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16. Abstract

This report summarizes field evaluation results of two innovative approaches used by District 12 (Houston) of the Texas State Department of Highways and Public Transportation for managing traffic during middle lane maintenance operations on a 3-lane urban freeway section. The two approaches are:

1. Traffic shifting with use of the shoulder.
2. Traffic splitting.

The results indicated that, compared to the multi-lane closure strategy commonly used at middle lane worksites, both approaches significantly increased capacity and reduced queueing on the freeway.

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TRAFFIC MANAGEMENT FOR MIDDLE LANE MAINTENANCE ON URBAN FREEWAYS

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Research Report 228-2

Traffic Management During Urban Freeway Maintenance Operations
Research Study Number 2-18-78-228

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The project was conducted with the guidance of a Technical Advisory Committee. The contributions of the Committee members are gratefully acknowledged:

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SUMMARY

This report summarizes field evaluation results of two innovative approaches used by District 12 (Houston) for managing traffic during middle lane maintenance operations on a 3-lane urban freeway section. The two approaches are:

- traffic shifting with use of the shoulder
- traffic splitting

The results of the field evaluations indicated that, compared to the multi-lane closure strategy commonly used at middle lane worksites (closure of the middle lane and an adjacent exterior lane), both approaches significantly increased capacity and reduced queueing on the freeway.

With regard to traffic shifting and use of the shoulder, the studies revealed that: 1) the strategy could be used to manage traffic at relatively long worksites on freeways with discontinuous shoulders, and 2) shoulder use at sites where the strategy was employed was greatly influenced by traffic demand. Traffic splitting around an isolated middle lane worksite, on the other hand, was used effectively at a relatively short worksite on a freeway section with no shoulders.

IMPLEMENTATION

The middle lane closure approaches summarized in this report can be effectively used on urban freeways where current procedures of multi-lane closure used at middle lane worksites would create excessive queueing. The traffic shifting and splitting approaches should reduce queueing and congestion, thus reducing travel times, delays, gasoline consumption, and air pollution.

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INTRODUCTION

Generally, when maintenance work is required on the middle lane of a 3-lane freeway section, both the middle lane and one of the exterior lanes are closed (Figure 1). Capacity flow in the open exterior lane ranges between 1400 and 1600 vehicles per hour (vph).

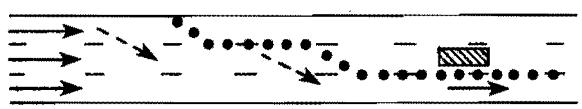

Figure 1. Multi-Lane Closure Strategy Commonly Used to Accommodate Middle Lane Maintenance Operations

In planning for middle lane work on a 2.5 mile section of I-45 in Houston, available volume data indicated that use of the multi-lane closure strategy illustrated in Figure 1 would result in severe congestion. District 12, therefore, developed a traffic management plan intended to maximize workzone capacity and reduce mainlane demand.

The primary feature of the management plan was the attempt to increase workzone capacity through innovative management practices. On days when the work was on sections with shoulders, traffic was "shifted" out of the median and middle lanes, then encouraged to use the shoulder lane and outside shoulder as travel lanes. When the work was on bridges and overpasses without shoulders, the middle lane alone was closed and traffic was permitted to travel in the median and shoulder lanes.

To reduce mainlane demand, entrance ramps in the 2.5-mile work area were closed. Generally, two to four ramps were involved. Motorists normally using these ramps had to remain on the frontage road and enter the freeway downstream of the work area.

TRAFFIC CONTROL AT LOCATIONS WITH SHOULDERS

Figure 2 shows the traffic control devices used to manage mainlane traffic during work on sections with shoulders. All signs shown in the figure were temporary workzone signs and had a black legend on an orange background. The signs and channelizing devices were removed each afternoon after completion of the day's work.

The approach illustrated in the figure made use of a typical multi-lane closure, as presented in Figure 1, to remove traffic from the work-occupied middle lane. Along with the multi-lane closure, however, motorists were encouraged, using special signs and cones, to utilize the outside shoulder as an additional travel lane.

