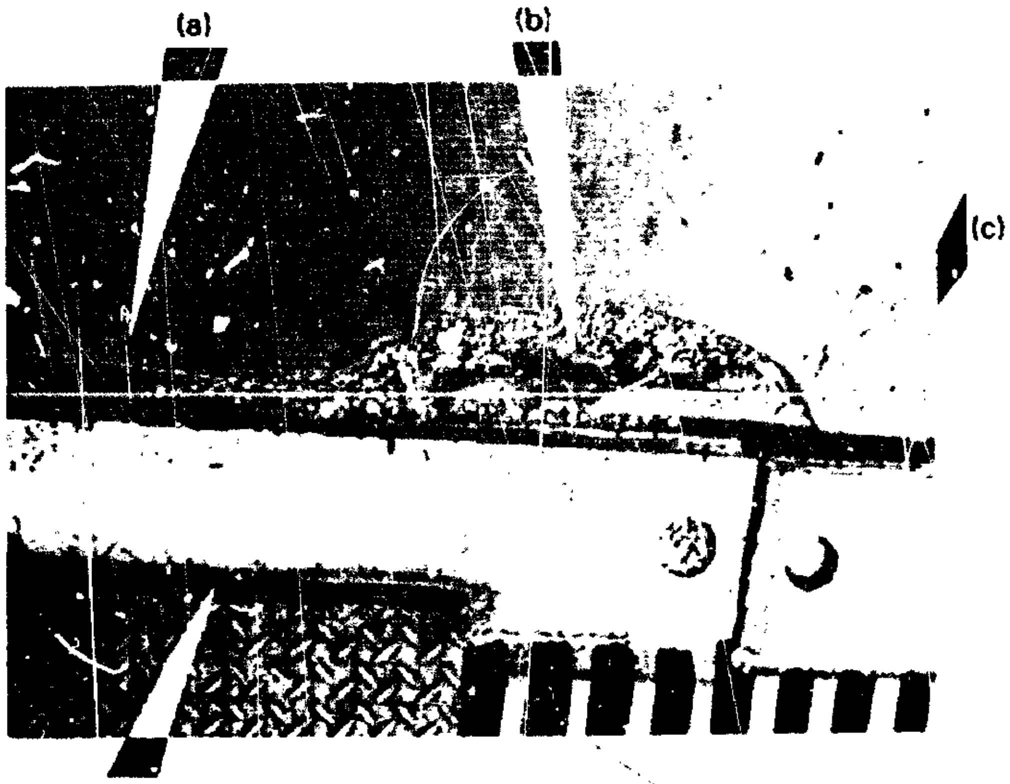

Figure 12.--Photograph of repaired section after the spill accident. Note debris between the repaired finger section and the steel support backing plate (a) and the space between the backing plate and the concrete bridge deck with accumulation of debris (b). Also, note how the pavement patch was placed on top of the support backing plate (c). Repair plate (d) was installed after the accident.

the repair plate was burned into the end cover plate. However, no significant amount of welding material remained attached to the end cover plate near finger 16, and only a very thin line of welding material could be seen along the edge of the end cover plate at other locations. (See figure 10.)

Further evidence of poor weld penetration 2/ and poor effective weld thickness was found for all of the separated welds that remained attached to the repair plate. Where the welded material between the repair plate and the end cover plate separated, weld thickness varied from a knife-like edge, or no thickness, for about one-third of the 15 3/4-inch-long weld, particularly near the attached finger 16, to about 1/8-inch average thickness for the remainder. Where the welding material separated between the repair plate and finger 8, weld thickness averaged about 1/4-inch. For the size of the items being welded, a maximum effective weld thickness of 3/8-inch was possible. In some areas, notably between the repair plate and the fingers, not enough welding was done to provide that much weld thickness. Some of the bottom edges of the separated welds were heavily pounded by vehicle tire loadings after weld separation occurred, indicating that the welds may have separated relatively early in the failure sequence. No pieces of finger or end cover plate material were attached to the bottom edges of these welds, and matching areas on finger 8 and the end cover plate had no welding material attached. This indicated a lack of weld penetration into the end cover plate and finger 8, which would further reduce effective weld thickness.

2/ For a proper weld, metal from the pieces to be welded must be melted and mixed together with the welding rod material while the weld is being made. When this combination of metal cools and sets, the weld is formed. Good penetration of the weld means that a sufficient amount of metal from the pieces to be welded is melted; poor penetration is the opposite.

Irregular wear marks were found on the bottom of the repair plate. The marks, which were produced by contact between the bottom of the plate and the tops of the fingers under the plate as traffic traveled across the plate (see figure 13), further indicated that the fingers were not all at the same height when the repair plate was installed. There were no wear marks on the bottom of the plate in the vicinity of the failed welds which attached the repair plate to the end cover plate and finger 16 which further indicated the repair plate was not butting against these items, and there was a poor potential for proper fit of the repair plate when it was welded.

A wear mark, 1 inch long and 1/4 inch wide, was found on the left bottom surface of the still-attached finger 16. (See figure 13.) The mark was in the vicinity where the finger would make contact with the center support beam, but the dimensions of the mark indicated that the 3/4-inch-wide finger was not in full contact with the 4-inch-wide center support beam and was leaning toward the hole that had been produced by the three missing fingers.

The still-attached finger 16 fractured in front of the original weld that held the end cover plate to the fingers and just behind the original welds that attached the spacers to each side of the finger when the finger section was originally built. Therefore, the top edge of the fracture could be seen during an inspection, but the side edges would be hidden by the spacer welds and the end cover plate. No photographs were available to determine if the top edge of the fracture was visible when the first repair plate was installed.

At the point where finger 16 fractured and broke into two pieces, a heavily rubbed and oxidized fatigue crack began at the top of the finger and extended about halfway down through the finger. (See figure 14.) The wear and oxidation indicated this cracking occurred relatively early in the overall fracture sequence. Two other small areas of fatigue cracking were found in the bottom right (away from the hole left by the three missing fingers) and left corners of the fracture plane. The bottom right corner crack was heavily rubbed and oxidized, indicating the crack occurred early in the overall fracture sequence. Characteristics of the lower left crack indicated that it occurred later in the overall fracture sequence and it began either at the bottom of the finger or from the right. The remaining area in the lower half of the fracture plane contained fresh slanted fracture planes that were indicative of shear overload that occurred later in the overall fracture sequence.

