

# Work Zone Safety

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In 1976 the Federal Highway Administration initiated a program to improve safety in construction and maintenance zones. The program pressed for improvements in the Manual on Uniform Traffic Control Devices relating to traffic control at work sites, initiated a number of training programs on work site safety, allocated \$2.5 million for research in innovative safety practices in work areas, and measured progress through an extensive national review of safety practices at work sites. As a result, safety at work sites has improved, but there are still major problem areas. As an example, accident data are still not used to identify safety problems at work sites, and construction materials and equipment are often stored hazardedly close to the roadway. If considerably more progress is not made in improvement of work site safety, the Federal Highway Administration will be forced to consider more stringent requirements for work site activities, including traffic-control plans developed as a prerequisite for project approval. In addition, we must provide additional guidance on driver needs in work sites based on human factors research.

Early in 1976 the Federal Highway Administration (FHWA) initiated a program that emphasizes improved safety in construction and maintenance zones. Safety is a serious problem in construction and maintenance zones and we are using our resources in a concentrated effort to reduce the number of casualties at these sites. FHWA has stressed five areas for improvement:

1. Pressed for improvements in the Manual on Uniform Traffic Control Devices (MUTCD) related to work site control;
2. Launched at least three different training courses on the subject;
3. Initiated over \$2.5 million in research to develop new and innovative safety practices in work areas;
4. Conducted two extensive national reviews of safety practices at actual work sites; and
5. Issued an advance notice of proposed rule making, which requires specific plans and responsibilities relating to work site safety.

As a result of these activities, work sites are now safer for the motoring public than they were a few years ago, but progress has been disappointingly slow and the work site safety problem still persists. We still have the problem of getting the word to highway construction and maintenance personnel. This may be caused by a long-established attitude toward risk management. Risk management is a very popular concept in highway safety today. Its basic premise is that any field of human endeavor involves a safety risk. Generally, these risks are much higher in the construction industry than in many others. Often the hazards related to construction are expressed as, "You can expect to lose a certain number of lives for every so many floors you construct in a new building." In the construction industry the primary objective is to get the job done at a minimum of risk, but getting the job done is first and foremost.

The construction industry has made great strides in enhancing the safety of the worker. As an example, the worker is required to wear steel-toed shoes, insulated gloves, and hard hats, and safety inspectors are present to see that the worker is protected. This is a good, solid philosophy for safety at isolated work sites. Unfortunately, transferring this philosophy to highway construction sites does not provide adequate attention to the motorists. At the highway construction sites we

must consider the safety of the public that passes through the area as well as the worker, which has not always been the case in the past.

At most highway construction sites, management knows the exact number of kilograms of asphalt used, the cubic meters of excavation, and the exact details of on-the-job injuries. But, very seldom does the management keep any records of traffic accidents that occurred at the job site, except when construction personnel are involved. Admittedly, protection of the public is far more difficult than protection of the worker alone. The local constructor has far less control over the public than over the workers. The public cannot be required to wear hard hats or steel-toes shoes although they pass through hard-hat areas; they cannot be docked their pay for unsafe acts or provided with special training. Often the act of protecting the worker by barrier systems or lane closures increases the hazard to the motorist. The reverse conditions and effects also exist.

The point is that the concept of accepting a certain amount of risk to get the job done is no longer valid at construction sites when the public is involved. The public will not, and should not, accept the same risks as a construction worker; it is the responsibility and moral obligation of the work site management to provide the public with the highest degree of safety that is feasible. We know that there are at least 500 traffic fatalities a year at work sites.

An example of the safety problem at construction sites recently occurred in one of the southeastern states where there were five fatalities during reconstruction of an elevated section of an Interstate. The most recent fatality occurred on November 8, 1977, when a truck jackknifed in a temporary transition lane at the construction site. This caused a chain reaction collision and a fire, which killed one person and injured two others.

