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Forensic Engineering: Highway Construction Work Zone Accidents

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This paper will discuss Highway Construction Work Zone accidents, and how not adhering to generally accepted engineering principles and practices in the field contributes to their occurrence. Highway Construction Work Zone accidents have increased over the years due to higher speeds on our highways and the lack of adequate advance warning signs before the start of the Construction Zone. Higher speeds require increased distances in the placement of Advance Warning signs to inform motorists that they are entering a Construction Work Zone Area. Problems occur where lanes merge and vehicles have to move into an adjacent lane. This causes traffic to suddenly slow down, or even stop, thereby causing traffic to back up even before the advance warning signs. This situation can lead to rear end collisions.

The 2005 National Highway Safety Administration statistics state that 1,074 fatalities occurred in Construction Work Zones, up from 1,063 in 2002 and 989 in 2001. The highest number of fatalities in Work Zones were 1,186 deaths and 52,000 injured during 2002. Drivers and passengers accounted for about 85% of the Work Zone fatalities, with the remainder being construction workers. Since 2002, about 45% of Work Zone fatalities have occurred during nighttime construction.

The Federal Highway Administration made major changes to the Manual of Uniform Traffic Control Devices for Streets and Highways (MUTCD) in its 2003 edition. They required that all States and Federal agencies change their State laws to follow the Federal Department of Transportation Highway Administration Manual of Uniform Traffic Control Devices for Streets and Highways (MUTCD) regulations, or loss highway funding:

> *"In accordance with 23 CFR 655.603(b) (1), States or other Federal agencies that have their own MUTCDs or supplements shall revise these MUTCDs or Supplements to be in substantial conformance with changes to the National MUTCD within 2 years of issuance of the change."* [1]

The MUTCD 2000 and 2003 editions spelled out the proper procedures to set up Temporary Traffic Controls (TTC) for all types of construction within

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highway rights-of-way under its Part 6 Temporary Traffic Control Section 6A.01 General, which applies both to rural and urban areas. It states the following:

> *"TTC plans and devices shall be the responsibility of the authority of a public body or official having jurisdiction for guiding road users. There shall be adequate statutory authority for the implementation and enforcement of needed road user regulations, parking controls, speed zoning, and management of traffic incidents. Such status shall provide sufficient flexibility in application of TTC to meet the needs of changing conditions in the TTC zone."*

Many States have added to their Standard Specifications that all Construction Plans shall contain a Temporary Traffic Control Plan (TTCP) and that personnel in charge of the TTCP shall be trained and/or certified in the development and maintaining of the TTCP.

Section 6C-1[2] states the following:

> *"TTC plans should be prepared by persons knowledgeable (for example trained and/or certified) about the fundamental principles of TTC and work activities to be performed. The design, selection and placement of TTC devices for TTC plan should be based on engineering judgment."*

Qualified TTC personnel shall be involved in the design, and qualified TTC personnel shall be assigned by the resident engineer's staff, and also the contractors shall have qualified personnel assigned to set up, maintain, and remove TTC devices. The resident engineering staff shall approve changes by the contractor to the TTCP. To aid in the design and operations of a TTC Plan the MUTCD has 46 typical applications for different situations[3].

Work duration[4] is a very critical component in creating a TTC Plan, and there are five categories:

1. Long-term stationary work is work lasting more than 3 days.
2. Intermediate-term stationary work is work lasting up to 3 days during the daytime hours and at least one hour during nighttime hours.
3. Short-term stationary work is work lasting at least one hour during a single daylight period.
4. Short-term duration work is work lasting less than one hour.
5. Mobile work is work that is moving intermittently or continuously.

Two types of Highway Construction Zone Accidents are divided into the following categories:

1. Lack of a Temporary Traffic Control Plan being provided;
2. Inadequate number of warning devices used in approaching a Work Zone.