Other Information

Sight Distance.—A truckdriver sitting about 8.5 feet above the pavement, would begin to see the long 5 percent downgrade ahead eastbound when he was at the crest of the Calcasieu River Bridge. However, even with this eye height advantage, a truckdriver would probably have to be quite close to the beginning of the 5 percent downgrade and the repaired expansion joint that was 600 feet from the crest before he would be able to see that the pavement was wet or distinguish the actions of the traffic ahead.

Accident History.—The average daily traffic volume on the bridge is 33,000 vehicles per day. Between 1978 and 1980, the I-10, Calcasieu River Bridge averaged about 120 accidents and one fatal accident per year. For 1980, the bridge had about half the rate of injury accidents for the number of vehicle miles traveled as compared to the average national rate for all interstate highways. However, in 1979 the bridge had the 3d highest accident frequency rate statewide for interstate urban highways and the 10th highest rate of accidents statewide for such highways in 1980, as determined by the critical accident

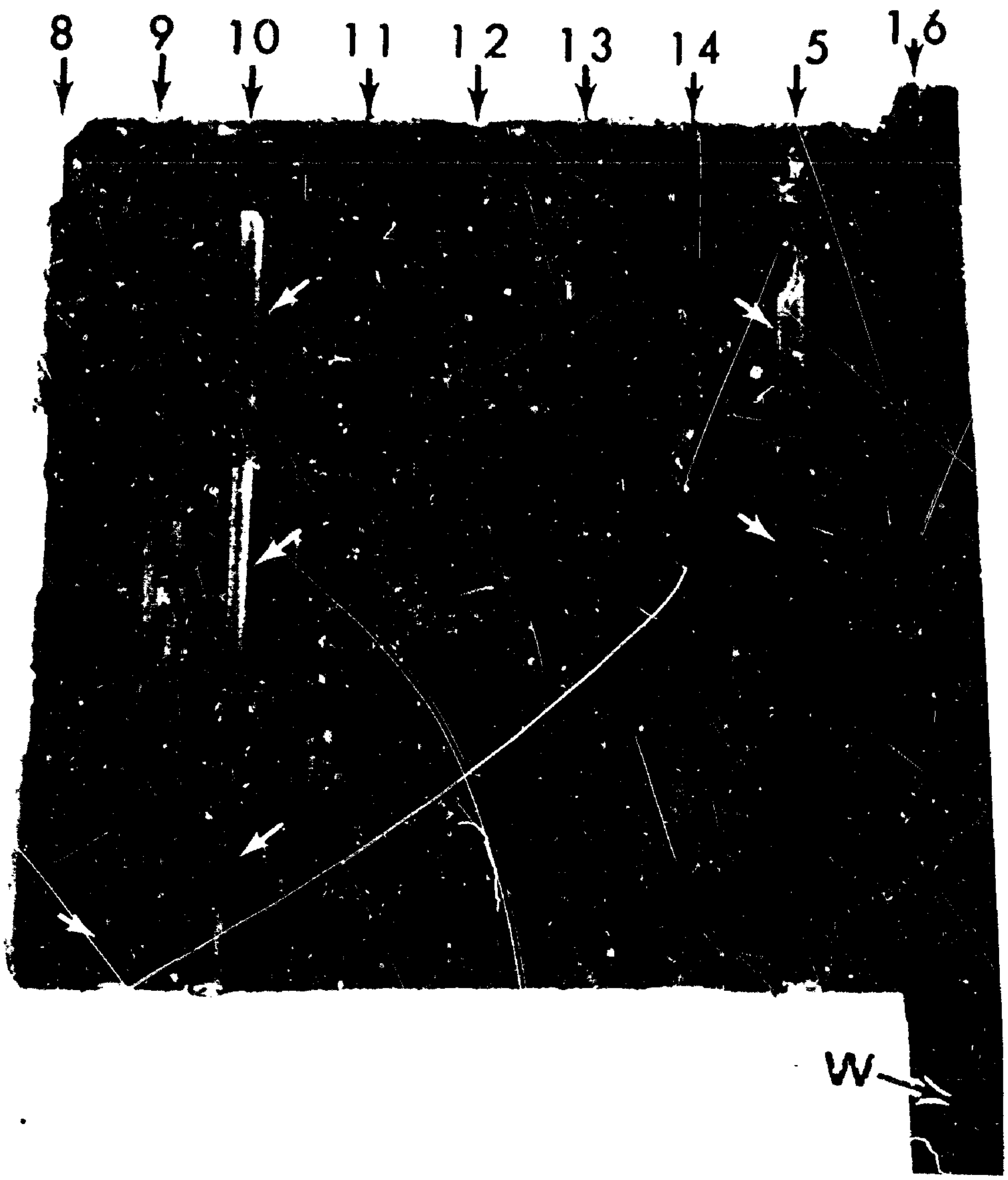

Figure 13.--View of the repair plate underside showing wear imprint from matching fingers (arrowed). Wear mark from the center support beam is located by arrow "w."

