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16. ABSTRACT

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The analysis fundamentally consisted in going to each construction zone, noting what seemed to be same and unsafe about the area, making recommendations on how to alleviate the "unsafe" conditions and then making observations to determine if the recommendations produced results.

A number of recommended practices on geometric standards, delineation and signing evolved which are now widely accepted.

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construction zone, detour and temporary connection accidents

NOVEMBER 1971

STATE OF CALIFORNIA

BUSINESS AND TRANSPORTATION AGENCY

DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS

CONSTRUCTION ZONE, DETOUR AND TEMPORARY CONNECTION ACCIDENTS

NOVEMBER 1971

Prepared in cooperation with the
U.S. Department of Transportation,
Federal Highway Administration

Prepared by: W. R. Juergens

November 8, 1971

Mr. Sam Helwer
Deputy State Highway Engineer
Sacramento, CA

Dear Sir:

Submitted herewith is the report "Construction Zone, Detour and Temporary Connection Accidents."

Study under general direction of. . . . . W. R. Juergens

Principal Investigator. . . . . Alan Lew

Project Assistant . . . . . Gale Gifford

Report by . . . . . Alan Lew

Gale Gifford

Sincerely,

A. C. ESTEP
Traffic Engineer

TABLE OF CONTENTS

ABSTRACT

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Before and during construction accident rates were computed for 41 construction zones. The construction involved was either on the existing roadway or immediately adjacent to it. Also those projects with more than $500,000 work and lasting for at least a year were reviewed.

The analysis fundamentally consisted in going to each construction zone, noting what seemed to be safe and unsafe about the area, making recommendations on how to alleviate the "unsafe" conditions and then making observations to determine if the recommendations produced results.

A number of recommended practices on geometric standards, delineation and signing evolved which are now widely accepted.

INTRODUCTION

Studies in other areas have indicated that construction zones, detours, and temporary connections are generally more dangerous and difficult to deal with by the motorist than normal highway travel. For instance, one state found that about 75% of all accidents occurring within construction detours have characteristics inherent only to the detours themselves.

This construction zone study is divided into three phases. These are:

Phase I:

1. Is there in fact an accident problem in construction zones?
2. If so, how big is it?

Phase II:

What specific conditions are causing the problem?

Phase III:

What can be done to eliminate or reduce the problem?

Phase I has been completed. As expected, there is a problem. The next section provides answers to the two questions in this phase.

Phase II will constitute the bulk of the research. A short pilot study, involving a limited number of construction

zones (less than six), will be used to design the methodology to answer the question: What specific conditions are causing the problem?

The method involves getting supplemental data regarding the geometry, signing, road condition, and the contractor's activities at the time of the accidents. This information is required to adequately analyze the problem, and is not available in sufficient detail on most police accident reports, or in sufficient quantity on any other presently completed documents. This data will be submitted by each resident engineer involved in the study. The suggested instructions and data sheet to be tested are shown beginning on page 11.

Once the questionnaire has been refined and the procedures established, a larger number of construction zones will be selected that will be representative of conditions throughout the State.

Phase III will depend on the outcome of Phase II. It is expected that various changes in signing, striping, traffic control, and perhaps vehicle communications, etc., will be tested. Recommendations to design, construction, traffic and other interested personnel will be made.

PHASE I

The two questions are: 1) Is there in fact an accident problem in construction zones?; 2) If so, how big is it? Enough data has been gathered to determine there is a problem and to estimate its magnitude.

Is there a problem?

Ten construction zones were used. They were selected at random with only two major requirements. The first requirement was that the construction involved was either on the existing roadway or immediately adjacent to it. Secondly, only those projects with major construction were used. This would be a project with more than $500,000 work and lasting for at least a year. (In two special cases, the one year minimum was not fulfilled.) Also, all of the projects except one were completed in 1964. Other than the requirements stated above, no other criteria were used to select the construction zones. Therefore, they are not necessarily the worst or best construction zones; but simply ten random projects.

Before and during construction accident rates were computed. A full year before and during construction was used to obtain the rates whenever possible. In four of the projects it was not possible to use the full year. When this was the case, equal and identical calendar portions of the year before and during construction were used.

Table I lists the 10 projects. Table II shows the number of accidents and the accident rates for each project before construction and during construction. The percentage changes in accidents and rates are also shown.

For the ten projects studied, the total accident rate was up 21.4% during construction. The PDO accident rate was up 17.8%, the injury rate was up 21.1% and the fatal accident rate was up 132.4%. This indicates that, over-all, not only does the accident rate go up, but also that the accidents become more severe.

Table III divides the projects into rural and urban areas and also by the type of project. The two types chosen are conversion to a higher type highway on the same alignment, and realignments. The first type consists mainly of converting expressways to freeways and also widening shoulders and adding extra lanes to existing expressways and conventional roads. The realignment projects cross the old highway, often several times.

CONSTRUCTION ZONES

TABLE I

PROJ. NO.	DIST-CO-RTE	POSTMILE LIMITS	CHANGE IN RDWY FROM	TO	AREA	PERIOD OF CONST.	1963 STATEWIDE ACCIDENT RATES FOR TYPE		
							TOTAL	FAT+INJ	FATALITY
1	03-ED-50	21.1 to 22.8	2 LANE EXWY	4 LANE EXWY	RURAL	8-9-63 to 8-20-64	2.47	1.13	9.94
2	04-SM-1	42.2 to 45.5	2 LANE CONVEN.	4 LANE FWY	URBAN	5-28-63 to 1-29-65	4.80	1.62	4.70
3	06-Ker-5	0.3 to 4.7	4 LANE EXWY	8 LANE FWY	RURAL	4-9-63 to 9-18-64	1.77	0.81	7.35
4	06-Ker-99	27.7 to 36.5	4 LANE EXWY	6 LANE FWY	RURAL	12-11-62 to 11-4-64	1.77	0.81	7.35
5	07-LA-210	5.6 to 11.6	2 LANE CONVEN.	4 LANE CONVEN.	URBAN	5-21-64 to 11-13-64	4.80	1.62	4.70
6	07-Ora-05	33.1 to 34.5	4 LANE FWY	6 LANE FWY	URBAN	8-7-62 to 9-14-64	1.57	0.68	2.38
7	08-Riv,SBd-62	7.1-9.2/0.0-1.9	2 LANE CONVEN.	4 LANE EXWY	RURAL	1-3-63 to 10-23-63	2.47	1.13	9.94
8	08-SBd-15	104.4 to 121.1	2 LANE CONVEN.	4 LANE FWY	RURAL	7-26-63 to 10-19-64	2.47	1.13	9.94
9	10-SJ-99	21.6 to 28.6	4 LANE EXWY	6 LANE FWY	RURAL	6-18-63 to 12-7-64	1.77	0.81	7.35
10	10-Sol-80	24.7 to 29.3	4 LANE EXWY	6 LANE FWY	URBAN	11-17-61 to 10-27-64	3.91	1.56	7.85