Lack of a Temporary Traffic Control Plan

The lack of a Temporary Traffic Control plan is quite common on projects not involving State or County roadways. A Town in New Jersey commissioned a Consulting Engineer to redesign a 4,300 foot long two lane rural roadway in 2003. The Consultant set up a contract, and was responsible for the inspection of the Contractor's work. The scope of the project was to remove the existing pavement and replace it with 6 inches of base course, 3.5 inches of asphalt base, and 2" of top course. NJDOT Standard Specifications required conformity to the MUTCD, and that the Consulting Engineer shall provide a Traffic Control Plan signed by a Professional Engineer licensed to practice in the State. In addition, the Contract Specifications and Plans called for the Contractor to provide a Traffic Control Plan.

The low bidder payment item for Maintenance and Protection of Traffic was a Lump Sum of $3,000 Dollars, which included Advance Warning signs, Construction signs, and Traffic Directors (Police personnel), etc. The Consulting Engineer hired an inspector (bean counter) whose responsibility was to check only quantities, and to report if the Contractor had any questions. The inspector was not required to have the Contractor comply with the requirement of providing a Traffic Control Plan. The procedure for approval of a Traffic Control Plan was for the Contractor to submit the TCP to the Design Engineer who would then submit it to the Town Consulting Engineer for approval, which happened to be the same person.

FIGURE 1
ROADWAY BEING PAVED

The subject accident occurred within the intersection of a County Road and a Town Road. The Town Road was under construction with an asphalt base course placed in the left lane only. The right lane had only a gravel subbase for a distance of 600 feet, and it stretched back from the intersection and around a bend (Figure 1). There were no advance warn-

ing signs in place to inform motorists that the right lane was for two way traffic. There was only one Flagger at the other end, 600 feet from the intersection. The subject accident occurred during the paving operation at the intersection.

There were no advance warning signs on any of the approaches to the intersection. The posted Speed Limit was 50 MPH on the County Road, and there was no posted Speed Limit on the Town Road or a reduced speed zone within the 4,300 foot construction area. The Contractor closed the left lane in order to do paving and permitted two-way traffic in the right lane. The pavement roller was going back and forth into the center of the intersection, blocking the sight distance on both the County Road and the Town Road.

Figure 2 shows the pavement roller just before the intersection three days (on a Monday) after the accident.

Figure 3 shows the intersection and traffic cones, the only advance Temporary Traffic Control Devices used to warn motorists during the placement of the asphalt top course. During the subject accident, the owner of the contracting company was acting as a Flag Person, and he was standing next to the Stop Sign directing the roller operations.

Figure 4 shows the intersection and the placement of the Temporary Traffic Control Devices. This was the extent of the Temporary Traffic Control Plan.

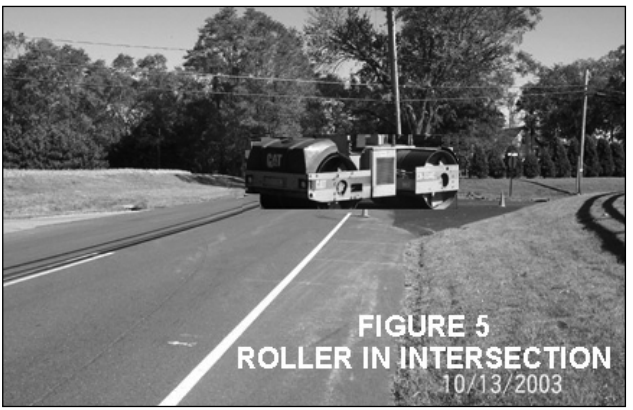


Figure 5 shows the sight distance problem created by the pavement roller in the middle of the intersection during the subject accident