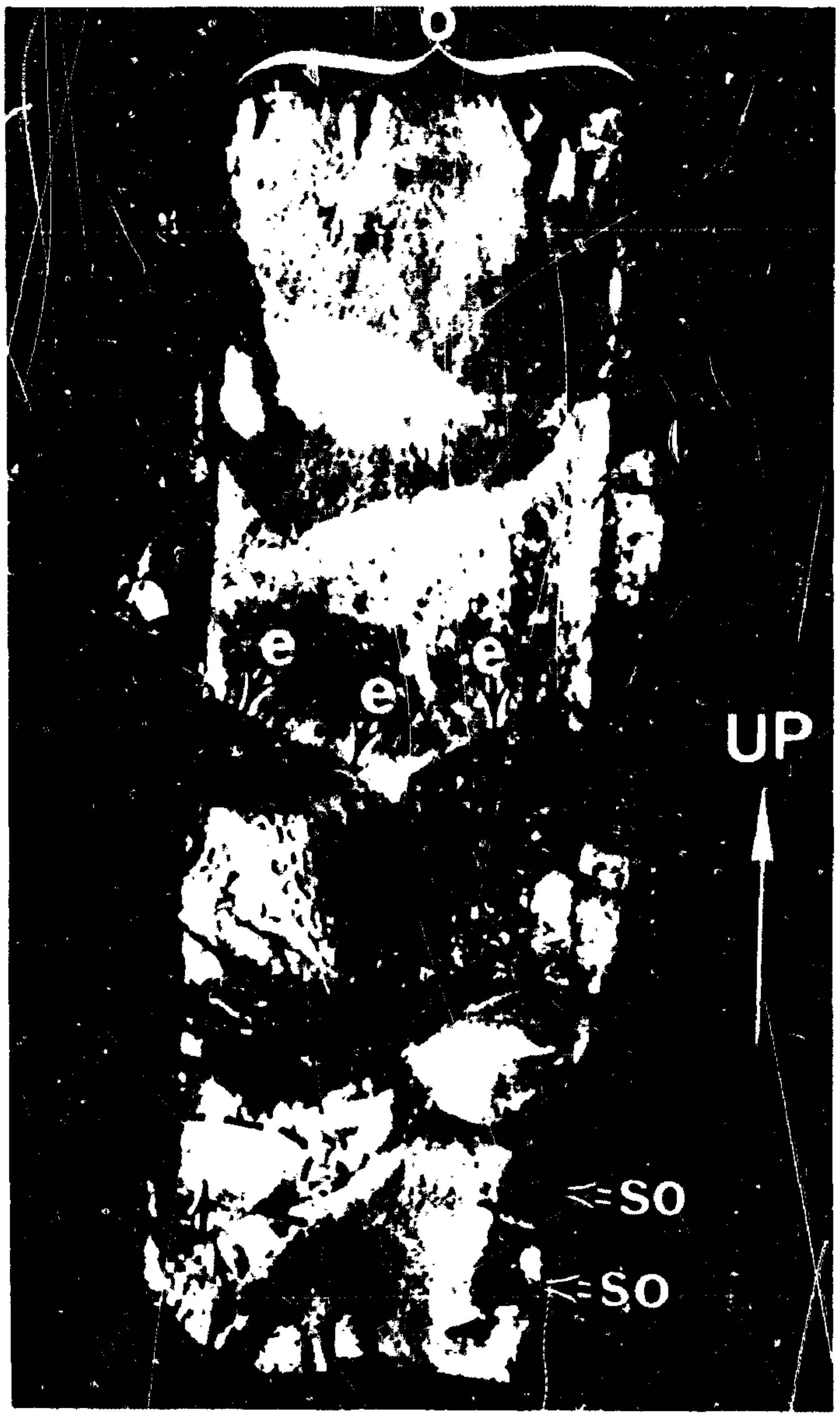

Figure 14.--Fracture of expansion joint finger. This photo magnifies the fracture about 1 1/2 times normal size. Three fatigue cracks extended from bracket "O" to arrows "e," arrows "so" to the thumbnail-shaped lines just to the left, and within the dashed lines. The arrows within the dashed line indicate the direction of fatigue progression for that third area.

rate method. 3/ Rear end, sideswipe, and hitting fixed objects, such as curbs and median walls, constituted the majority of accidents, which are the type of accidents that normally occur on limited access roadways.

Electronic Changeable Message Highway Signs.—Because of such factors as no shoulders and the high number of accidents, maintenance activity, and vehicle breakdowns as compared to other State locations, the LADOTD awarded a contract using 90 percent Federal-aid and 10 percent State funds to install the electronic, changeable message highway signs. The purpose of these signs was to advise motorists of traffic problems and improve traffic control on the bridge. The project was to be completed in December 1980, with State Police personnel to be trained in the operation and control of the signs. The project was not completed on time; the major delay has been the inability of the sign system to function for 10 consecutive days without failure per contract requirements. The on-duty State Police dispatcher at the time of the accident had been instructed in its use only 4 days before the accident, but had been off duty for 2 days after the training session, and had no experience in changing the signs in response to actual incidents.

ANALYSIS

The analysis section examines the type-F expansion joint problems and the fabrication, maintenance, and repair practices followed by the LADOTD maintenance personnel. The quality and adequacy of the maintenance and repair work is addressed. The police function and their response to the reports received from passing motorists is considered and improvements proposed. And, finally the adequacy and timeliness of current motorist advance warning systems are commented on and recommendations are made.

Type-F Expansion Joint Operational Problems

Several operational problems were noted at the type-F expansion joint where the steel plate dislodged on the Calcasieu River Bridge. The first operational problem involved significant wear to the L-shaped support backing plate and center support beam. This wear developed in reaction to the tire loads that were being transferred, as intended by design, through the curved rod pivot points and fingers. An increase in vehicle weights since the expansion joint was designed and installed and 30 years of use would contribute to such an operational problem. The approach taken by LADOTD to correct this problem was to install new support pads and to raise the height of the pavement to meet the new height in the finger sections that was produced by adding the pads. However, no provision was made to raise the height of the steel support backing plate at the joint; rather, an attempt was made to attach the pavement patch to the top of the backing plate. (See figure 12.) With heavy truck traffic, the patch could easily begin to break up at the backing plate since there was no side edge support and a thin layer of pavement was placed over a relatively unyielding steel support.

Fingers on the uphill side of the expansion joint were making limited or no contact with the center support beam while under vehicle load, both in the original right wheel path section that had a spring design to permit relatively unrestrained movement and in the replaced/repaired, left wheel path section without springs. Some mechanism had to raise the finger sections and lock them in place so that they could not remain in full contact with the center support beam. The natural movement of the bridge as various elements expand and contract, caused by temperature and environmental conditions, could have been the mechanism to raise the relative height of the center support beam and,

3/ The critical accident rate method gives more weight to the more serious accidents in determining the accident rate.

therefore, the fingers. Rebound from traffic loads was another possibility. Once the fingers were raised, debris from the pavement patch, which had worked its way down and behind the finger sections, could have formed a wedge to lock the fingers in a raised attitude above the center support beam when conditions changed and the center support beam moved to a lower position or the finger sections tried to return from rebound.