CONSTRUCTION ZONE ACCIDENTS

TABLE II

PROJ. NO.	BEFORE CONSTRUCTION: NUMBER MONTHS	MVM	NUMBER OF ACCIDENTS: TOT.	FAT.*	INJ.	PDO	ACCIDENT RATES: TOT.	F+I	FATALITY	DURING CONSTRUCTION: NUMBER MONTHS	MVM	NUMBER OF ACCIDENTS: TOT.	FAT.*	INJ.	PDO	ACCIDENT RATES: TOT.	F+I	FATALITY	PERCENT CHANGE: MVM	NUMBER OF ACCIDENTS: TOT.	FAT.*	INJ.	PDO	ACCIDENT RATES: TOT.	F+I	FATALITY
1	12	4.7	10	0	4	6	2.12	0.85	0	12	5.1	16	0	10	6	3.14	1.96	0	+8	+60	0	+150	0	+48	+131	0
2	5	8.7	44	0	21	23	5.07	2.42	0	5	9.2	41	0	18	23	4.45	1.95	0	+6	-7	0	- 14	0	-12	- 19	0
3	12	20.1	33	0	22	11	1.65	1.10	0	12	24.3	54	3(3)	23	28	2.23	1.07	12.50	+21	+64	+ ∞	+ 4	+154	+35	- 3	+ ∞
4	12	62.6	68	4(5)	21	43	1.08	0.40	7.99	12	62.0	118	5(5)	61	52	1.90	1.06	8.06	-1	+59	+25	+190	+ 21	+76	+165	+ 1
5	5	17.3	27	0	13	14	1.57	0.76	0	5	17.4	37	1(1)	27	9	2.13	1.61	5.75	+1	+37	+ ∞	+108	- 36	+36	+112	+ ∞
6	12	28.1	64	0	26	38	2.28	0.93	0	12	27.1	78	0	29	49	2.88	1.07	0	-4	+22	0	+ 12	+ 29	+26	+ 15	0
7	12	4.4	20	1(1)	11	8	4.55	2.73	22.73	9	4.4	25	0	11	14	5.73	2.52	0	0	+25	-∞	0	+ 75	+26	- 8	- ∞
8	12	41.1	65	1(1)	33	31	1.58	0.83	2.44	12	47.2	74	8(9)	29	37	1.57	0.78	19.07	+15	+14	+700	-12	+ 19	- 1	- 6	+681
9	12	54.9	130	4(5)	58	68	2.37	1.13	9.09	12	63.9	188	9(11)	77	102	2.94	1.35	17.18	+16	+45	+125	+33	+ 50	+24	+ 19	+ 89
10	24	36.4	98	1(2)	42	55	2.68	1.18	5.50	12	44.5	114	2(6)	49	63	2.56	1.15	13.63	+26	+16	+100	+17	+ 14	- 4	- 3	+148
Total	118	278.3	559	11(14)	251	297	2.01	0.94	5.03	103	305.1	745	28(35)	334	383	2.44	1.19	11.47	+9.6	+33.3	+154.5	+33.1	+29.0	+21.4	+26.6	+128.0

DURING CONSTRUCTION:

PDO	accident rate increased	17.8%	(1.07 to 1.26 acc/mvm)
Injury	accident rate increased	21.1%	(0.90 to 1.09 acc/mvm)
Fatal	accident rate increased	132.4%	(3.95 to 9.18 acc/100 mvm)
TOTAL	accident rate increased	21.4%	(2.01 to 2.44 acc/mvm)

**Figures in parenthesis show the number of persons killed.*

TABLE III

	Before Const. No.	Before Const. Rate	During Const. No.	During Const. Rate	% Change, Rate
Projects 1, 3, 4 and 9. Rural areas: Upgrading on same alignment.					
Total Accidents	241	1.69	376	2.42	+ 43
Fatal + Injury Acc.	113	0.79	188	1.21	+ 49
Fatalities	10	7.03	19	12.23	+ 74
Million Vehicle Miles	142.3		155.3		+ 9
Projects 7 and 8. Rural areas: Realignments.					
Total Accidents	85	1.87	99	1.92	+ 3
Fatal + Injury Acc.	46	1.01	48	0.93	- 8
Fatalities	2	4.40	9	17.44	+296
Million Vehicle Miles	45.5		51.6		+ 13
Projects 5, 6 and 10. Urban areas: Upgrading on same alignment.					
Total Accidents	189	2.31	229	2.57	+ 11
Fatal + Injury Acc.	82	1.00	108	1.21	+ 21
Fatalities	2	2.44	7	7.87	+223
Million Vehicle Miles	81.8		89.0		+ 11
Project 2. Urban area: Realignment.					
Total Accidents	44	5.07	41	4.45	- 12
Fatal + Injury Acc.	21	2.42	18	1.95	- 19
Fatalities	0	0	0	0	0
Million Vehicle Miles	8.7		9.2		+ 6

The data in the tables indicate that construction zones do generally present a safety problem. Conversions on the same alignment in rural and also in urban areas appear to be the most severe. It is noted that in those projects where the total accidents do not change materially, there is often substantial increases in the number of persons killed (fatality rate). The urban area realignment project (#2) does not contain enough data to reach any firm conclusions.