This case being defended on the basis that the Contractor was to provide a Temporary Traffic Control Plan. However, the Contractor never provided a TTCP and the Consulting Engineer never required one after the award of the contract. The NJ Standard Specifications required that the Consulting Engineer provide a TTCP as part of the Contract Drawings. In addition, the Contractor was the low bidder because he allocated only a Lump Sum of $3,000 dollars in his bid for the Maintenance and Protection of Traffic. The $3,000 allocation could have been for Advance Warning signs, or for Police Director. Police Directors were part of the Contract Specifications, with a prevailing rate of $37.00 per hour. Converting a one lane roadway into a two-way single lane roadway required at least two Flaggers for the entire 5 days of paving, resulting in a cost of $2,960.00. The Contractor claimed he used up the entire allocation of the Maintenance and Protection of Traffic item. After three trial postponements, they reached an out of court settlement.

Inadequate Number of Warning Devices Used In Approaching a Work Zone

Another major problem in a Highway Construction Work Zone is that the Contractor does not follow the existing Temporary Traffic Control Plan. The Advance Warning Signs shall give adequate warning to motorists as they approach a Construction Work Zone. Many accidents occur on the approaches to the Work Zone where lanes closures and/or lane shifts starts. In many cases, both one and two lane closures did not have adequate advance warning signs, which were then followed by the abrupt shifting of two lanes.

This type of case occurred on westbound I-495 just before the I-95 interchange in Norfolk County, Massachusetts. The Contractor was repaving three lanes of the I-495 northbound lanes for 10 miles. The Contractor changed the Temporary Traffic Control Plan by closing two lanes for 5 miles and converting the shoulder lane into a second lane of traffic (see Figure 6). The Contractor saved money by closing off two lanes to create a 7.6 meter (25 feet) Work Area for five miles, thus providing two through lanes for vehicular traffic. His purpose was to reduce the cost of closing down each lane on a daily bases. This concept worked well until the Contractor had to shift the travel lanes from the right side of the roadway to the left side. Another major factor was that the Work Zone had a speed limit of 65 MPH, because in 2002, the Commonwealth of Massachusetts State Legislators did not pass the annual bill to reduce the speed limit in a Work Zone. The Contractor placed Advance Warning signs 5 miles from the start of the Construction Work Zone, with no intermediate signs at each interchange to warn the motoring public that the roadway was under construction. Figure 6 shows the I-495 and I-95 under construction.

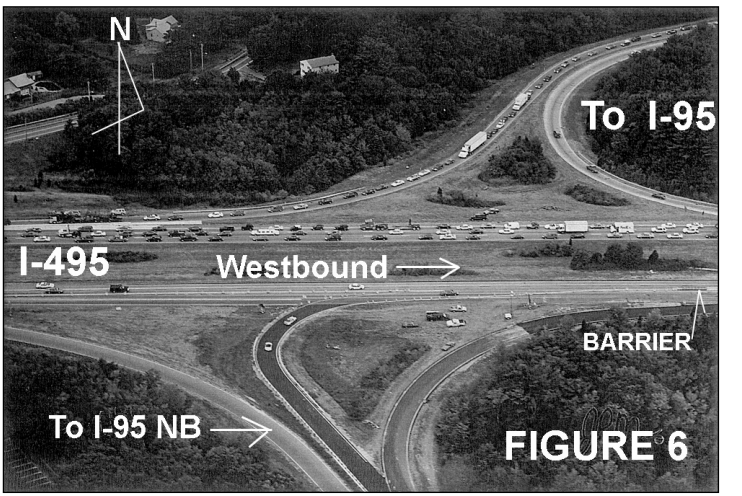


FIGURE 6

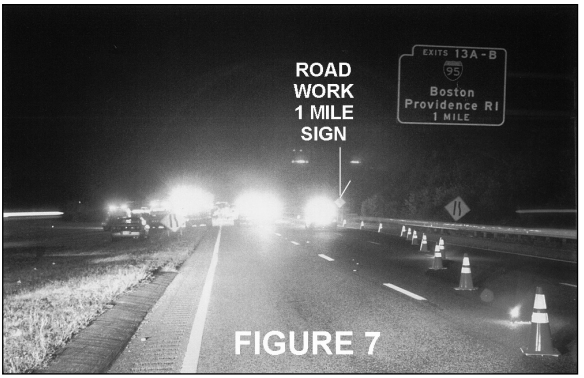


FIGURE 7

The accident location was at the overhead I-95 1 Mile Exit sign (Figure 7). The start of the Work Area ROAD WORK 1 MILE sign was located just west and at the start of the two Right Lane Merge signs.