Given the lack of other tight controls, general vertical misalignment of the fingers during fabrication may have played a role in raising and locking some fingers higher than others in the repaired left wheel path section without springs. The extra welds during fabrication would have made that finger section more rigid and a small amount of debris in a few spots could more easily lock the entire finger section in a raised attitude.

Fingers had broken off in the repaired section at: (1) the end cover plate where the thickness of the fingers was reduced by cutting a platform for the end cover plate, and where spacers and the end cover plate had been welded to the sides and bottoms of the fingers and (2) a point just at the beginning of the center support beam where the thickness of some fingers was reduced by cutting a notch for traction. These were points where high shear and bending forces could not be easily tolerated because the amount of metal resisting these forces would be lower and the resistance of the metal to fatigue would be reduced during cutting and welding operations that were called for by design. The additional reduced amount of metal and the extra welds along the bottom of the fingers and spacers that were introduced during fabrication of the repaired section would have added to reducing metal strength and resistance to fatigue at these points.

Normally, with unrestricted movement in the finger sections and simple support by the support backing plate and center support beam, calculated bending and shear forces would be quite low at these points and would present no particular problem. Calculations also indicated that as long as the fingers were not raised and remained in full contact with the center support beam, bending and shear forces would still be quite low, even at a section that had restricted upward movement because of locked bolts. However, in those areas where the fingers were locked in a raised attitude and above the center support beam, such as those near the hole, the fingers would be forced to function like a diving board at a swimming pool. Any load at the raised, free end of that "diving board," or cantilever beam, would produce increasingly higher bending forces when measuring back from the load and toward the locked end of the beam.

Calculations indicated that loads in the range of 1,000 to 1,500 pounds at the raised, free end of the fingers would produce enough bending force at the end cover plate to begin the fatigue cracking noted in the upper half of fractured finger 16. Such loads would normally be produced by the large, heavy trucks that would be traveling in the curb lane, even with all fingers in one section raised to the same height. With adjacent fingers in the same section at differing heights, the condition in some areas, more of a truck tire load would have to be supported by fewer fingers, and earlier failure could be expected at the higher fingers. (See figure 8.)

Such loading also could have caused the pulling away of the support backing plate and the loose rivets connecting the backing plate to the end support beam in the repaired section. Debris falling into the space between the backing plate and the bridge deck would continue to keep the finger sections "locked."

There were at least two possible methods for developing the fatigue cracks that were observed at or near the bottom of fractured finger 16. At some point in the general movement of and damage to the various bridge and expansion joint components, some fingers were partially in contact with the center support beam, but the free ends of the fingers were still raised above adjacent fingers (see figures 8 and 11 for relative heights and wear patterns for the fingers near finger 3 that broke near the center support beam).

This would set up a condition equivalent to a playground "see-saw" where a load is applied to the raised free end of the "see-saw" while the other end is tied down or locked in position.

Under this condition, the highest bending moment for any particular load would be produced at the pivot point of the "see-saw," i.e., the part of the finger in contact with the center support beam. If the finger was equally strong at all points and the load was high enough, the top of the finger would begin to fatigue first at the pivot point, just as finger 3 may have been loaded before it broke off at the center support beam. Calculations indicate that a 3,000-pound load would begin to fatigue the finger at the center support beam. Such high loads were possible near finger 3 because it was close to the end of the finger section and the adjacent section of fingers was lower; therefore, more of a truck tire load would have to be supported by fewer fingers, resulting in higher loads.

However, if a finger was previously weakened by fatigue at the end cover plate, the bottom area of the finger could be fatigued first at the end cover plate rather than the pivot point and by lower loads under the "see-saw" configuration. Calculations indicate that a 1,000- to 1,500-pound load would begin to fatigue the bottom area of a finger that had previously been weakened halfway down from the top, like finger 16 that remained attached to the repair plate. Therefore, it was possible for the "see-saw" configuration to have produced the fatigue cracking that developed in the lower left corner of finger 16 after the top of the finger fatigued.

The second method for developing the lower fatigue cracks would involve truck tires passing over the repair plate, but only to the left of finger 16, and producing bending and twisting moments that would act on the bottom of the finger. The center support wear pattern that was found on the bottom of finger 16 indicated the finger was leaning to the left and that such moments may have been present.

Fatigue cracking from the various loading conditions would progress to the point where the fingers could eventually yield from shear forces, like the fracture that developed in finger 16. These findings indicate that the main problems from a maintenance standpoint are assuring all components of the joint are present and according to design and preventing the buildup of debris that could lock the fingers into a raised attitude with respect to the center support beam. For inspection purposes, finger sections should be periodically examined for raised fingers and fatigue cracking at the end cover plates and center support beams, which are evidence of a potential debris buildup or other finger locking problem.

Adequacy of Expansion Joint Repair

The initial and primary objective of the bridge maintenance crew was to cover the hole that was left by the three missing fingers so vehicle tires would not drop into the hole. Their initial mission was not and should not have been to determine why the hole developed since such a mission would be an engineering analysis task and not a maintenance crew task. However, given the character of the previous known expansion joint problems, the poor potential for proper fit and retention of the repair plate before it was welded, and limited welder qualifications, the first design for repairing the hole that was left by the three missing fingers was inadequate.

Not replacing the missing fingers and placing the repair plate over the remaining fingers would set the stage for producing concentrated loads on the repair plate and welds. The repair plate was sized to be welded to a finger that was already giving evidence of problems by spreading adjacent fingers apart and another finger that apparently was not butting up against the bottom of the repair plate. The repair plate was sized to span only three fingers on each side of the hole, even though these fingers must have been subjected to higher than normal loads when they had to support all of a single or dual truck tire that was partially riding over the hole or riding over falling fingers that produced the hole. The repair plate was not or could not be sized or positioned to fully butt against the fingers and the end cover plate. No second backup method, such as the bolted plates that were used in the second repair to further guarantee attachment was used. A second backup method would have been appropriate given the lack of welder credentials, the fitting problems posed by the fingers, and the history of problems at this joint. These were more commonsense, rather than engineering-oriented, mistakes.