Enough information is now available to assume that a problem does in fact exist in construction zones. The study will be continued to determine specifically what factors are involved and what measures can be taken on future projects to reduce the problem.

How Big is the Problem?

A "shotgun" estimate of the number of accidents per year in construction zones has been made. This estimate is based on the following assumptions:

1. 190 major construction projects with a mileage of 810 miles are under construction during a year. (Based on "Going Contract" list of March 20, 1965.)

2. The average daily traffic in construction zones is the same as the average on the entire State highway system.

3. Accident rates in construction zones before construction begins are at the average of all State highways.

4. Accident rates increase during construction as follows: Total accident rate + 21%; PDO accident rate + 18%; Injury accident rate + 21%; Fatal accident rate + 132%; Fatalities + 128%. (Based on sample of 10 projects.)

The analysis shows:

1. There are about 7,800 accidents statewide in construction zones each year.

2. There are the following increased number of accident per year because of the existence of construction zones:

   a. 1,340 total more accidents per year.

   b. 680 more PDO accidents per year.

   c. 520 more injury accidents per year.

   d. 140 more fatal accidents per year.

   e. 170 more people killed per year.

This gives a rough idea of the magnitude of the problem. It is emphasized that the above is a "shotgun" estimate only. The error could be considerable if traffic is heavier, or lighter, in construction zones than throughout the State, if accident rates are higher, or lower, than average on roads being reconstructed, or if the sample of the ten projects used to determine the increased accident rates are not typical.

It does not mean that all of the above increased number of accidents can be prevented. Some lowering of geometric standards, and thus the presentation of potentially dangerous situations, is obviously unavoidable. However, there appears to remain a considerable area for potential improvement.

PHASE II

The following pages show an introductory letter to those resident engineers chosen for the pilot study. The questionnaire to be tested in the initial stage of this phase is also shown.

CONSTRUCTION ZONE
ACCIDENT RESEARCH

To: Resident Engineer _____:

The Headquarters Traffic Department with the cooperation of the Headquarters Construction Department is conducting a highway safety research project whose objective is to determine whether construction zones have higher than usual accident rates; and if so, what remedial measures can be taken. The study is in three phases.

Phase I is a determination of whether, in fact, the accident numbers and rates increase on sections of highways under construction. This portion of the study has been completed. It was determined, as expected, that accident rates do increase. On the average, the rate for all types of accidents increases approximately 20%. The rate for PDO type accidents increases approximately 18%. The rate for injury accidents increases 21% and the rate for accidents in which fatalities are involved increases approximately 130% (more than doubling of the rate before construction starts). These increases, of course, are averages and there is a great deal of fluctuation between projects. In some cases, rates have even come down during construction.

We have estimated that there are about 7,800 accidents in construction zones each year. The increased accident rates listed above amount to about 680 PDO (Property

Damage Only), 520 injury, 140 fatal (170 persons killed) more accidents per year because of the existence of constructi zones. These cannot all be prevented, of course, but there does appear to be a considerable area for potential improvement.

Phase II of the study will attempt to isolate the specific factors which are peculiar to construction zones and which tend to increase the numbers and rates of accidents, especially the more severe type accident. For this phase, supplemental information concerning construction zone accidents is needed over and above the information normally included in the Highway Patrol and police accident reports. The supplemental information generally concerns the geometry, the signing, the condition of the road, and the contractor's activities at the time of the accident. A special form, as attached, has been devised for recording and transmitting this additional information. Because we are not sure that this is the best form or the best information to include, the form is tentative in nature. We are asking your group to participate in a short pilot study to test out the form and the methodology to be used in Phase II.

The attached form should be completed by the Resident Engineer or a member of his staff. For accidents occurring during non-working hours, it is anticipated that the Highway Patrol or local police department will notify the

Resident Engineer the following Monday morning and the form can then be completed. It is suggested that you request the enforcement agency patrolling your section of highway to keep you informed of all accidents occurring during both working and non-working hours. A member of the Headquarters Traffic Department will be available to explain the requirements of this study and to work out the details of how accidents should be reported on the attached form.

The Construction Zone Accident Reports compiled for this study will be for the confidential use of the Headquarters Traffic Department. They will not be sent or routed through other departments. The information in summary form, without identification to individuals, will be used in the study reports however.

We need your ideas, experience, and thought on how to alleviate this problem of accidents in construction zones. We are <u>not</u> trying to place the "blame" on anyone, but merely want to find out what is wrong and what can be done to improve the situation.

Phase III will involve the design of remedial measures. It is hoped that your group can contribute some suggested measures.

Your contribution to this study is appreciated.

CONSTRUCTION ZONE ACCIDENT REPORT

_____ _____ _____

Dist. Co. Rte. Sta. or PM | Date of Accident | Time of Accident

Severity: ☐ Fatal ☐ Injury ☐ PDO Light Condition: ☐ Day Light

☐ Dark

Date Construction Began:_____ Percent Complete:_____%
(Approximate)

I. Location of accident.

☐ 1. Main traveled lanes (including shoulders).

☐ A. Two-way traffic on future one-way roadway.

☐ a. On roadway existing before construction.

☐ b. On new or reconstructed roadway.

☐ 2. At-grade intersection.

☐ 3. Median cross-over.

☐ A. At road intersection.

☐ B. Not at road intersection.

☐ 4. Ramp connections with main traveled lanes.

☐ 5. Ramp roadways, over-crossing or undercrossing roads, auxiliary or connector roads.

☐ 6. Detour.

☐ 7. Temporary connection.

☐ 8. Other location.

If other location, describe:_____

_____.

II. Condition of roadway at accident site.

☐ 1. In same condition (essentially) as before any construction.

