Abridgment

Collection of Work-Zone Accident Data

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The objective of this research was to recommend, based on analyses of current practices and the trial implementation of a promising new system, an effective yet simple information procedure that relates accident factors to traffic control deficiencies in highway work zones. The procedure, called the work-zone accident data process (WZADP), is appropriate for two major applications: (a) it provides information that can be used to determine if a correction or change is needed in the traffic control at the work site where the accident occurred, and possibly the type of change indicated; and (b) it provides information that can be combined with that from other sites to form a data base from which accident trends and the relations between accidents and the various traffic control devices and strategies can be determined. In the first phase of this research a user's manual was developed that described the WZADP. This manual was used in trial implementations in Iowa and North Carolina. The results of the trials indicated that the WZADP is a useful procedure for collecting work-zone accident data and that, in general, the safety record of the work zones monitored was extremely satisfactory. Problems were noted in some discrepancies between the number of accidents reported under the WZADP and other state accident records systems, and in some instances the police did not report all work-zone accidents to project managers.

Traffic safety in highway work zones has drawn increasing emphasis because of an alarming number of lawsuits involving construction-zone fatalities and the growing need for maintenance of highway facilities under traffic. The most direct indicators of the level of traffic safety in work zones are work-zone accidents.

In 1976 Midwest Research Institute (MRI) undertook a project that examined the problems of work-zone traffic control from both safety and operational viewpoints. The final report of this project was entitled, "Accident and Speed Studies in Construction Zones" (1). During this project an accident data base was formed by using data from 79 construction projects in seven states. From the analysis of this data base, several recommendations were made concerning the safety of work-zone traffic controls. For example, it was found that the accident rate is much higher on six- or eight-lane freeways when two lanes are closed rather than a single lane. Also, during the analysis of hard copy accident reports for three projects, it was observed that there was a predominant accident type throughout the project duration that remedial actions could have alleviated.

On October 13, 1978, FHWA issued Federal-Aid Highway Program Manual (FHPM) 6-4-2-12 (2), a regulation pertaining to all Federal-Aid construction projects. This regulation contains many procedures that assure that adequate consideration is given to the safety of motorists, pedestrians, and work-force personnel.

Two mandatory procedures described in the regulation are as follows.

1. The highway agency shall designate a qualified person who will have primary responsibility and sufficient authority to assure that the traffic control plan and other safety aspects of the contract are effectively administered:
   a. On small projects this person may be the resident or project engineer;
   b. On large projects this person should be a designated person who is trained in traffic control measures; the individual would be assigned to this task on a full-time basis and would not be responsible for other duties; and
   c. Such persons may be responsible for one or more projects, depending on project magnitude and proximity to other projects.
2. Work-zone accidents shall be evaluated on both a short-term and long-term basis:
   a. On a short-term basis the responsible person makes arrangements to obtain accident information, including accident locations, as quickly as possible so that current operational problems can be evaluated and appropriate changes can be made in the traffic control plan; and
   b. On a long-term basis a sampling of accidents that occur in work zones is identified and analyzed; this information should be used to correct deficiencies in traffic control standards and to improve the content of future traffic control plans.

OVERVIEW OF RESEARCH

The results of an FHWA research project entitled, "The Collection of Work-Zone Accident Data," are described in this paper. The project was based on the idea that further gains in work-zone traffic safety could only be obtained if states have reliable work-zone accident data bases. These data bases must contain enough information about the work-zone traffic controls to establish the relationship of these controls to accidents that occur in the work zone.

The project work plan was comprised of two phases. The first phase involved a survey of the current practices in nine states, the development of three alternative reporting procedures, and the preparation of a user's manual describing one or more of the reporting procedures. The second phase was a trial implementation of the accepted reporting procedure in two states. The focus of this paper is on the effectiveness of the work-zone accident data process (WZADP) during the trial implementation in Iowa and North Carolina.

[The user's manual developed during this project has been published as Report FHWA-IP-82-15, "Work-Zone Accident Data Process-User's Manual," and is available from the U.S. Government Printing Office. The project final report is Report FHWA/RD-82/501, "The Collection of Work-Zone Accident Data," and is available from the National Technical Information Service, Springfield, Virginia.]