Had the repair plate been properly sized/positioned and the welds that were used to attach the repair plate been optimally made, the additional metal from the repair plate may have been sufficient to resist the bending forces on the fingers for a longer time. For example, calculations indicate that properly adding the repair plate would have made the finger/plate combination about 8 times stronger than a finger alone in resisting cantilever loads, even if the repair plate was added to a partially fatigued finger. Calculations also indicate that the weld placed between the repair plate and the end cover plate could have been made at least 5 times stronger by providing the maximum possible weld thickness. However, the problems of poor fit, limited weld penetration, and limited weld thickness produced welds that were not able to adequately integrate the repair plate with the attached fingers and finger section.

The expansion joints on the bridge and the joint, which the repair plate was part of, had experienced a long history and increasing frequency of operational problems and deficiencies that were known or easily seen by LADOTD personnel. Problems and deficiencies at the joint with the repair plate included significant wear to support components, missing springs and pads, breaking up of a pavement patch leading to the joint, a split finger section, and fingers that were raised above their center support beam and breaking off. The repair did not determine and correct the probable cause of the problem of the missing fingers nor did it rehabilitate or restore the finger section to at least its prior design condition or a known, proven equivalent. Therefore, it would have been inappropriate to have considered the repair a relatively permanent repair.

The Safety Board considered the repair plate installation inadequate from the standpoint of not providing the best possible repair of its type, which was especially appropriate since the joint and finger sections had a known history of recurring problems and the cause of these problems had not been determined. However, since the repair held for 4 months, it was an adequate temporary repair from a time standpoint, and it should have provided sufficient lead time for the LADOTD to have done something more permanent about the recurring operational problems at this finger section.

The Safety Board is aware that current resources to maintain highways are limited. For example, currently the LADOTD headquarters bridge maintenance division has three of eight engineering positions unfilled, and personnel cutbacks are under consideration for Lake Charles district maintenance crews. Efforts to obtain spare finger sections for the Calcasieu River bridge and other maintenance supplies are being hampered apparently by budget restrictions even after this accident demonstrated the need for such supplies to assure adequate, timely followup. The LADOTD has and should continue to seek appropriate funding levels for proper maintenance of State highways. In addition, the LADOTD should: (1) advise LADOTD personnel of the circumstances of this accident and emphasize the need for repair designs that consider known operational problems, repair personnel qualifications, and the need for timely followup to temporary repairs; and (2) establish a program to upgrade maintenance welder qualifications through certification in accordance with performance standards promulgated by the American Welding Society.

Since there is a potential for similar maintenance problems in Louisiana and nationwide at bridge and all other repair sites, the FHWA should: (1) evaluate the current capability of LADOTD maintenance forces to provide timely followup to the type of expansion joint repair that caused this accident and similar repairs of relatively high priority on Federal-aid highways, and (2) advise all State Departments of Transportation of the circumstances of this accident and emphasize the need for proper maintenance practices.

Expansion Joint Repair Plate Final Failure/Tank Puncture Sequence

The fuel tank, which had a 10-inch ground clearance, was punctured to the right of the left front tire by a 15 3/4-inch square plate. Therefore, the final phase of the failure/tank puncture sequence simply could have involved the left front tire passing over the left edge of the repair plate, causing the repair plate to be levered to a perpendicular position, and resulting in the right edge of the repair plate with the attached finger being in a position to be struck by the oncoming fuel tank.

The 60-pound repair plate and attached finger punctured and split the tractor's left fuel tank at the lower right corner of the tank -- the strongest point of the tank -- and split open the tank at one of the securing straps -- a zone where metal thickness was almost twice the thickness of the tank itself. Therefore, no reasonable increase in tank strength or thickness would help to prevent future fuel tank strikes of this type.

Driver and Police Response to Diesel Spill

Drivers who traveled through the diesel spill before any accidents occurred were able to do so apparently because they recognized that the road was wet with diesel fuel and made no sudden maneuvers. The first driver who lost control reported he did not fully recognize what was on the road, and, at least according to a following witness, applied his brakes, thereby losing control. Even a slight brake application can lock the wheels on a slippery pavement surface. Drivers should maneuver through a diesel spill or unknown wet area as though they are traveling on ice. The best approach is not to enter any unknown wet area, especially with any degree of speed, and failing that, not to attempt to perform any steering and braking maneuvers. If such maneuvers are necessary, they must be made very gradually because even a normally light brake application can lock the wheels and contribute to loss of control on a slippery surface.

Apparently, there was some initial problem in communicating the severity of the spill problem to the State Police. Although the State Police were not required by the existing agreement to respond to incidents on the east side of the bridge, a State Police officer did leave to check out the reports on the bridge. This action indicated that the State Police were not treating the reports too lightly. According to the Lake Charles Police Department records and testimony, about 4 minutes of travel was required to respond to the initial report and arrive at the bridge. The truckdriver with the punctured fuel tank was the only person who was at the scene from the time the spill occurred to the time accidents began to happen, and he estimated that 3 to 5 minutes passed during that time interval. This confirmed the State Police's report that they had notified the Lake Charles Police Department as soon as the spill was reported.

A truckdriver who was involved in the first accident group saw the first police unit approach the bridge as he was attempting to avoid a collision. The first police unit saw a large amount of sparks in his rear view mirror as he pulled away from the second accident group, which apparently occurred as a result of the collision of the asphalt tank truck with the Continental, Nova, Honda, the rear of the second accident group, and the median wall. This indicated that the accidents developed to that point in a relatively short time frame.

The fate of the two people who had left their vehicles in the second accident group indicated that the first officer to arrive had correctly judged the situation and took an appropriate course of action by deciding to block the eastbound lanes with his car, rather than attempting to stop traffic on foot.

About 2 of the 4 minutes of the first police officer's travel time to the bridge was at less than maximum speed in responding to the first report. The Safety Board found that about 4 minutes was required to travel the 2 1/2 miles necessary to drive across the bridge, exit and return to the eastbound lanes, and drive to the top of the bridge to block the eastbound lanes while operating at the speed limit. Since the fatal accidents occurred as the first police unit was just beginning that trip, the Safety Board concludes that the time to be gained by no communication difficulties and a maximum effort police patrol response would not have prevented those vehicles that were involved in the third, or fatality-producing, accident group from entering the bridge and spill area.