☐ 2. Under active construction.

☐ A. Rough grade.

☐ B. Subgrade completed.

☐ C. Paving started, but not completed.

☐ D. Pavement finished (except for incidental items as A.C. dikes, side drainage, etc.).

☐ E. Roadway completed.

III. Contractors activity at accident site.

☐ 1. Has not begun work at accident site.

☐ 2. Has begun work at accident site.

☐ A. Not working at site at time of accident.

☐ B. Working at site at time of accident.

☐ a. Working completely off the traveled lanes (including shoulders).

☐ b. Working on the shoulders.

☐ c. Working on the traveled lanes.

IV. Traffic control at or preceding accident site.

☐ 1. Controlled by flagmen.

☐ A. For work on the roadway.

☐ B. To form line for follow-me vehicles.

☐ C. For equipment crossing.

☐ 2. Controlled by traffic signals.

☐ A. Permanent installation.

☐ B. Temporary installation.

☐ 3. Controlled by speed zone control. Posted speed _____.

☐ A. Permanent during entire construction period.

☐ B. Temporary during actual work.

☐ 4. Warning signs. Posted speed _____ (if any). List signs:_____

☐ 5. Construction signs. List signs:_____.

☐ 6. Barricades.

☐ 7. Guide markers or guide posts.

☐ A. Reflectorized.

☐ B. Not reflectorized.

☐ 8. Other

If other, describe:_____

_____

_____

V. Contractors equipment, material, or personnel involved in any way in the accident? ☐ Yes ☐ No

If yes:

	Description of Equipment, Material, or Personnel.	Action of Equipment or Personnel if Moving; Location of Equipment or Personnel if Stationary; or Location of Material.
1.	_____	_____
2.	_____	_____
3.	_____	_____
4.	_____	_____

VI. State equipment, material, or personnel involved in any way in the accident? ☐ Yes ☐ No

If yes:

	Description of Equipment or Material.	Action of Equipment or Personnel if Moving; Location of Equipment or Personnel if Stationary; or Location of Material.
1.	_____	_____
2.	_____	_____

3. _____ _____

4. _____ _____

VII. On a portion of the reduced plans, please show the location of the accident, the traffic routing being used at the time of the accident, and any traffic control devices within 1000 feet of the accident site.

VIII. In your opinion, did the construction activity contribute in any way to the accident? ☐ Yes ☐ No

If yes, explain:_____

_____

_____

_____

IX. Could this accident, in your opinion, have been prevented by any change in contractors operations, State's operations, changes in signing or other traffic control, etc.? ☐ Yes ☐ No

If yes, please explain:_____

_____

_____

_____

_____

X. Please include photos whenever possible.

Photo numbers:_____. Roll:_____.

_____
Name

_____
Title

_____
Date

PHASE III

When this study was conceived several years ago, it was unknown if construction zones, detours and temporary connections in California had accident rates higher than the average State highway rate. Consequently, this study was proposed to determine (1) if there was an accident problem in construction zones; (2) if so, the problem's magnitude; (3) the causative factors; (4) what could be done to alleviate the problem.

In July 1965, this department published a progress report (Phase I and Phase II) which indicated that a safety problem did exist in construction zones. Conversions on the same alignment were especially singled out as posing a serious safety problem. It was estimated that because of construction zones, California was then experiencing on a yearly basis:

a. 1340 more accidents of which 680 resulted only in property damage (PDO), 520 were injury producing and 140 were fatal.

b. 170 more fatalities.

Obviously, there was room for improvement.

Reasons generally cited as primary causative factors in construction zone accidents are:

1. A lowering of geometric standards.
2. Unexpected or unusual situations.
3. An increase in the number of hazards to which traffic is exposed.

Attempts to empirically isolate, through accident reporting procedures specially designed for this study, variables which might be shown to contribute to safe or hazardous construction zone conditions were accompanied with shortcomings. The most important of these is the fact that so little data was acquired that only through what could be termed as "extrapolating beyond the data" could any conclusions be drawn. Consequently, this method of analysis was abandoned.

The method of analyzing, in depth, construction zones chosen through random sampling techniques was then adopted. The analysis fundamentally consisted in going to each construction zone, noting what seemed to be safe and unsafe about the area, making recommendations on how to alleviate the "unsafe" conditions and then making observations to determine if the recommendations produced results.

Through such analyses, a number of recommended practices evolved which are now widely accepted. Most of these have been included in several publications by the Division of Highways. Enumerated, the recommendations are as follows:

Geometric Standards

1. Construction zone detours should be designed for the speeds vehicles will travel, not the speeds one hopes they will travel. Many drivers will not slow

down especially when they are accustomed to sustained high speeds on the approach highways. Detours located where high approach speeds are anticipated must be of high design standards. Transition lengths, curve radii and superelevations must be consistent with the design standards required for the speed of traffic that will be entering the detour. This could require an additional stage in the construction; for example, the placing of asphalt concrete over new Portland cement concrete pavement to build up superelevation.

2. Any sudden changes in either geometric standards or speed limits should be avoided. The element of surprise can be reduced by making gradual, step-down reductions. These reductions should be made in increments of not more than 10 miles per hour.

3. When traffic volumes are high and construction periods lengthy, detours should be built to standards consistent with those required for permanent roadways. They should be designed to the highest geometric standards relative to the limits of cost. No reductions in the design standards of the detour should be considered merely because the detour is temporary.

Delineation

1. Old traffic stripes or arrows on AC paving should never be merely blacked out with oil or paint.

Rather, the striped and adjacent areas should be sandblasted in a pattern different from the original marking and then painted or oiled. This minimizes the possibility that the original marking will still be visible to drivers especially at night or in rainy weather when covered over stripes have a tendency to shine in contrast to the pavement.