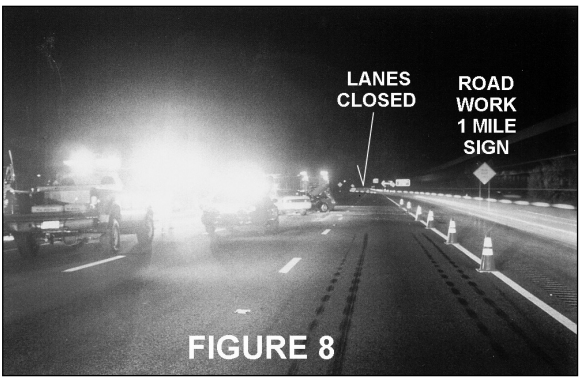


FIGURE 8

The ROAD WORK 1 MILE sign was located at the start of the Right Lane Merge. The detour closed both the right and center lanes to traffic and the traffic had to merge into the left lane (Figure 8).

The subject accident location was in the center lane at the ROAD WORK 1 MILE sign (Figure 9). Route I-495 starts to curve left at the I-95 Exit ½ MILE overhead directional sign, not shown.

FIGURE 9

During construction Stage 1, the two left lanes were closed and all three lanes of traffic were reduced to the two right lanes, with traffic shifted to the right.

During construction Stage 2, the roadway was shifted to the left side for repaving. Shifting the roadway lanes to the left required that all three lanes had to be shifted into the two left lanes. On the night of the subject accident, the Contractor was preparing for the official traffic pattern change before the

Labor Day Weekend. The plan was to relocate the Jersey Barriers and remove the existing Pavement Markings, and then place new Pavement Markings throughout the 5 mile Construction Work Area before the changeover. The nightly work required that installation of temporary Advance Warning signs one mile before the new Work Area started. The most dangerous times and locations for both motorists and workers occur during creation, removal, and relocation of any Maintenance and Protection of Traffic Plan traffic control devices.