Although it did not influence this accident, the Safety Board examined the unwritten traffic control agreement between the State and Lake Charles police departments to determine if there was a potential for further improvement in police response by giving the State full responsibility for bridge traffic control, especially since the State Police station is located near the bridge. State and city police did not indicate any problems with the existing agreement. Travel time from the State Police station to the bridge was equivalent to or more than travel time for city police units patrolling in the vicinity of the bridge, which is in the downtown/lakeshore district and is a high frequency patrol area for the Lake Charles police. The Lake Charles police have more patrol units on duty than the State police, and they have more emergency rescue equipment and training. Therefore, it was concluded that no recommendations were appropriate regarding the existing agreement between the State and Lake Charles police departments.

Changing the message on the electronic highway signs was delayed by problems in communicating the extent of the spill problem and personnel inexperience with the control of the sign messages or equipment problems. The growing awareness of the severity of the spill through drivers' reports did spur an increase in police patrol response to the incident, but no attempt was made to change the sign message from "50 MPH SPEED LIMIT" at that time. Given the character of the spill problem, a severe action had to be taken to gain some positive accident-reducing result — changing the sign to close the bridge and stop all traffic -- and that decision had to be made on the basis of varying drivers' reports. Since patrol arrival was known to be imminent, a delay to avoid a "false alarm" and accidents that might occur from traffic stopping/not stopping was somewhat understandable. Given the up to 5-minute delay in changing the sign messages after the accident occurred, it is likely that the sign could not have been changed in time to warn traffic, even if a decision had been made to change the sign on the basis of drivers' reports. This experience indicated that it may be necessary to provide more training in the use of such sign equipment.

The proposed TV surveillance system may have allowed earlier official confirmation of driver reports and more rapid decisions on police patrol response and sign message changes. Therefore, the Safety Board supports the use of this type of system at the Calcasieu River Bridge especially given its high State accident rate, lack of shoulders for vehicle breakdowns and high and increasing maintenance activity. Another potential improvement would be to provide one or more median openings on the bridge for emergency use in order to reduce response time and clear the bridge in emergencies. Further evaluation by the LADOTD is necessary to determine if this is structurally and operationally feasible and cost-effective.

Given the police experience with driver obedience to the sign messages and the reactions of those truckdrivers, who were warned about the diesel spill via C.B. radio but continued to drive onto the bridge and through the diesel spill, use of the signs alone may not have been effective in preventing further accidents. A public information program may be necessary to improve their overall effectiveness.

The C.B. radio network was of some benefit in warning some truckdrivers equipped with the radios of the presence of the diesel spill since these drivers seemed to react more appropriately to the diesel spill once they entered it. However, some of these drivers continued to drive onto the bridge and through the diesel spill. 4/ Perhaps this was due, in part, to the type of warnings being broadcast, the limited sight distance to see the diesel spill, and a lack of understanding about the relative consequences of attempting to travel through diesel spills and other environmental problems, such as fog and icy roads. The use and effectiveness of this network should be further enhanced. The Bureau of Motor Carrier Safety publishes an "On Guard Bulletin" periodically to advise interstate truckdrivers of problems affecting safety, and other journals and magazines are directed to truckdriver and other C. B. radio users. These publications have been and could be used to reinforce the need for proper use and reaction to messages that are transmitted over this network.

The Fatal Accident Sequence

Because the asphalt tank truck was the single principal vehicle that affected the severe injury consequences of the multiple vehicle accidents that resulted from the diesel spill, the Safety Board examined the actions of the tank truck in detail to determine if any action could be taken to reduce the influence of this type of vehicle in future accidents. To establish how the tank truck was interacting with other traffic as it approached the accident scene, a reconstruction of the sequence of events leading to the tank truck's collision with other vehicles was based on witnesses statements, vehicle damage, and other physical evidence.

After the last vehicles in the second accident group came to a stop, two occupants left their vehicles and walked to the front of their vehicles to inspect the damage. It was estimated that between 10 and 20 seconds would have been required for them to do this. The two occupants heard the tank truck braking and turned to run as the tank truck hit the Nova — the first fatal impact. Since the tank truck was traveling about 35 to 40 mph (51 to 58.5 feet per second), it could have been as far as 1,170 feet behind the point where it first struck the Nova when the vehicles in which the two occupants were riding came to a complete stop and they started to get out of their vehicles. Therefore, the tank truck could have been approaching or just entering the diesel fuel spill area when vehicles in the second accident group were coming to a stop. It would have been necessary for the tank truckdriver to look far ahead at the actions of other traffic when he was at a point where he was approaching or entering the diesel spill, the downgrade was getting steeper, and he had decided to try using his brakes.

Truckdrivers do have a special responsibility to be aware of the actions of traffic farther ahead because of the difficulties in vehicle handling during emergencies. However, it would have been difficult for the truckdriver to have been attentive to the traffic conditions ahead when he had limited sight distance up to the diesel spill, and then when he had more immediate problems ahead of him -- the spill and testing his brakes. The truckdriver probably would have needed special advanced warning of the diesel spill to have slowed and reacted this early in the sequence. As an example, the truckdriver who was operating behind the tank truck had special advanced warning

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4/ In the case of the last truckdriver in the accident, he could have taken I-210 as an alternate route around the city and re-entered I-10 on the other side of the bridge.

through his C. B. radio and was able to stop without striking other vehicles; the tank truckdriver had no C. B. radio or other advisory system, such as the electronic highway signs, available to him.

The asphalt tank truckdriver reported that after he tried his brakes he followed the two cars ahead for some short distance down the grade -- an area where he conceivably had time to survey the road farther ahead. He said that he thought that vehicles ahead of the two cars were traveling "straight-ahead, without trouble." At this point, vehicles in the second accident group ahead were stopped relatively straight-ahead without their four-way emergency flashers operating, and it may have been difficult to discern what the vehicles were doing. Brake lights may or may not have been on. Even if they had been on, however, it could have been difficult to determine if the lights ahead were brake lights or taillights, or if the vehicles were braking to maintain speed control on the long downgrade. Alternatively, four-way flashers directly indicate some hazard, such as a stopped or slow-moving vehicle ahead.

The tank truckdriver reported that he began to react when two vehicles ahead of him began to lose control, and his first reaction was to attempt to steer between them. The truck bumper impact marks to the sides of the Nova and Continental confirmed that they were out of control and sideways in the road when they were struck. This steering action was not the best action from the standpoint of reducing the severity of impact to the Nova and Continental, but it did direct the tank truck toward the center median wall, and striking that wall may have reduced the severity of later impacts with vehicles that were stopped in the second accident group.