2. Where detours of AC paving meet diagonally with PCC pavement, the longitudinal joint should be covered over with AC to reduce the contrast between the two pavements. At night and during rainy weather, the longitudinal joints often stand out much more clearly than the traffic stripes when such measures are not taken. (See photos 1A and 1B)

3. When normally divided traffic must be carried temporarily on an undivided PCC roadway, delineation of the division should be provided by a thin blanket of AC placed on the center of the pavement with barrier striping. (See photos 2A and 2B) In conjunction, special signing to notify and remind traffic that they are traveling on a two-way highway is also necessary. (See photo 3B) Additionally, on AC paving, 24' directional pavement arrows should be placed side by side at 700' intervals.

4. Barricades are inherently fixed object hazards. Therefore, they should not be used unless the construction hazard the motorist may encounter is greater than the hazard of striking the barricades. They should not be used as primary delineation to guide traffic. (See photos 3A, 4A, and 4B)

5. Delineation devices must be maintained. When delineators become covered with grime or are damaged, they become ineffective. The condition and positioning of such devices should be checked daily.

Signing

1. One should be judicious in the type and amount of signing to be used in construction zones. The use of too many signs can be dangerous because they may distract the driver's attention away from the roadway for an excessive span of time, cause confusion, or cause drivers to ignore them. "Too many" signs might be described as that number which creates a cluttered impression. A judgment based on the speed of traffic, amount of driver distractions, number of driver decisions necessary and the geometrics of the highway must be made to determine the proper number of signs.

In conclusion, recommendations and principles such as the above were the results of the in-depth analyses

that were employed in this project. These principles may be considered by some as merely reflecting common sense. However, prior to the projects inception, it was not even a known fact as to whether construction zones had an accident problem. Because of this research, safety in construction zones has become of increasing concern to the California Division of Highways. The policy practices today is to build detours of a high standard which permit traffic to flow through a construction zone safer and faster than before, with the emphasis on safety.

As shown in the Progress Report, 10 construction zone locations were examined to see if an accident problem existed. The total accident rate of these 10 locations increased from 2.01 Acc/MVM before construction to 2.44 Acc/MVM during construction; an increase of 21.4%. The fatal accident rate climbed a spectacular 132.4%, from 3.95 to 9.18 Acc/100 MVM. Many new principles for handling traffic in a construction zone were put into practice in California after the Progress Report was published.

Thirty-one construction zone locations were studied since applying these new principles, Table IV, Pg. 25. All of the construction jobs selected for study were of a type which necessitated routing traffic through the construction area. Most of the jobs studied were widenings (e.g., 2 lanes to 4 lanes, 4 lanes to 6 lanes or 6 lanes to 8 lanes). The accident rates during construction were compared to the

accident rates of corresponding months prior to construction. The total accident rate of the 31 locations increased from 1.77 Acc/MVM before construction to 1.89 Acc/MVM during construction; an increase of only 6.8%.

Although this increase is statistically significant, it is less than the increase experienced before the application of new construction zone practices. The most important and rewarding improvement achieved by establishing high standards in construction zones is the dramatic improvement to the fatal accident rate. Where that rate had increased markedly in the previous sample, there was no change (+1.6%) in the sample of 31 jobs studied after raising construction zone standards. In fact the level rates of the 31 jobs studied between before construction and during construction precipitated the decision that no further effort was needed in this accident area.

The results of this study have already been disseminated to highway district personnel via circular letters, seminars and safety courses. The appropriate recommendations are also published in our Manual of Warning Signs, Lights and Devices for Use in Performance of Work Upon Highways, which is incorporated as part of the Division of Highways Planning Manual - Part 8, Traffic..

CONSTRUCTION ZONE ACCIDENTS

TABLE IV

	BEFORE CONSTRUCTION								DURING CONSTRUCTION							
	NO. MONTHS	MVM	NUMBER OF ACCIDENTS				ACCIDENT RATES			NO MONTHS	MVM	NUMBER OF ACCIDENTS				ACCIDENT RATES		
			TOT.	FAT.*	INJ	PDO	TOT	F+I	FATALITY			TOT	FAT.*	INJ	PDO	TOT	F+I	FATALITY
10 Construction Zones Studied in 1965	118	278.3	559	11(14)	251	297	2.01	0.94	5 03	103	305.1	745	28(35)	334	383	2.44	1.19	11 47
31 Construction Zones Studied in 1970	415	239.3	4242	75(101)	1645	2522	1.77	0.72	4 22	415	260.6	4927	83(106)	1954	2890	1.89	0 78	4.07

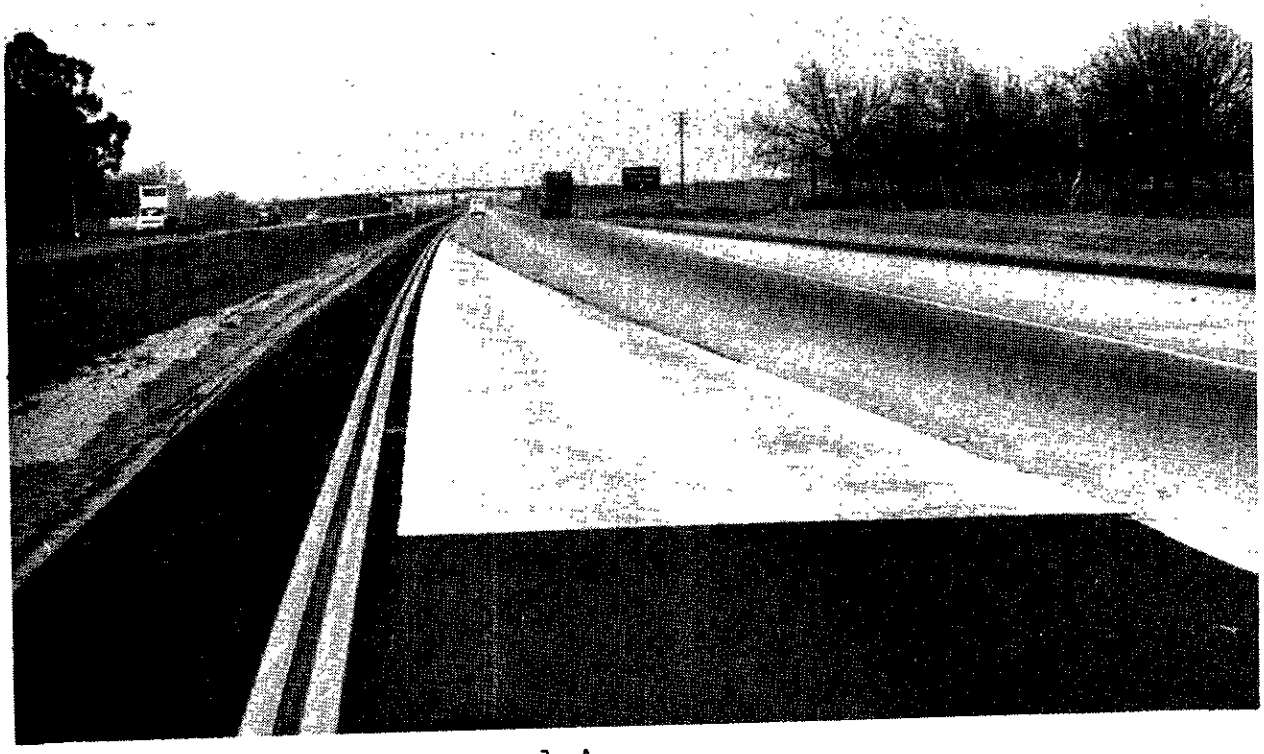
Figures in parenthesis show the number of persons killed.