Shoulder Utilization

The evaluation studies revealed that drivers will begin using the shoulder when some degree of congestion develops on the mainlanes. Shoulder usage will increase with increased demand and congestion on the main lanes. Prior to any significant speed restrictions, little or no traffic will use the shoulder. In Houston, about 8% of the drivers used the shoulder when the traffic demand flow rate was 1600 vph. Approximately 40% of the drivers used the shoulder when the rate was 2400 vph.

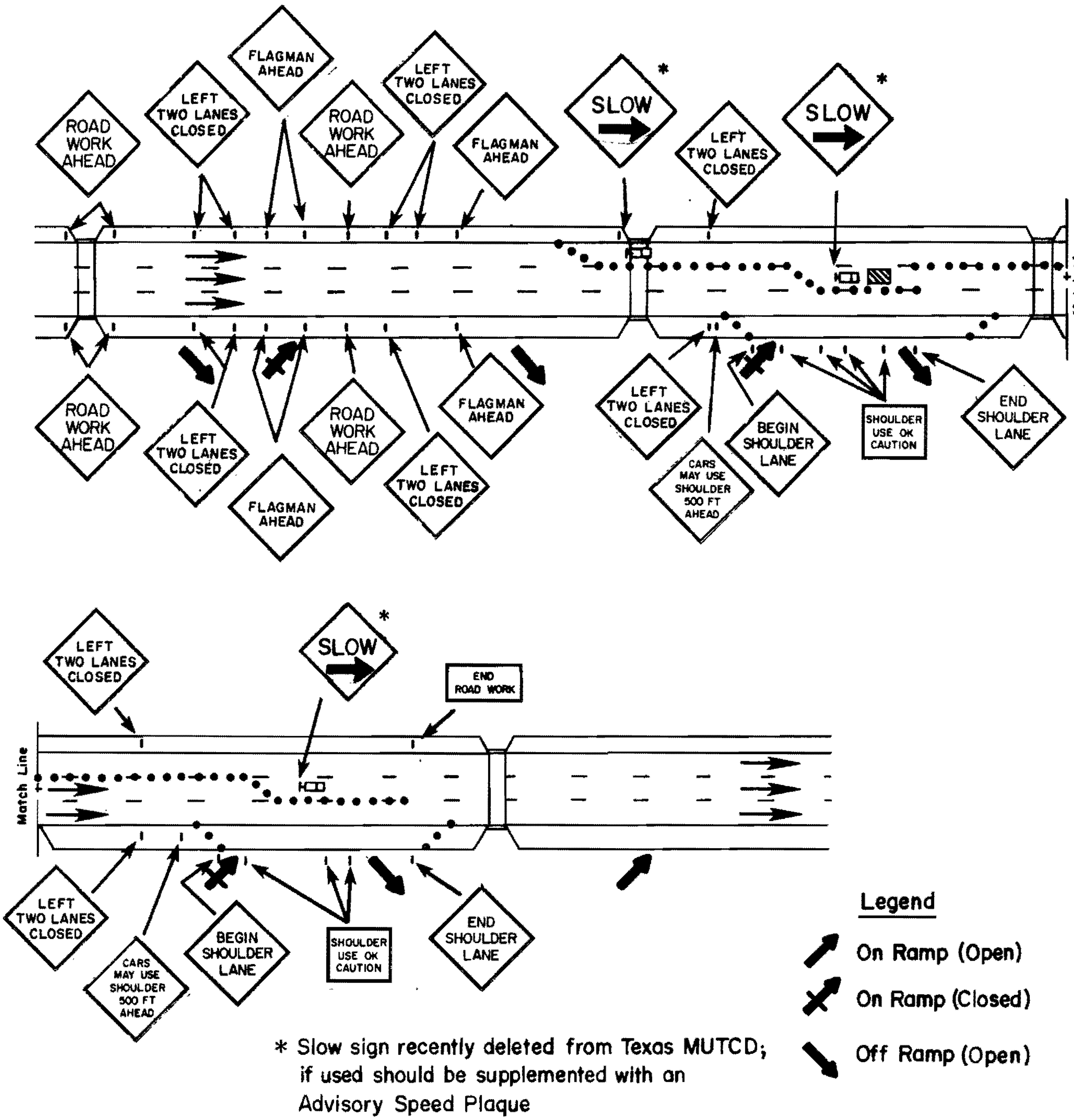

Figure 2. Traffic Control Strategy Used to Perform Center Lane Work on Sections of I-45 With Shoulders