TRIAL IMPLEMENTATION RESULTS

The ultimate goal of the WZADP is to reduce accidents in highway construction and maintenance projects by identifying potential hazards and problems and correcting them. It may be too early to determine all of the safety benefits to be derived from this research, although the safety records of the projects involved in the trial implementation are known. The results of the trial implementation are discussed in this section.

Safety

Forty projects were studied in Iowa. A summary of

Table 1. Iowa work-zone accident summary.

Project Type	No. of Projects Studied	No. of Accidents Before Construction	Before Accident Rate	No. of Accidents During Construction	During Accident Rate
Interstate	10	42	37[a]	11	95[a]
Primary route	26	42	70[a]	7	26[a]
Intersection	4	91	5.79[b]	60	3.89[b]
Total	40	175		78	

[a]Accidents per 100 million vehicle miles.
[b]Accidents per million entering vehicles.

Table 2. North Carolina accident data summary.

Project	No. of Accidents Before Construction			Before Accident Rate	No. of Accidents During Construction			During Accident Rate
	Fatal	Injury	PDO		Fatal	Injury	PDO	
1	3	146	329	327.5[a]	0	13	38	202.4[a]
2	3	28	63	55.7[a]	0	6	15	65.3[a]
3	0	7	24	2.44[b]	0	3	7	2.40[b]

[a]Accidents per 100 million vehicle miles.
[b]Accidents per million entering vehicles.

Table 3. Iowa accident reporting discrepancies.

Project	Accidents Reported Under WZADP	Accidents Reported by ALAS
1	4	8
2	16	42
3	16	34
4	24	12

Note: ALAS = accident location analysis system.

the accident rates before and during construction of these projects is given in Table 1. Intersections and primary route projects both had substantial decreases in accident rates. Interstate accident rates increased during construction, but the severity of the accidents was low [all property-damage-only (PDO) accidents]. Analysis of the data in Iowa revealed few changes in accident type occurring during construction. Most of the work-zone accidents occurred in the work area.

A summary of the accident experience on three North Carolina projects is given in Table 2. The first project had a significant decrease in the accident rate during construction, and the second and third projects did not change significantly. There were no fatal accidents on the projects during construction.

Overall, the review of the work-zone accident data in both states revealed that traffic controls performed satisfactorily.

Accident Data Discrepancies

In both states different accident reporting systems yielded different numbers of work-zone accidents. A comparison of the number of accidents reported by project personnel versus the number of accidents found in the computerized accident records system for four projects in Iowa is given in Table 3. For three of the projects, the number of accidents reported through the WZADP was much lower than the number found in the computerized system, but the fourth project had more accidents reported by the WZADP.

In North Carolina the number of accidents reported by the WZADP was much lower on all three projects. In general, project managers in North Carolina were aware of accidents that occurred near the work area; they were not aware of other accidents that occurred within the project boundaries that were not near the immediate work area.

Part of the reason for discrepancies could be that police officers did not notify project personnel of accidents within project boundaries that were not work related or that did not occur near any work activity.

Hazards Identification

The formalized procedures for identifying potential hazards presented in the user's manual required project personnel to identify problems in a logical manner. It is believed that the participants in the trial implementation will retain this experience and, by using the user's manual (or other similar publication) as a reference, will use the experience to identify and reduce hazards in future construction and maintenance projects.

In both Iowa and North Carolina, hazard identification led to changes in work-zone traffic control procedures. Procedures for operating pilot cars on rural routes in Iowa were changed after a rear-end accident occurred and other traffic problems were identified. At a high-volume lane closure in North Carolina, the location of an arrow board in advance of the taper was changed as a result of rear-end accidents and numerous skid marks.

Incidents

North Carolina formally did not plan to collect incident data. Nevertheless, examination of accidents and skid marks (a type of incident) was needed to solve a traffic control problem. In Iowa the collection of incident data at the project level proved useful mainly in rural areas where the number of accidents was low. In urban areas project managers at first tried to document every minor incident and found that too much time was required.