The initial accident, caused by a jackknifed truck, occurred on a temporary median crossover at one end of the construction area. This resulted in a lockup of traffic in the construction zone, which was partially obscured from approaching traffic by the crest of a hill. The results, a catastrophic rear-end collision, involved nine vehicles. More warning in advance of this construction site would have been desirable.

The signs at the project met the minimum requirements of MUTCD but could have been improved. Transition areas are historically accident-prone locations at best, but designation of a transition area on the far side of a crest vertical is asking for problems. Any disruption in the transition area, such as the jackknifed truck, will quickly result in a backup of traffic into the restricted sight distance condition that exists at the crest vertical. Additional attention to the design of the detour might have prevented this accident.

One of the results of our past research efforts was a seven-state study of construction zone accidents conducted by Midwest Research Institute. The research effort looked at 79 construction sites where, during the construction period, there was an increase of over 613 accidents at these sites (total accidents before construction, 8172; total accidents during construction, 8785; percent increase in accidents, 7.5). Table 1, derived from the project final report, compares the accident rates by states. In two states the accident rate during

Table 1. State rankings by increase in accident rate.

State	Number of Projects	Accident Rate Before Construction <sup>a</sup>	Change During Construction (%)
1	9	142	-9
2	15	75	-3
3	16	167	+8
4	10	174	+10
5	10	117	+28
6	5	130	+38
7	10	165	+163

Note: 1 km = 0.6 mile.

<sup>a</sup>Number of accidents per 100 000 000 vehicle-km.

Table 2. Change in mean accident rate by type of construction.

Construction	Number of Projects	Mean Accident Rate Before Construction <sup>a</sup>	Change in Accident Rate During Construction (%)
Bridge work	5	55	+50
Reconstruction of existing roadway	2	173	+33
Upgrading to Interstate standards	9	104	+16
Median barrier work	15	117	+9
Resurfacing, patching	26	92	+8
Pavement widening	12	359	+3
New alignment	5	132	+0.4

Note: 1 km = 0.6 mile.

<sup>a</sup>Number of accidents per 100 000 000 vehicle-km.

construction actually decreased; however, in two other states the rates increased by 38 and 163 percent respectively. This shows that increases in accidents are not inevitable. Good practices reduce accident rates and poor practices increase accident rates.

Table 2 (also derived from the project final report) compares the changes in mean accident rates by types of construction activities. The two types of construction activities that have the greatest increase in accident rates were bridge work and pavement reconstruction. These types of work will constitute the vast majority of construction activities occurring over the next 10 years. Consider that in 1970 only \$560 million in federal funds were obligated for reconstruction projects. In fiscal year 1977, almost \$2.3 billion in federal funds were obligated for upgrade of existing roads. That represents an increase of over 400 percent in reconstruction activities in the last 7 years. During fiscal year 1977, about 21 100 km (13 100 miles) of existing federal-aid highways were the site of construction zones during the year. This figure is expected to increase substantially in the future as we continue to increase the upgrading of our existing road system.

In the fall of 1977, FHWA again conducted a safety review of construction sites. This review indicated that the safety at these sites had been enhanced over the previous review conducted a year earlier, but there were still some major safety problems and the variation between states and regions was significant. There were four major areas where deficiencies exist that need vast improvement. The first area of deficiency was that management is still not collecting or using accident data at construction sites. Therefore, management still does not know how to overcome their specific safety problems nor even what their safety problems are.

The second major area was that of guardrail and barrier rail transitions. The use of barrier and guardrail to protect the work area has improved, but there are still too many blunt-end and transition hazards. A third area relates to a lack of understanding or concern by

construction personnel for the motoring public. As an example, construction equipment and vehicles were located hazardously close to the traveled way. The last area involved the problem of pavement dropoffs. In many cases, major dropoffs were not effectively shielded from the motorists. In other cases, unnecessary dropoffs were allowed to exist. The problem of removing unneeded and confusing pavement marking is still with us but is far less prevalent than in the past.