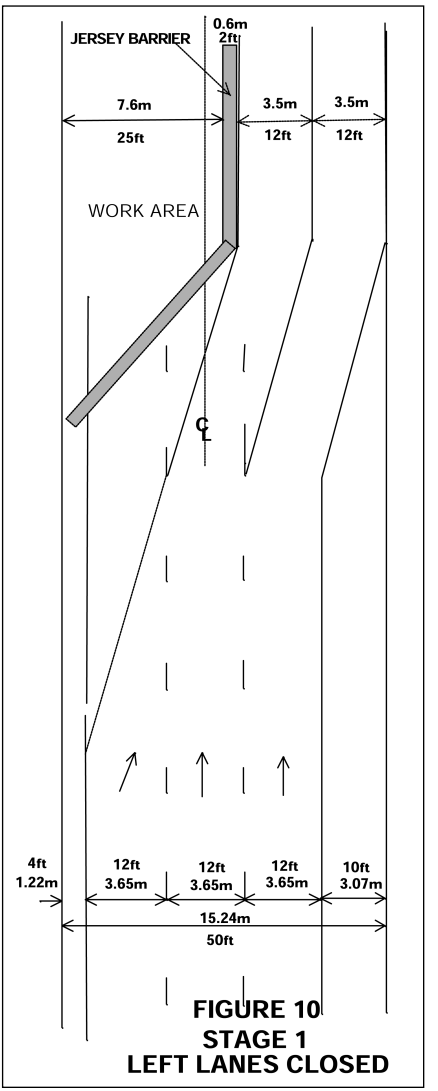


FIGURE 10
STAGE 1
LEFT LANES CLOSED

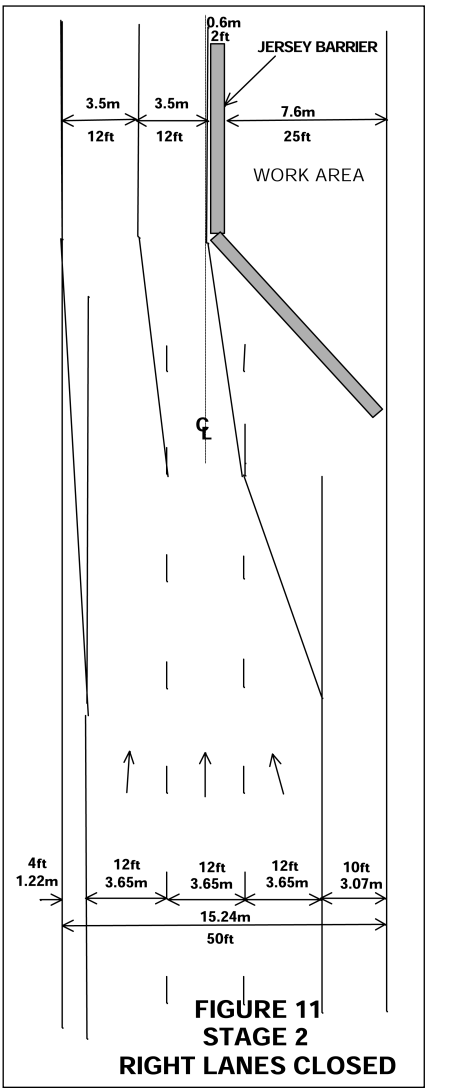


FIGURE 11
STAGE 2
RIGHT LANES CLOSED

The changeover from the Stage 1 detour operation to the Stage 2 detour operation took five nights. The Contract Specifications required a Temporary Traffic Control Plan for the shifting of traffic from the right side to left side of the roadway. On the first night (Monday, August 19, 2002), the Contractor shifted the Jersey Barriers and started the Pavement Markings removal without a TTCP. The Resident Engineer found out about the lane shift after the subject accident. The Contractor provided only two advance Right Lane Merge low mounted signs (see Figures 6 to 9). There were no other Advance