Because of those initial problems, no data on incidents were collected in urban areas, even though project managers knew about some unreported accidents.

Amount of Additional Work for Project Managers

There is no doubt that the project managers were required to do a lot of extra work during the trial implementation. Accident and incident reporting and investigation took up to 2 hr per accident or incident. Time was also spent going to the local police departments to obtain copies of the accident investigation reports. Time was also spent observing traffic driving through work zones. Nevertheless, in many states this observation is part of standard departmental procedures. The procedure of identifying potential hazards by observing traffic was probably improved by the training the project managers received.

Transmittal of Information

In Iowa information transmitted through reports submitted by the resident engineers to the district office worked satisfactorily. In North Carolina the project managers were not always sure of how the information was transmitted or who received the information. Accident reports were to go from the project manager through the district traffic engineer to the state traffic engineer. Not all of the requirements of reporting and summarizing accidents as specified in the training were fulfilled in North Carolina. Note that these same requirements are standard procedures in North Carolina, which means that some persons were not complying with departmental requirements.

Training

The people who received the training believed it was beneficial to understanding their responsibilities. Some also believed that the information that did not directly pertain to them (such as project and statewide accident summaries) was of little benefit.

Some type of training is required for all people who participate in the WZADP. The participants believed that training could be taught by persons within the highway agency. The training should be informal and could be done at the district level. Headquarter officials, who would probably present the training, would need an indoctrination before presenting the WZADP at the districts.

Police Cooperation

In both states police agencies agreed to cooperate in the trial implementation. Nevertheless, project managers were not always notified of accidents that occurred within project limits. Part of this may be due to the training the police received and their definition of a work-zone accident. An accident was usually noted as a work-zone accident by a police investigator if there was a definite relation to the work activity. It may be that project managers will have to put forth extra effort in order to learn about all work-zone accidents. It appears that the police agencies will continue reporting work-zone accidents as they have been doing.

EFFECTIVENESS OF WZADP

The ultimate goal of the WZADP is to eliminate work-zone accidents and increase the efficiency of traffic control procedures. In both states the trial construction projects were no more hazardous than the roadways were before construction began. This low accident record may have been because of the WZADP or because Iowa and North Carolina may be especially aware of the need for satisfactory work-zone traffic controls. Nevertheless, the real proof of success will be in the accident records of future construction and maintenance projects. If the WZADP is worthwhile, accident records will substantiate this fact.

Project managers have stated that the formalized process of identifying and correcting potential hazards has been a benefit to them. These people now know how to identify and correct potential hazards, and they will continue to use the procedures specified in the user's manual.

The headquarter personnel of both states that managed the trial implementation were supportive of the project and believed that the procedures are beneficial in increasing safety in highway work zones. Each state highway agency has its ideas on managing the WZADP and will continue this program in a way that meets the needs and requirements of their individual states.

CONCLUSIONS

1. The WZADP has proved to be a usable procedure for collecting work-zone accident data and analyzing these data to make needed corrective changes in work-zone traffic control.
2. Because there is a great deal of variability in the organization, personnel, and facilities of the various state highway departments, there is a need for a great amount of flexibility in the design of the WZADP.
3. Some states may wish to implement the WZADP on special projects or in selected areas only. This approach could also be used to implement the WZADP in stages.
4. Project-level personnel who are expected to record work-zone accident data should be trained by using the WZADP user's manual.
5. Care must be taken in specifying actions required of project personnel. If the work load is excessive, parts of the procedure may be abandoned.
6. Police cooperation should be established at the headquarters level and reconfirmed with investigating officers. Experience in phase 2 of this project revealed that cooperation will normally only extend as far as furnishing reports that are requested. Reliance should not be placed on officers informing someone that an accident occurred. The project manager will normally have to contact police agencies at regular intervals to obtain accident reports.
7. Discrepancies in the number of accidents reported under the WZADP and other state accident records systems were discovered in both Iowa and North Carolina. These types of cross-checks should be made to ensure that all regularly reported accidents within work zones are coming to the attention of project managers.