Some drivers were not quick in reacting to the shoulder use signs. The "follow-the-rabbit" phenomenon was noticeable. When one driver entered the shoulder, several others followed. Distrit 12 personnel observed that when a flagman was posted at the BEGIN SHOULDER LANE sign and pointed to the sign, this seemed to encourage drivers to enter the shoulder much sooner.

Capacity

As expected, traffic flow through the workzone where shoulder use was encouraged was significantly greater than similar sites where the multi-lane closure strategy along (Figure 1) was used. Although traffic demands never exceeded capacity during the Houston studies, volumes through the workzone averaged 2400 vph during a two-hour study period. Capacity, therefore, will be greater than 2400 vph. This is significantly higher than that expected from the strategy shown in Figure 1 which is between 1400 and 1600 vph.

Shoulder Use by Vehicle Type

The advance sign employed to encourage shoulder use presented the message CARS MAY USE SHOULDER 500 FT. AHEAD, thus implying only passenger cars should use the shoulder. The signs located intermittently in the shoulder-use zone contained the message SHOULDER USE OK CAUTION.

Observations in Houston revealed that shoulder usage by each type of vehicle increased with traffic volumes. When mainlane demand was approximately 1600 vph, 9% of all passenger cars, 8% of all the pickup trucks and vans, and 3% of all the trucks used the shoulder. When the demand increased to 2400 vph, 40% of all the passenger cars, 41% of all the pickup trucks and vans, and 25% of all the trucks used the shoulder.

TRAFFIC CONTROL AT LOCATIONS WITHOUT SHOULDERS

Figure 3 shows the traffic control scheme used to manage traffic during middle lane work on sections of I-45 without shoulders. All signs shown in the figure were temporary workzone signs and, except for the flashing arrow-board, they had a black legend on an orange background. Special symbolic signs were used to warn drivers that the middle was blocked ahead and they can proceed through the work area by remaining in their lanes. Note in the site layout that cones were placed on the lane line between the middle and shoulder lanes to discourage lane weaving. These cones extended 500 feet upstream of the taper closing the middle lane. Sight distance to the actual closure was approximtely 1300 feet.

The rationale to this approach for "splitting traffic" is to require drivers in the left lane to merge into the middle lane far in advance of the actual middle lane closure, thus moving the merging away from the work crew. As drivers approach the middle lane closure, they are "funneled" into convenient well-defined paths along each side of the work. Because these paths are well-defined, there should be no confusion on the part of drivers in the middle lane as to which direction they should move to proceed past the work activity.

Capacity

Because of the short duration of maintenance work, data were collected for only 30 minutes. Flow rates based on 5-minute volumes ranged from 2160 vph to 2928 vph. Capacity was not reached during the data collection perod, but it is estimated that capacity would be approximately 3000 vph.