Vehicle inspection indicated that the tank truck did not have full braking capability, with 2 of the 10 wheel brakes not working and 7 of the remaining 8 wheel brakes out of adjustment. The 7 wheel brakes that were out of adjustment would not have posed a significant problem during a stop on a very slippery surface because even if they had been further out of adjustment, the brakes would have been able to lock the wheels on a slippery surface. 5/ The nonworking brakes were on opposite sides of the vehicle and, therefore, may not have had a serious effect on maintaining stability during braking. But the lack of brakes at these two wheels would have reduced the driver's ability to stop the truck.

According to witnesses, the tank truckdriver did not apply his brakes until just before he struck the Nova. Therefore, the reduced braking capability would not have had a significant effect since the extensive damage to the Nova and the Continental indicated that a large reduction in speed beyond that attainable by the best of brakes would have been necessary to reduce the severity of impact to the vehicles.

The Nova driver would not have survived the collision if she had been wearing seat and shoulder belts because the asphalt truck impact was directly into the driver's side of the Nova, and the driver's area was demolished. The severe side impact to and collapse of the Continental passenger compartment also did not provide any survivable space for occupants. Therefore, belt use would not have changed the injury severity.

5/ Brakes that are out of adjustment similar to the tank-truck would mainly introduce problems during a high speed, rapid stop on a nonslippery surface, or would pose a problem in resisting brake fade during a long, continuous series of brake applications, such as a multi-mile, long steep downgrade.

CONCLUSIONS

Findings

1. The source of the diesel fuel spill on the Calcasieu River Bridge was a punctured tractor-semitrailer engine fuel tank; the tank was punctured by a dislodged steel repair plate that had been used to cover a hole in a bridge expansion joint.

2. A piece of an expansion joint finger remained welded to the repair plate; this finger broke off at the same point where other fingers that produced the hole had broken off.

3. The expansion joints on the bridge and the joint, which the repair plate was a part of, had experienced a long history and increasing frequency of operational problems and deficiencies; problems and deficiencies at the joint with the repair plate that were known or easily seen by LADOTD personnel included significant wear to support components, missing springs and pads, breaking up of a pavement patch leading to the joint, a split finger section, and fingers that were raised above their center support beam and breaking off.

4. Other irregularities, which were found during a detailed inspection of photographs made during repair of the joint and on-site inspection after the accident included: (1) a lack of tight control over fabrication of the just-replaced finger section that was being repaired 4 months later, (2) accumulation of debris between the finger section and its supports from the broken up pavement patch, (3) loose end support attachments, (4) poor potential for proper fit and retention of the repair plate before it was welded, and (5) a less than optimum welding technique and welds.

5. Evidence of fatigue cracking was found along the top half and at the lower corners of the break in the finger that remained attached to the repair plate; evidence of shear overload was found in the remaining area of the break.

6. The pavement patch was breaking up because a thin layer of pavement was placed over a relatively unyielding steel support with no side edge support. The thin layer of pavement would have little resistance to heavy truck traffic.

7. The natural movement of the bridge or rebound from traffic loads could have been the mechanisms to raise the expansion joint finger sections, and debris from the broken-up pavement patch could have been the mechanism to lock the fingers in a raised position above the center support beam.

8. General vertical misalignment of the fingers and extra welds during fabrication may have played a role in raising and locking fingers in the replaced/repaired finger section.

9. The raised fingers were forced to function like a diving board, or cantilever beam, and high bending forces were transferred to points where such forces would not normally be present or designed for. The amount and strength of the metal was reduced by cutting and welding operations at these points and the fingers began to fatigue from this combination of events.

10. Given the character of the previous expansion joint problems and limited welder qualifications, the use of a welded steel repair plate which butted poorly against the end cover plate and expansion joint fingers which were near the hole and showed evidence of problems, was an inadequate design.

11. Problems of poor fit between components, limited weld penetration, and limited weld thickness produced welds that were not able to integrate the repair plate adequately with the expansion joint.

12. From a quality standpoint, the repair plate was inadequate because it did not provide the best possible repair of its type, which was especially appropriate since the joint and finger sections had a known history of recurring problems and the cause(s) of these problems had not been determined.

13. From a time standpoint, the 4-month period between the expansion joint repair and the accident should have provided LADOTD sufficient lead time to have done something more permanent about the recurring operational problems at this joint; personnel and budget limitations may have reduced LADOTD capability to do something more permanent.

14. The final phase of the repair plate failure/tank puncture sequence could have simply involved the left front tire of the truck passing over the left edge of the repair plate and levering the repair plate to a perpendicular position so that it would be in position to be struck by the fuel tank.

15. Since the repair plate punctured and split open the tractor fuel tank at one of its strongest and thickest areas, no reasonable increase in tank strength or thickness would help to prevent future fuel tank strikes of this type.

16. Apparently, there was some problem in communicating the seriousness of the spill problem to State Police stationed within 3/4-mile of the bridge and in understanding its potential consequences; however, the time that could have been gained by no communication difficulties and a maximum effort police patrol response would not have prevented those vehicles that were involved in the fatal-producing phase of the accident from entering the bridge and spill area.

17. No attempt was made by the State Police to change the message of electronic highway signs that were located on the approach to the Calcasieu River Bridge on the basis of varying drivers' reports; this decision was somewhat understandable because of the imminent arrival of police at the bridge and the potential for a false alarm with accidents in announcing the only appropriate message to close the bridge.

18. State police personnel inexperience or equipment problems would have prevented changing the electronic sign message in time to warn traffic even if a decision had been made to change the sign on the basis of drivers' reports.

19. A currently proposed television surveillance system for the bridge may have afforded earlier official confirmation of drivers' reports and more rapid decisions on police patrol response and sign message changes.

20. The C.B. radio network was of some benefit in providing advance warning of the presence of the diesel spill to some truckdrivers, and these drivers were able to react more appropriately to the diesel spill once they entered it; however, not withstanding these warnings, some of these drivers entered, rather than stopping short of or detouring around the diesel spill.