One effective method of removing pavement markings is the excess oxygen burner method. FHWA is presently developing an implementation package for this method, which will be distributed to the states in the near future. This device and other stripe-removal equipment will be included in a national demonstration project. The excess oxygen method consists of mixing high-pressure propane gas and high-pressure air or oxygen. This produces a 1371°C (2500°F) gas, which quickly burns off and removes old markings. The Office of Development and Texas have been evaluating this method and several modifications. From the Texas experience, the methods appear quite successful. The cost of the burning method is estimated at \$0.33/m (\$0.10/ft) compared to an estimated \$1.05/m (\$0.32/ft) for sandblasting. The burning units are commercially available from a few equipment manufacturers in the United States.

Another effective method is a combination of water and sandblasting. During the review 2 years ago, acceptable methods of pavement removal were almost impossible to find.

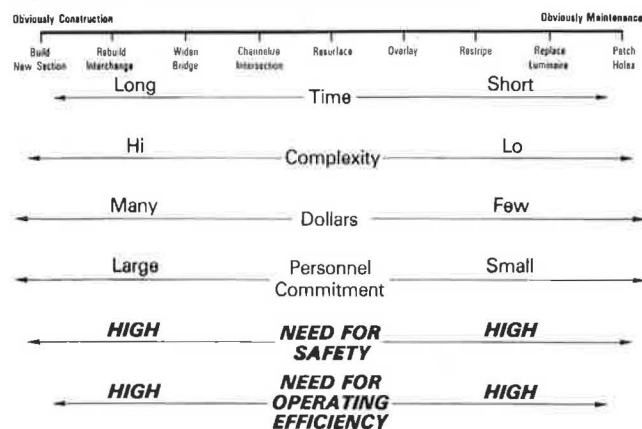
The 9-state survey also found a number of other problems prevalent throughout the states. These include the use of damaged and dirty warning signs, inadequate taper lengths, and other conditions that could be vastly improved through minor modification or with a better understanding of safe traffic operations. In the last survey FHWA also found that only 7 states currently are attempting to use accident data to improve work site safety. In 39 states traffic control at construction sites is considered either incidental to other construction costs or covered by lump-sum bid prices. What does FHWA plan to do to accelerate safe practices at work sites? If considerably more progress or improvement is not made, the Office of Engineering will be forced to consider more stringent requirements for all projects, including traffic-control plans in the plans, standards, and estimates (PS&E) phase of development.

The PS&E phase should contain traffic-control plans and address the matter of safe location of contractor equipment, hazardous pavement dropoffs, and other instructions and requirements to provide protection in cases where the nature of the work creates unsafe conditions. Consideration should also be given to providing unit prices for maintaining, cleaning, and replacing traffic-control devices for projects that cover a long period of time. A notice of proposed rule making on traffic safety in highway and street zones was published in the Federal Register last year. In January a task group began the study of responses to this notice and the development of recommendations on further regulation development.

Only a minimum portion of FHWA's attempts to increase work zone safety is aimed at regulation. Many of our present work zone safety problems are caused by lack of knowledge on how to improve traffic operations at work sites.

The basic source of guidance for traffic control in work zones is Part VI of MUTCD, and this document does not cover everything. The criteria on placement and design of work site traffic control are generally vague. In some cases it is purposely vague so as to be applicable to a variety of conditions. But often the criteria are vague because of a lack of basic knowledge as

Figure 1. The construction-maintenance continuum.



to the best method of controlling traffic. The vagueness of MUTCD has been highlighted in a recently completed study by the General Accounting Office (GAO) as one of the major problems in improving work site safety. In the report summary GAO concludes:

The Highway Administration's Manual on Uniform Traffic Control Devices described devices that can be used in construction zones. It does not contain enough information on how and when these devices should be used. Until uniform standards for using these devices are established, state planners, project officials, and federal inspectors will not have sufficient guidelines for safe highway worksites! As a result of these findings, the GAO report made as its first recommendation that FHWA: '... revise the Manual on Uniform Traffic Control Devices to include specific guidance on how and when to use traffic control devices in construction zones.'