DURING CONSTRUCTION 1965: PRIOR TO APPLYING NEW PRINCIPLES

PDO	accident rate increased	17.8%	(1.07 to 1.26 acc/mvm)
Injury	accident rate increased	21.1%	(0.90 to 1.09 acc/mvm)
Fatal	accident rate increased	132.4%	(3.95 to 9.18 acc/100 mvm)
TOTAL	accident rate increased	21.4%	(2.01 to 2.44 acc/mvm)

DURING CONSTRUCTION 1970: SINCE APPLYING NEW PRINCIPLES

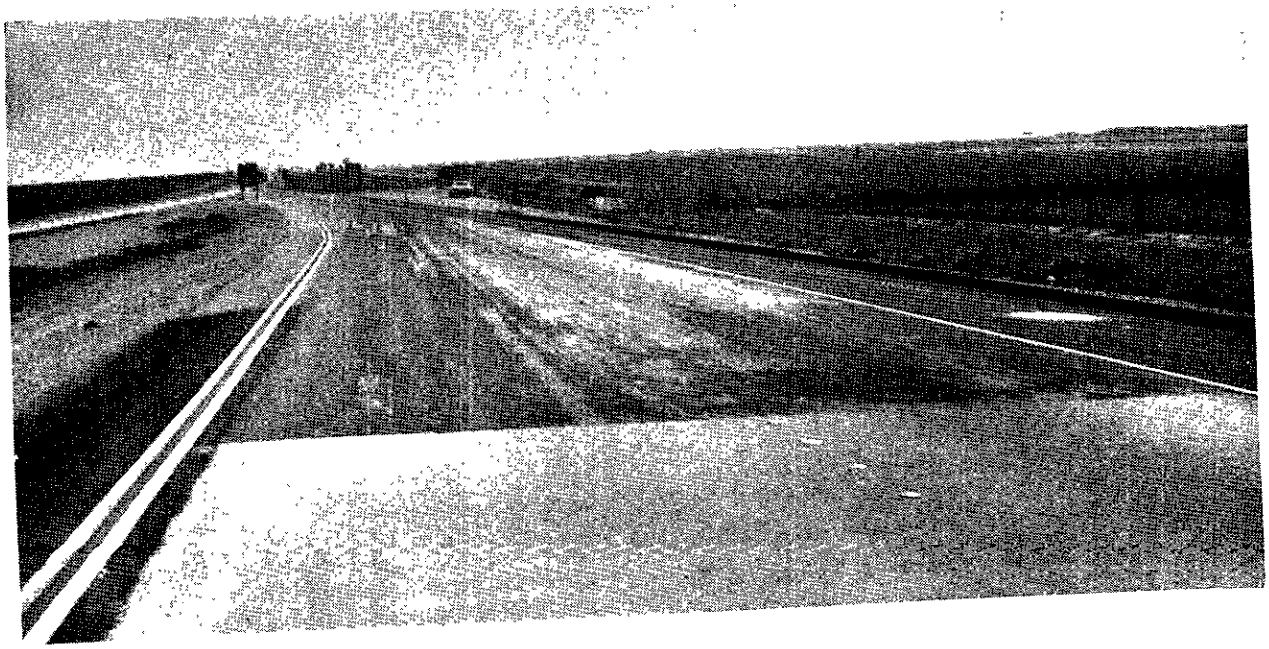
PDO	accident rate increased	5.7%	(1.05 to 1.11 acc/mvm)
Injury	accident rate increased	8.7%	(0.69 to 0.75 acc/mvm)
Fatal	accident rate increased	1.6%	(3.13 to 3.18 acc/mvm)
TOTAL	accident rate increased	6 8%	(1 77 to 1.89 acc/mvm)