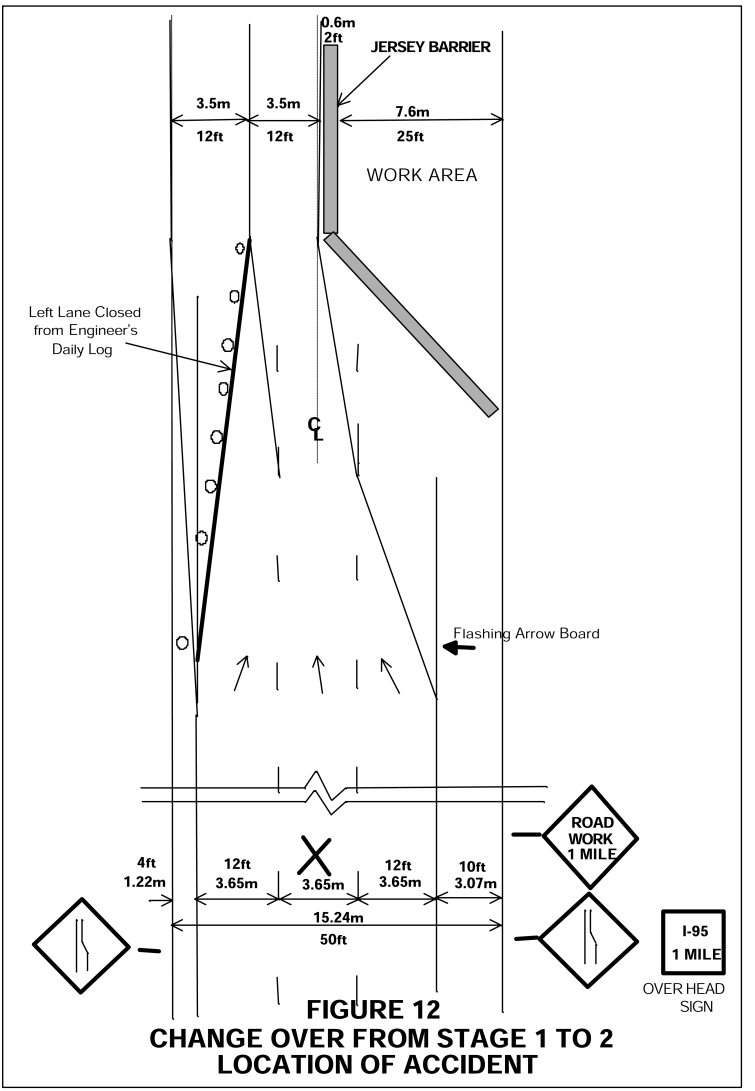


FIGURE 12
CHANGE OVER FROM STAGE 1 TO 2
LOCATION OF ACCIDENT

Warning signs provided between the I-95 1 Mile and the I-95 2 MILES overhead signs. A review of the Engineer's Daily Log showed that there was no record of any right lane merge operation by the Contractor that night. In addition, a crest in the roadway was 430 meters (1,500 feet) before the Advance I-95 1 MILE Exit sign. The Contractor stated that he had installed two Variable Message Signs (VMS) at the preceding interchange under the overhead Advance I-95 2 MILE sign.

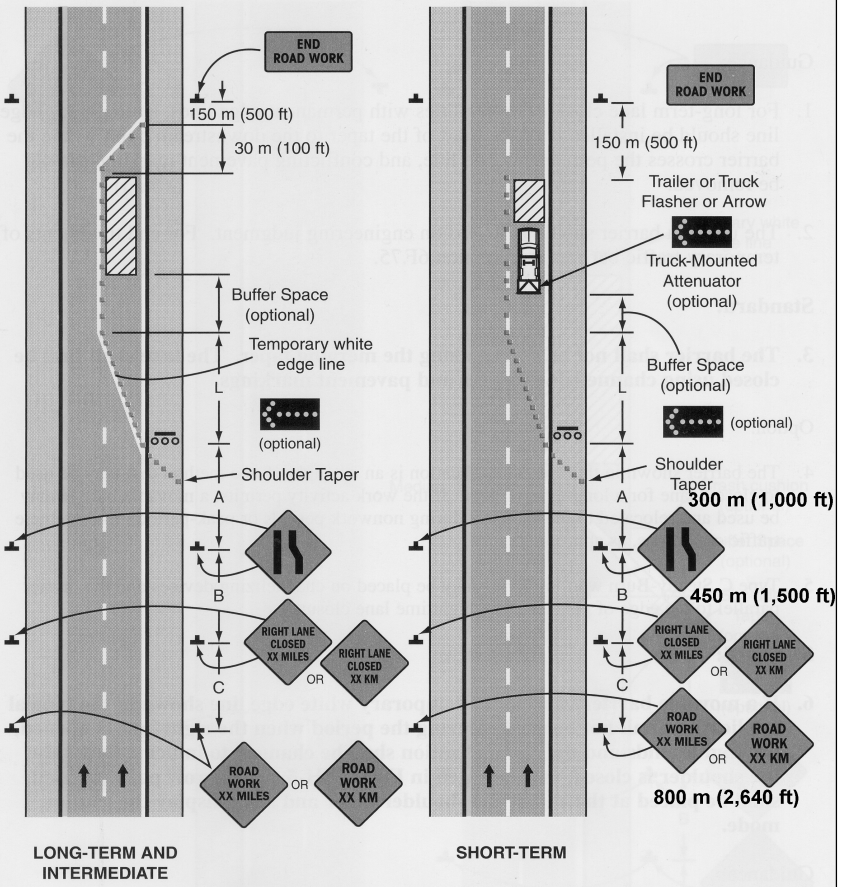
On the night of the subject accident, the Engineer's Daily Log showed that the Contractor closed the left lane to traffic, which resulted in all left lane traffic merging into the center lane. From the One Mile sign to the detour the travel lanes were reduced from three lanes then to two lanes then to one lane without Advance Warning signs, thereby creating motorist confusion and a stoppage in traffic entering into the single lane of traffic. The Contractor used the standard Maintenance and Protection of Traffic Detail Sheets, which showed a left lane closure TTCP located per the Contract Specifications.