The MUTCD criteria must be improved and FHWA hopes to gain much of the needed knowledge through research.

We have never really established driver needs to safely negotiate a work site. We do not even know how well the driver perceives our work site signs, such as the diamond-shaped warning signs, or the graphic and word messages they contain. Simple questions, such as how much advance warning is needed and how far in advance can the driver see and perceive the signs, are still unanswered. The problem becomes even more acute at night. We require colored reflectorized control devices and barricades, but does the driver perceive the color of the reflectorization? Does the driver recognize its significance? Does he or she really need or use the color coding we attempt to provide at night? Are graphic signs easier to distinguish and comprehend than word signs?

All we can say today is that the MUTCD provides uniformity in control techniques so the driver has at least a basic familiarity with what is expected. The underlying problem is that we have no idea whether the basic uniformity we provide is the most effective method of meeting the driver's needs.

We are presently debating in the national advisory committee the reflectivity requirements for signs and barricades. Most engineers agree that reflectivity of construction-traffic-control devices is desirable, but how much is needed? We do not have the knowledge to firmly say 40 or 80, but we know the driver must see the sign. He or she has visibility requirements regardless of whether the sign or barricade is new or old. Eventually we must stipulate the distance at which a sign or barricade must be visible and readable with low-beam headlights. This must be a maintained value—something the project manager or maintenance supervisor can use to evaluate the quality of traffic-control devices.

The problem for the driver is further complicated by

the vast multitude of work site situations encountered. This is probably best illustrated by Figure 1. The time, complexity, cost, manpower, and control devices available in construction and maintenance activities vary considerably, but safety and operating needs are high regardless of activity.

Those responsible for work sites must provide a consistently high level of safety regardless of the nature of the work. The driver rarely knows the difference between a construction zone and a maintenance zone or utility work. All he or she knows is that there is a potential hazard, but the same degree of safety in driving is expected in all three classes of work sites and the driver should receive it.

The need to protect the driver at a consistently high level of safety requires that where traffic-control strategies are limited because of time or resources, the devices used to guide the driver must have greater visibility and comprehension. Criteria for new or additional devices must be developed through research. As an example, the steady-burn warning light probably provides the most effective nighttime visibility available. However, it is expensive and, where batteries are used, it must be checked frequently to assure its reliability. For minor or short-term work sites we need an inexpensive, convenient alternative to the steady-burn warning light. Since a variety of reflective materials is available, an alternative device must be practical.

The FHWA has initiated a number of research and development activities to improve our knowledge of safety needs at work sites and to develop better methods of protecting traffic. This research effort is already providing us with some answers. Crash tests with various types of barricades have led to the prohibition of timber barricades as a positive barrier. A number of other barriers are being tested and look like they could provide a relatively inexpensive and portable positive barrier for work sites. These studies should be completed within the next 2 years. Another area where research and development have shown an excellent payoff is in determining alternative methods to overcome the paint marking removal problem. The excess oxygen burner shows great promise. The use of raised pavement markers in lieu of painted markings was tested during the last construction season and appears to be quite effective in guiding traffic and practical for temporary markings on construction projects.

The ongoing National Cooperative Highway Research Program project to evaluate traffic controls for street and highway work zones should provide us with some much needed information on traffic-barrier spacing, temporary pavement markings, and effective methods to mark and make control devices reflective. We are not waiting for the results of these studies before developing new initiatives. We are presently initiating a major \$500 000 study on the vital problem of driver needs in work zones. This effort, which will start this spring, should fill some of the knowledge gaps relating to the human factor in work site safety. We are also initiating a study to determine basic planning and scheduling requirements needed for short-term work sites.

There is also a continuing effort to develop new concepts and improvements for traffic control in work zones. We plan to be actively developing these new concepts over the next 4-year period and have budgeted another \$1 million for this effort. FHWA has developed a training course on safety through construction zones, which will be offered by the National Highway Institute throughout the country and on a continuing basis at the U.S. Department of Transportation's Transportation Safety Institute in Oklahoma City, Oklahoma.