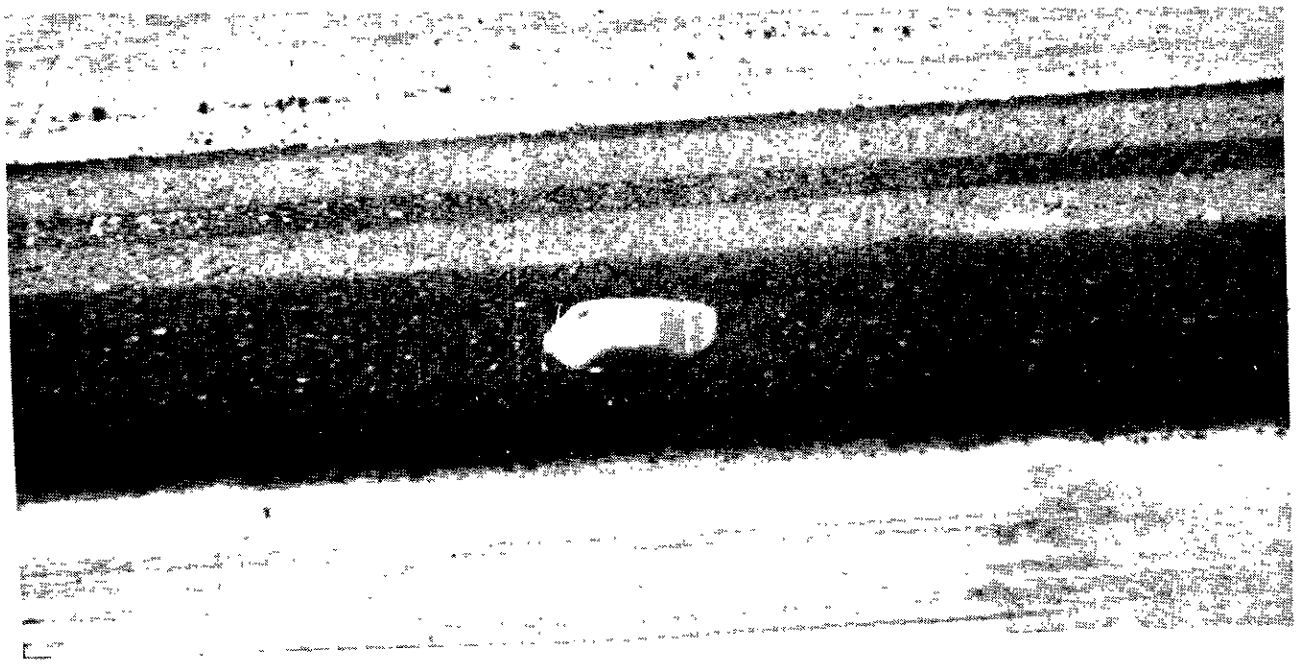
1-A

In the above photo the AC pavement has been painted white. This treatment eliminates the diagonal AC/PCC joint which would be mistaken for the edge of pavement. With this treatment, the driver makes the transition from black to white pavement all at once and is not led off the road by the diagonal joint.

The PCC pavement in the photo below has been treated with oil to eliminate the same problem.



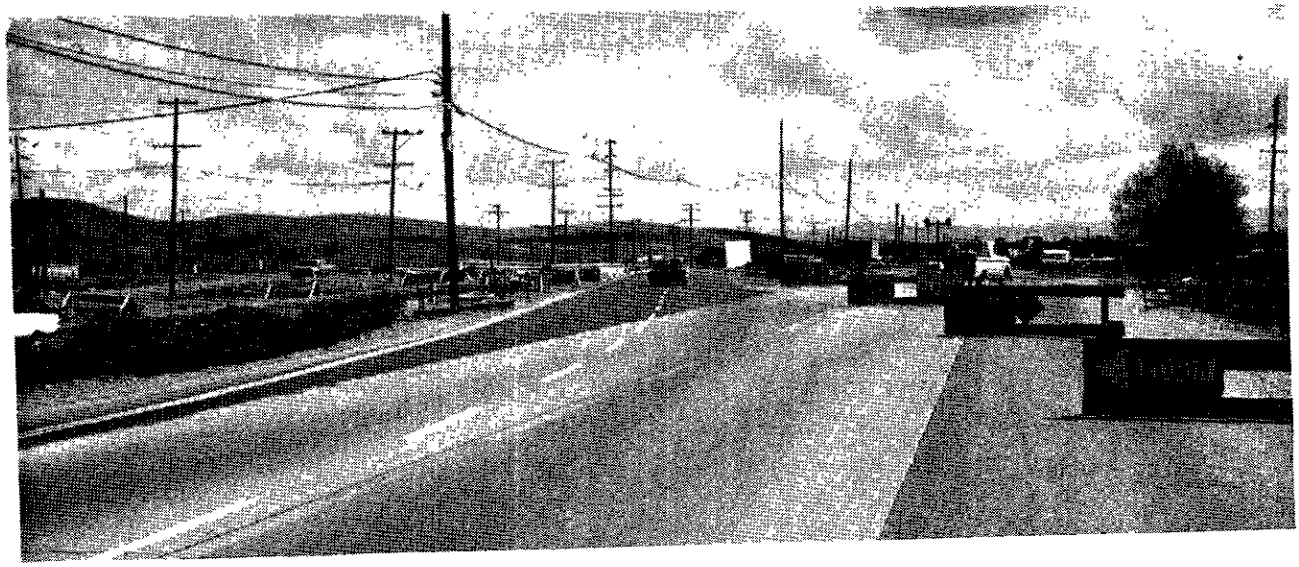
1-B



2-A

A temporary AC divider with barrier striping and reflective pavement markers may be placed on PCC pavement. When traffic volumes are high, temporary concrete or double metal beam barriers are recommended.