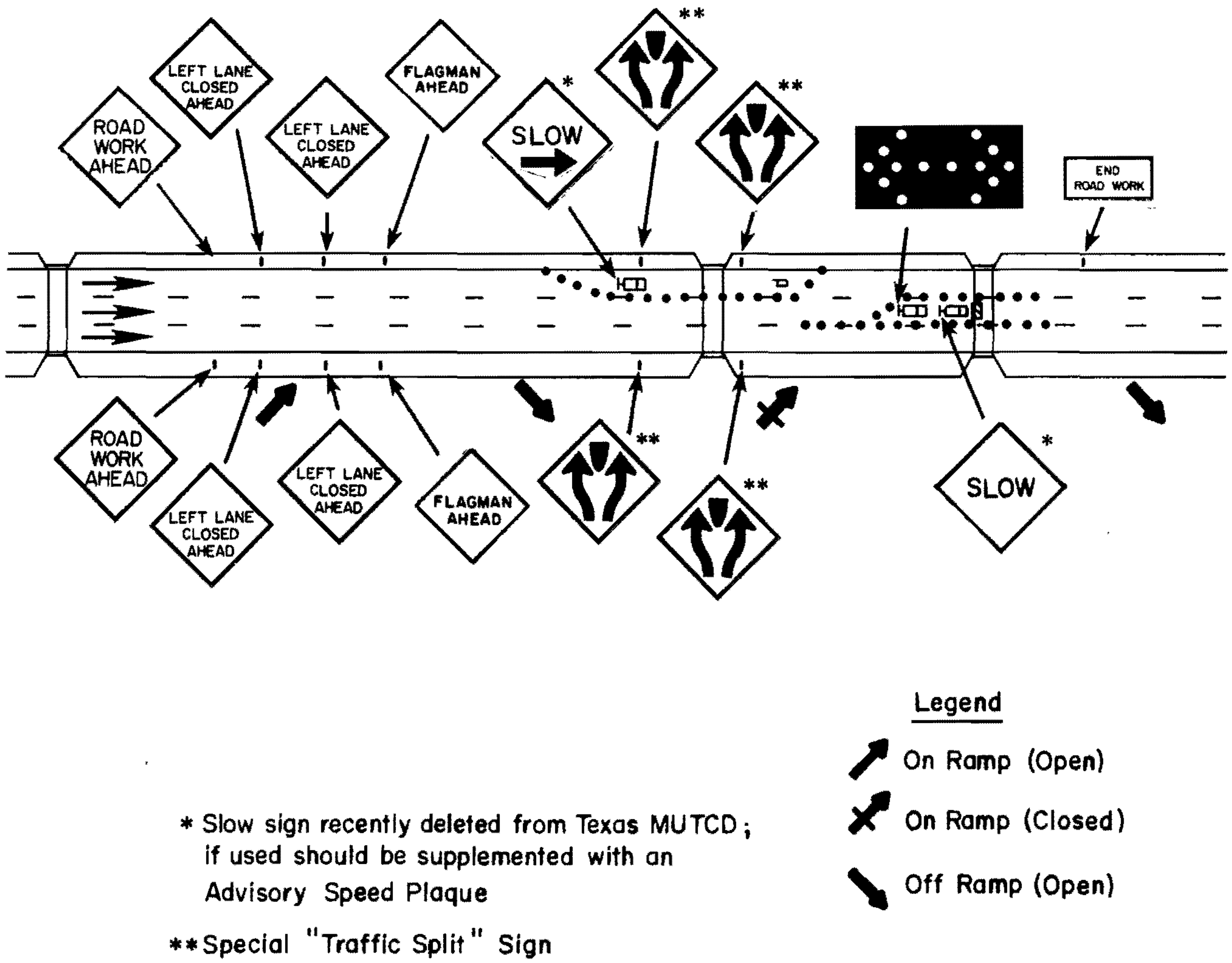

Figure 3. Traffic Control Strategy Used to Perform Center Lane Work on Sections of I-45 Without Shoulders

Lane Changing

Observations revealed that only 1.5% of the drivers changed lanes in a section within 1,000 feet immediately upstream of the middle lane closure. There did not appear to be any noticeable adverse driver reactions.

Based on observed lane change maneuvers and flow past the worksite, the strategy appeared to provide an adequate level of safety to both motorists and the work crew. This fact, combined with the increased workzone capacity achieved, indicates that traffic splitting is a useful strategy for managing traffic at relatively short middle lane worksites where no shoulders exist.

Applications

The "traffic splitting" approach should only be used for short sections and should not be used immediately upstream of high-volume exit ramps. There is a possible danger that drivers desiring to exit could be trapped in the left lane; erratic maneuvers may occur.

Summary of Estimated Capacities

The following table summarizes the estimated capacities of the three strategies used to close the middle lane of a three-lane freeway section. The capacities are based on the Houston studies reported herein.

Strategy	Number of Lanes Open	Estimated Capacity (vph)
Conventional 2-Lane Closure	1	1,400-1,600*
Traffic Shifting (Shoulders)	1 + Shoulder	3,000
Traffic Splitting (No Shoulders)	2	3,000

*Influenced by site conditions

APPENDIX

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F