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Field Evaluation of Snowplowable Pavement Markers

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The objective of this study was to evaluate available snowplowable markers under similar traffic and snowplow operations. Five different markers were tested: Stimsonite 96, Dura-Brite, recessed, Kingray, and Prismo roadstud. The evaluation revealed that the Stimsonite 96, Dura-Brite, and recessed markers were acceptable snowplowable markers, because all three had adequate reflectivity during both dry and wet nighttime conditions. This reflectivity was maintained over the test period, and the markers proved to be durable when subjected to snowplow operations. Nevertheless, considering all available input, the recessed marker is recommended as the most functional and cost-effective marker.

Raised pavement markers have proved to be an effective delineation treatment during wet nighttime and poor visibility conditions, especially in states outside of the snowbelt. Nevertheless, the problems that result from snowplow operations are particularly severe, and marker applications are limited. Even in a border state such as Kentucky, where more than 1 million raised pavement markers have been installed, only one winter of heavy snow and resultant snowplow operations can destroy a significant part of the installations.

In an attempt to provide wet nighttime delineation by using the concept of raised pavement markers, considerable effort has been devoted to developing snowplowable pavement markers. The most widely used and most successful approach to the development of a snowplowable marker has been to retain the reflective unit of a raised pavement marker and attempt to protect it from snowplows. Usually the reflective unit is encased or surrounded by a material that is resistant to snowplow blades. Consistently mixed results, particularly with regard to the cost-effectiveness of the markers, have been the rule in almost all experimental and large-scale installation projects.

Several types of snowplowable markers have been field tested in the past few years. These tests have been conducted independently under different field conditions. The objective of this study was to evaluate all available snowplowable markers under similar traffic and snowplow operations.

BACKGROUND

A recent survey (1) of the use of snowplowable markers indicated that the majority of existing markers were the Stimsonite marker--either the Stimsonite 96 model or the older Stimsonite 99 model (see Figure 1). This marker consists of an iron casting with an attached prismatic retroreflector. Both ends of the castings are shaped to deflect a snowplow blade. This marker has been evaluated (2-4), but it had not been compared directly with other markers.

The survey indicated that several states experimented with a recessed marker (1). The installation in this study involved placing a regular or low-profile raised marker into a groove cut into the pavement so that the top of the marker was flush with the pavement surface. A recessed marker, which used a regular raised marker in the groove, was included in this study. Some installations have used a groove with a cross section that had several peaks and valleys (5,6). However, this study used a full-width groove similar to installations in Tennessee and South Carolina. The Stimsonite 911 marker (Figure 2) was installed in the groove.

In an effort to include all other available snowplowable markers in the test, various manufacturers were contacted. As a result, two additional markers were included in the original installation, and a small number of another marker were installed shortly thereafter. The new markers were the Dura-Brite (Figure 3), Kingray (Figure 4), and Prismo roadstud (Figure 5) markers. The Dura-Brite marker includes a steel frame set in precast concrete. The replaceable reflector is mounted between the two steel runners that protrude above the pavement surface. The runners are shaped so that the marker can be plowed at an angle. The Kingray marker involves placing the reflective lens in an insert that is depressed in an outer sleeve when struck by a tire or a snowplow blade. The Prismo roadstud is a die cast aluminum marker that provides an anchor stem for additional durability.

A few other potential snowplowable markers were investigated. However, the development or marketing of these markers had either stopped or was progressing so slowly that they were not available for testing.

The lane-delineation survey also obtained information about installation costs (1). The average cost of numerous installations of Stimsonite markers was approximately $16 per marker, but a more accurate current cost would be close to $20 per marker when installed in large quantities. Cost data were not available for the Dura-Brite marker at the time of the survey, but estimates place the cost of this marker to be similar to the Stimsonite markers. No cost figures are available for large installations of the Kingray marker, but its cost would not be less than that of the Stimsonite or Dura-Brite markers. The most inexpensive snowplowable marker installed to date has been the recessed marker, which has a reported cost per marker in the $8 to $9 range. The cost for a regular, raised pavement marker is approximately $3 per marker.