Progress has been made in work site safety but we



have a long way to go. Improved methods in work site safety must be developed through research so that we can develop meaningful safety criteria based on facts. But we cannot wait for research results to make improvements. The problem is with us today, and we must take immediate action to reduce the present unnecessary accident toll. We can accomplish this through more stringent controls, more awareness of the problem on

the part of work site management, and a sincere desire to enhance the safety of the motoring public. FHWA stands ready to assist and support the highway community in developing safer work sites in any way we can.

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*Abridgment*

## Liability for Improper Traffic Signaling, Signing, and Pavement Markings

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The liability for improper traffic signaling, signing, and pavement markings is an area of importance because of the increasing number of negligence claims brought against highway departments. In the past, the states generally had sovereign immunity and could not be sued. In recent years, however, this has changed as more and more states, by court decision or statute, have abolished or eroded immunity to a large extent. The states have a variety of approaches to the question of tort liability. Certain rules, however, seem to be applicable in most jurisdictions.

Although there has been a significant increase in tort litigation against highway departments, court decisions and recent tort claims acts recognize that states and state agencies should not be held liable for negligent performance of governmental functions that are discretionary in nature. The general view is that the state is not liable for negligence in the performance of functions that involve a high degree of discretion but is liable for negligence in the performance of ministerial or operational level tasks. The exemption from liability for duties discretionary in nature is rooted in the common law. It emerged from the law on personal liability of public officials, who also were not liable for negligence in the exercise of discretionary duties but were liable for the exercise of purely ministerial functions.

Any activity, of course, involves the exercise of discretion, but as used here, a discretionary duty is one involving the power to make choices among valid alternatives and to exercise independent judgment in choosing a course of action. Conversely, ministerial duties are more likely to involve clearly defined tasks that are to be executed with minimum leeway and individual judgment. Ministerial tasks are said not to require any evaluation or weighing of alternatives before performance of the assigned duty.

A case that illustrates executive activity that is discretionary in nature is *Weiss v. Fote* [7 N.Y. 2d 579, 167 N.E. 2d 63, 200 N.Y.S. 2d 409 (1960)]. In this case the issue was the adequacy of the clearance interval in a traffic light system that had been approved by the city board of safety after ample study and traffic checks. The court held that New York's general waiver of im-

munity did not extend to areas of lawfully authorized planning and that it would be improper to submit to a jury the reasonableness of the plan approved by the expert body.

Weiss and other cases hold that the decision to provide or withhold a certain service is discretionary in nature; thus, negligent design of a traffic light or the failure to erect a traffic light may be discretionary in nature and protected from liability. Immunity usually attaches to governmental decisions about signs, signals, or markings if the government shows that the plan, design, or program has been adopted after reasonable consideration and deliberation. Of course, the decisions should be made by a public body or official vested with authority to exercise discretion in formulating such decisions. The cases state that evidence should show that the decision was (a) reasonable, (b) duly prepared and approved, and (c) not arbitrary or capricious. Moreover, duty may require review of these decisions later to determine whether they are safe once implemented and in actual use. As one court has said, the public official must be cautious; the discretionary field of activity should not be used to justify the omission of obvious safeguards for the protection of the public.

Some decisions are clearly more discretionary than others, and court decisions differ on what falls within the discretionary field of activity. The trend appears to be that only decisions made at a policy level or decisions that involve a consideration of policy factors are discretionary. The result has been to narrow the duties that are discretionary; more decisions that once would have been immune from liability no longer enjoy that protection.

The narrowing of discretion is demonstrated in several cases construing tort claims legislation. These acts usually contain a provision that immunizes the public agency for negligence in the performance or failure to perform discretionary functions (the discretionary function exemption). This exemption has its roots in the exclusion from liability for discretionary activity previously discussed.

The courts have struggled to construe the tort claims acts' exemption from liability for a discretionary func-