2-B



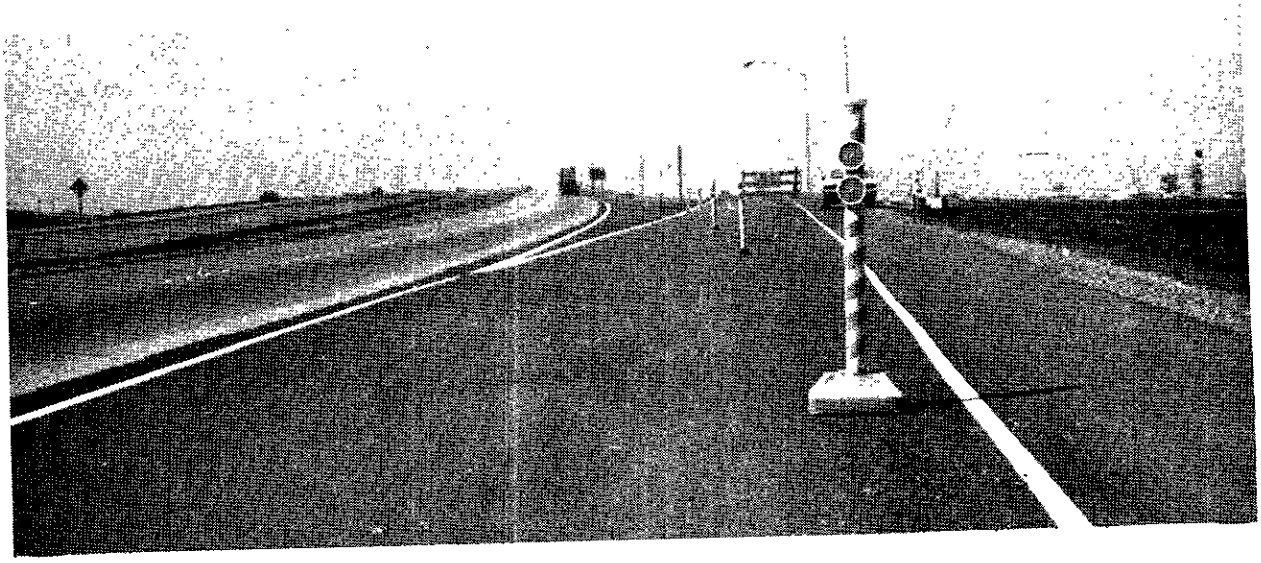
3-A

Above is an example of a construction zone detour. Practices which have been revised, partly as a result of the research reported in this report, include:

1. The PCC pavement should be treated to eliminate the AC/PCC diagonal joint.
2. Reflectorized delineation markers should be used instead of barricades.
3. Pavement arrows and a shoulder stripe would also help a driver through this detour.

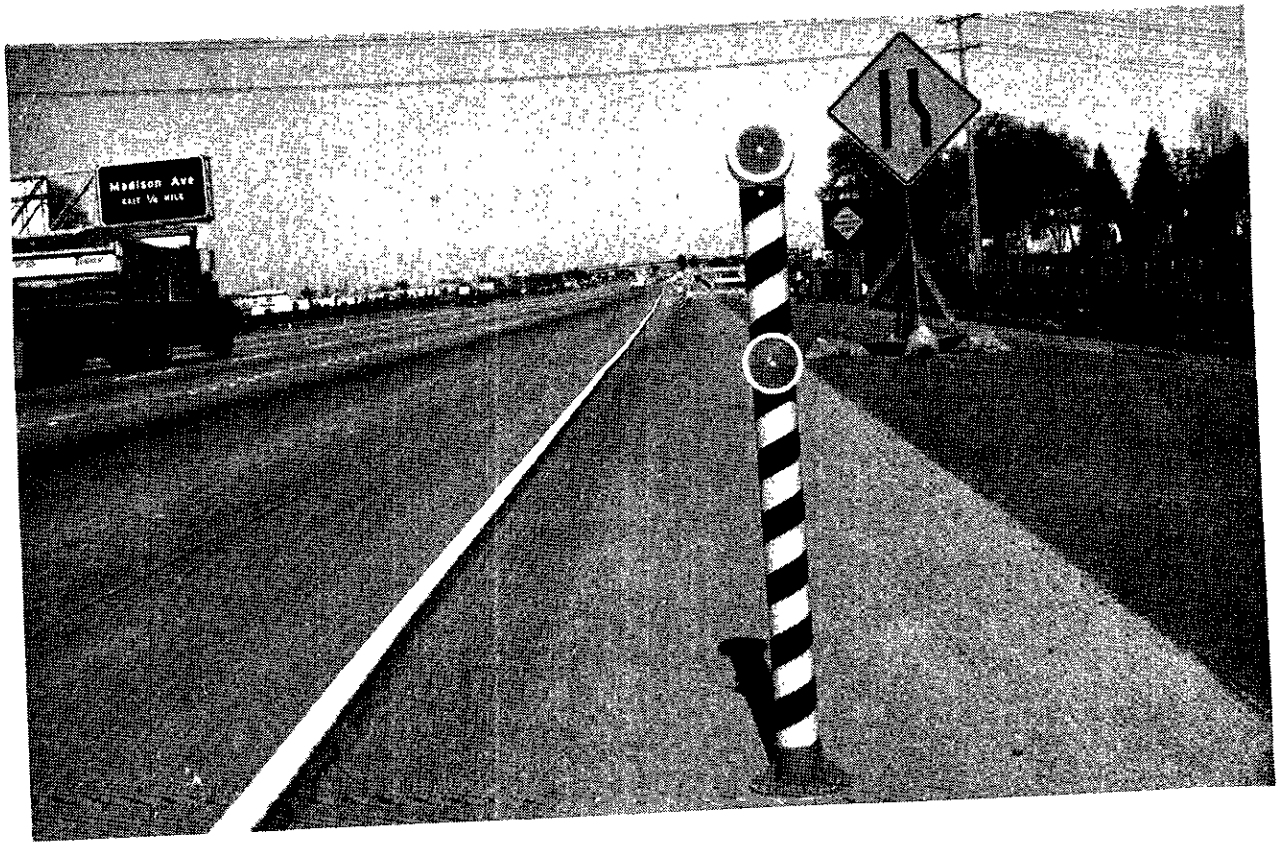
The TWO WAY TRAFFIC sign shown above should be used in conjunction with painted pavement arrows. An example location would be a two-lane highway being upgraded to an expressway or a freeway. Often the graded subbase or unopened paved opposite lanes give strong indications of a divided highway.

3-B



4-A

These reflectorized plastic delineation markers may be held in place by weighted bases, epoxy, or nails. These markers present a clean uncluttered line, are easily maintained, and do little damage when struck by a vehicle.



4-B