21. A tractor-cargo tank semitrailer that was loaded with asphalt was the principal striking vehicle in the fatal accidents that occurred.

22. The asphalt tank truckdriver entered the diesel spill at a point in the accident sequence in which it would have been difficult to detect and react to the type of accidents and traffic backup ahead that were getting closer to the beginning of the diesel spill, and, thus, reducing time available for vehicles entering the spill to react.

23. Vehicles involved in accidents ahead of the asphalt tank truck were stopped relatively straight-ahead and were either holding their brakes on or otherwise not employing their four-way emergency flasher systems, which could have delayed the truckdriver's recognition that they were stopped.

24. Special advance warning of the diesel spill before the tank truck entered the diesel spill area probably would have been necesary to avoid its collisions, but such a warning system -- C. B. radio, the electronic highway signs —was not available to the tank truckdriver.

25. The tank truckdriver's decision to steer between the two vehicles ahead that lost control was not the best action for reducing the severity of impact with the two vehicles, but it did direct the tank truck toward the center median wall, and striking that wall may have reduced the severity of later impacts with other vehicles that were stopped ahead.

26. The braking capability of the tank truck was reduced because 2 of the 10 wheel brakes were not working; however, this reduced braking capability probably did not affect the severity of the fatal impacts because the tank truckdriver only initiated braking just before these impacts; thus, sufficient time or distance was not available to achieve the large decrease in speed that would have been necessary to reduce the severity of these impacts.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the loss of vehicle control on a slippery highway surface, produced by a diesel fuel spill from a truck fuel tank punctured by a dislodged steel plate used as a temporary repair of a bridge expansion joint. Contributing to the accident was the failure of the Louisiana Department of Transportation and Development to make a permanent repair at that joint.

RECOMMENDATIONS

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

--the Federal Highway Administration:

Assist the State of Louisiana in providing a television surveillance system for the section of Interstate 10 which crosses the I-10, Calcasieu River Bridge. (Class II, Priority Action) (H-82-22)

Evaluate the current capability of the Louisiana Department of Transportation and Development (LADOTD) to provide timely followup to the type of expansion joint repair that caused this accident and similar repairs of relatively high priority on Federal-aid highways. If necessary, assist the LADOTD in resolving discovered problems. (Class II, Priority Action) (H-82-23)

Advise all State Departments of Transportation of the circumstances of this accident and emphasize the need for repair designs at bridges and all other repair sites that consider operational problems, repair personnel qualifications, and the need for timely followup to temporary repairs. (Class II, Priority Action) (H-82-24)

--Bureau of Motor Carrier Safety of the Federal Highway Administration:

Issue an On-Guard Bulletin to advise truckdrivers of the circumstances of this accident, and the potential benefits to be derived from the use of the citizens band radios, when properly used, and encourage positive reaction to messages that are transmitted over this network. (Class II, Priority Action) (H-82-25)

--the Louisiana Department of Transportation and Development:

Advise maintenance personnel of the circumstances of this accident and emphasize the need for repair designs at bridges and all other repair sites that consider operational problems, repair personnel qualifications, and the need for timely followup to temporary repairs. (Class II, Priority Action) (H-82-26)

Establish a program to upgrade maintenance welder qualifications through certification in accordance with performance standards promulgated by the American Welding Society. (Class II, Priority Action) (H-82-27)

Conduct a study to determine if it is structurally and operationally feasible and cost-effective to provide a median opening(s) on the I-10, Calcasieu River Bridge for emergency use. If the study determines that the median openings are feasible and cost effective, immediately provide such an opening on the bridge. (Class II, Priority Action) (H-82-28)

Publicize the purpose of and need for compliance with the I-10/210 electronic, changeable message sign system through local media. (Class II, Priority Action) (H-82-29)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JIM BURNETT
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ DONALD D. ENGEN
Member

PATRICIA A. GOLDMAN, Vice Chairman, did not participate.

G. H. Patrick Burlsey, Member, filed the following concurring and dissenting statement:

I concur in the probable cause and in the recommendations, except the recommendation to the Bureau of Motor Carrier Safety (No. H-82-25) which I disapprove. I do not concur in the adoption of the report as written. In my view, the unduly extended discussion of the metallurgical aspects of the failure of the temporary repair grossly overemphasizes the significance of an episodic element of the accident and detracts from the more important lessons to be gained from the accident by highway maintenance and enforcement personnel. A greater emphasis on scheduling timely permanent repairs and on emergency traffic control measures would better serve the public interest than a detailed exposition of engineering principles which do not come into practical play in day-to-day road maintenance activity.

July 15, 1982

APPENDIXES

APPENDIX A

INVESTIGATION

1. Investigation

The National Transportation Safety Board was notified of the accident at 6:00 a.m., on August 28, 1981. Investigators were dispatched from the Washington, D.C., headquarters and arrived on the scene at 10:30 a.m., on August 29, 1981. The Safety Board was assisted by representatives of the Bureau of Motor Carrier Safety, the Federal Highway Administration, the Louisiana Department of Transportation and Development, the Louisiana Department of Public Safety (State Police), and the Lake Charles Police Department.

2. Deposition/Hearings

Depositions were not taken and a public hearing was not held in connection with this investigation.

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APPENDIX B

SIGN MESSAGES AVAILABLE FOR EASTBOUND TRAFFIC AT CALCASIEU BRIDGE ON OCTOBER 27, 1981

1 BRIDGE CLOSED ALL TRAFFIC STOP	2 ACCIDENT AHEAD USE RIGHT LANE KEEP MOVING	3 ACCIDENT AHEAD USE LEFT LANE KEEP MOVING	4 LEFT LANE CLOSED USE RIGHT LANE KEEP MOVING	5 RIGHT LANE CLOSED USE LEFT LANE KEEP MOVING
6 CAUTION DEBRIS ON BRIDGE USE RIGHT LANE	7 CAUTION DEBRIS ON BRIDGE USE LEFT LANE	8 SLOWER TRAFFIC KEEP RIGHT	9 CAUTION HIGH WINDS ON BRIDGE REDUCE SPEED	10
11	12	13 EVACUATION UNDERWAY TUNE TO LOCAL RADIO FOR INFORMATION	14	15
16 SPEED LIMIT 50				

U.S. GOVERNMENT PRINTING OFFICE : 1981