The Federal Manual on Uniform Traffic Control Devices (MUTCD) 2000 Edition [Figure 6H-33 Stationary Lane Closure on Divide Highway TA-33] shows a standard lane closure plan for a short (daily) term operation. The placement of the Right Lane Merge sign should be 300 m (1,000 ft) from the start of the lane merge. The placement of the Advance Right Lane Closed ½ Mile sign should be 450 m (1,500 ft) in advance of the Right Lane Merge, at the crest of the hill. The placement of the Advance ROAD WORK 1 MILE sign should be 1,600 m (1 mile) in advance of the Right Lane Merge. The placement of a second Right Lane Closed ½ Mile sign should be located another ½ mile from the first right lane merge. The right lane closure came before the center and left lanes shifted to the left. At that point, the left lane closure came into effect. A motorist could only see the right lane closed less than 30 m (100 ft) ahead, and traffic had to merge into the center lane. The two left lanes then shifted to the left lane with no additional warning signing. At this point, traffic was using the two left lanes. During the lane shift, the Contractor closed off the left lane, forcing all the left lane traffic into the center lane during the shifting operation.

The Contractor never submitted and the Resident Engineer did not approve any TTCP for the shifting of the roadway traffic from the right lanes to the left lanes.

During the trial, in which the author was a Forensic Engineering Expert Witness, the major question was were the two advance VMS signs in place before the subject accident. According to the Engineer's Daily Report the installation of the advance VMS signs occurred three days after the subject accident.

Figure 6H-33. Stationary Lane Closure on Divided Highway (TA-33)



Typical Application 33

FIGURE 13

Note: See Tables 6H-2 and 6H-3 for the meaning of the symbols and/or letter codes used in this figure.

Conclusion

Highway Construction Work Zone accidents occur frequently because the work crews are within a few feet of moving traffic, and vehicles must shift to unfamiliar traffic patterns. The most dangerous time for the motoring public and construction workers is during the set up and removal of lane closure signs. Temporary Traffic Control Plans are now required for all Highway Construction Work Zones, and Design Engineers are required to prepare Drawings showing a TTCP. The Contractor shall comply with the Plan or develop a new TTCP that must be approved by the Resident Engineer and Government Agencies having jurisdiction.

By not providing Temporary Traffic Control Plans, Contractors and Design Engineers place themselves in a position where they can face extensive lawsuits from Highway Construction Work Zone accidents. Proper planning and operation of a Temporary Traffic Control Plan is the only way to reduce potential Highway Construction Work Zone accidents.

The USDOT is allocating extensive time and money in order to reduce accidents in Highway Construction Work Zones, in order to protect motorists and workers. The Maintenance and Protection of Traffic through a Highway Construction Work Zone must be given the highest priority by everyone involved.

Reference

1. National MUTCD November 2003, Page I-3
2. National MUTCD 2003 Section 6C.01 Temporary Traffic Control Plan
3. National MUTCD 2003 Section 6H (Typical Applications TA-1 to TA-46)
4. National MUTCD 2003 Section 6G.02 Work Duration