Motorist Comprehension of Signing Applied in Urban Arterial Work Zones

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Motorists encounter numerous problems that are not currently addressed in traffic control manuals for urban work zones. The motorists' understanding and properly attending to signing in these work zone areas is critical to ensure safe operations. A detailed survey about Farm-to-Market (FM) 1960 in Houston, Texas, investigated motorists' comprehension of construction signing. FM 1960 is a four-lane, undivided major arterial with a continuous left-turn lane. The continuous left-turn lane was excluded during construction because of a restricted right-of-way. The survey was designed to meet three objectives: (a) to ascertain knowledge about work zone signing, (b) to determine problem areas of the FM 1960 signing, and (c) to elicit information from motorists concerning overall problems with the FM 1960 project. Personal interviews were conducted with 205 respondents from the FM 1960 areas. These participants were asked to respond to questions about work zone signing and other forms of traffic control devices. The response percentages revealed that motorists have some difficulty interpreting both word and symbol messages on signs. This lack of comprehension intensifies the existing problems in work zone areas and indicates a need for further research to improve urban arterial operations.

As a result of continued increase in congestion on many freeways in major Texas cities, the arterial street systems next to these freeways are being forced to carry a larger load of the traffic burden. In September 1987, the Texas State Department of Highways and Public Transportation implemented a $100 million program, the Principal Arterial Street System (PASS), to upgrade many urban arterials to provide additional capacity and improve traffic flow. However, construction traffic control on arterials in highly developed urban areas presents many problems not currently addressed by signing in the *Manual of Uniform Traffic Control Devices* (*1*). These problems include increased driver workload associated with construction sign requirements, constricted rights-of-way, moderate speed and volume combinations, compressed spacing between signalized intersections, heavy protected and unprotected turning movements, and excessive provisions for access to adjacent property (driveways).

Vehicle speeds are typically lower in urban areas than in rural areas. A driver may have more time available to comprehend the traffic environment. However, the high density of signing and congestion on a typical urban arterial will usually offset the advantage of lower operating speeds.

Other literature (*2,3*) indicates a large discepancy between the amount of applicable signing for freeway and rural highway work zones and that recommended for use in urban arterial work zones. One study (*4*), which evaluated the implementation of traffic control plans, specifically cited motorist confusion with signing in urban arterial work zones. Motorist misunderstanding of signing, in general, was documented by the Texas Transportation Institute (*5*).

Because of the special problems associated with urban arterial work zones, motorists traveling these roadways must comprehend and properly attend to the signing used for traffic control. This understanding is critical to ensure that communication in these areas promotes good operations and safety. Therefore, the level of motorist comprehension of signing within an urban arterial work zone was assessed.

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INTRODUCTION

FM 1960 is included in the Farm-to-Market (FM) road program, which was approved by the Texas legislature as a classification of highways in the state of Texas. Reconstruction of FM 1960 in Houston, Texas, which began in January 1988, proceeded from Interstate 45 to State Highway 249, a 7-mi segment of roadway (Figure 1). FM 1960 consists of four undivided lanes with 100 ft of right-of-way. The reconstructed facility will include six lanes with a continuous left-turn lane. The primary land use along this major arterial is retail and residential. The traffic volume before construction was approximately 45,000 veh/day. Approximately 360 driveways and 27 signalized intersections are within the project limits.

All aspects of the implemented traffic control plan met or exceeded the requirements of the *Texas Manual on Uniform Traffic Control Devices* (*6*). However, complaints and comments from FM 1960 motorists and adjacent retailers suggested that the volume and speed of traffic, as well as the number of turning vehicles, posed significant problems warranting study. An origin-destination and opinion survey (*7*) confirmed motorist confusion and poor understanding of signing through the reconstruction area. On the basis of this information, a detailed survey was initiated in 1989 to investigate motorist comprehension of construction signing within this corridor.

STUDY DESIGN AND METHODOLOGY

A survey was designed to meet the following objectives:

- Ascertain knowledge about work zone signing in general,
- Determine confusing or problematic areas of the FM 1960 signing in particular, and
- Elicit information from motorists concerning problems with the FM 1960 project that may not be related to understanding traffic control devices.

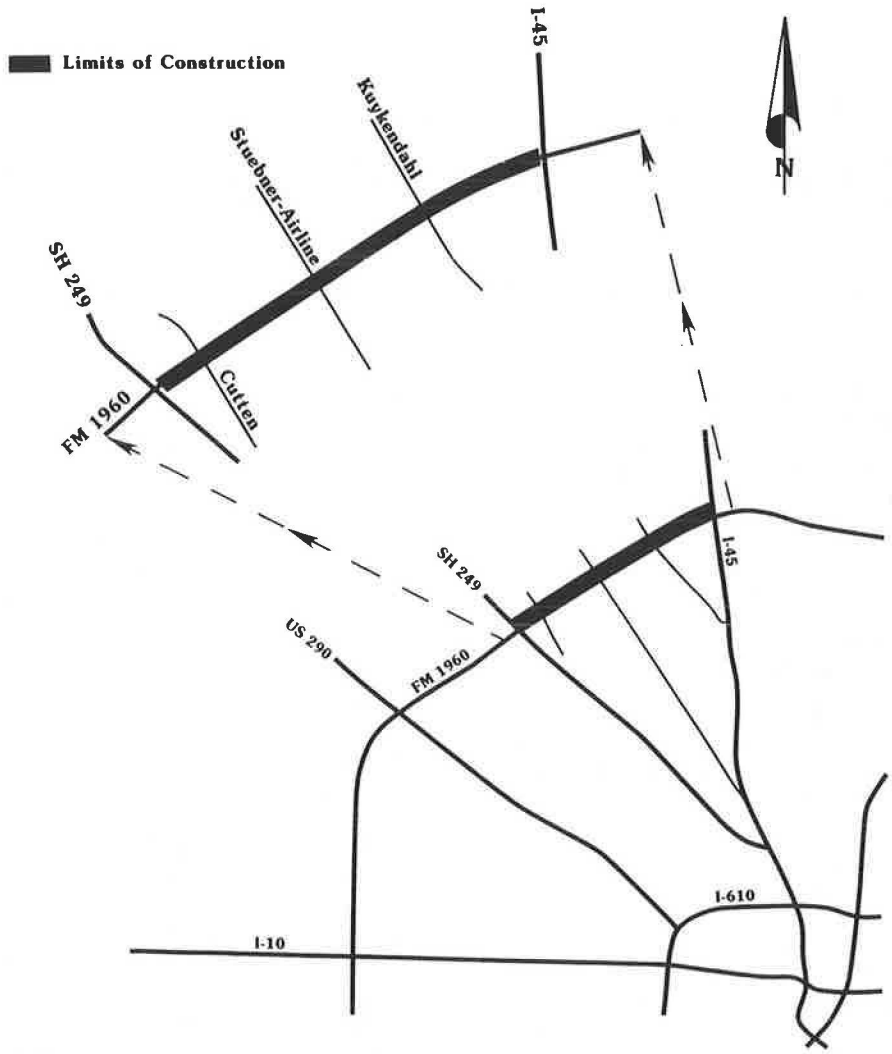

FIGURE 1 Construction project map.

More specifically, three questions were posed: (a) Are motorists having difficulties with the construction area because of confusion or the number of signs and traffic control devices or both? (b) Are motorists having trouble finding destinations in the construction area because of problems with signing? and (c) Are primary FM 1960 users primarily concerned about traffic control and signing, or are other factors more important?

Personal interviews were conducted with 205 respondents in February 1989 at two locations, Willowbrook Mall and the Grant Road Texas Department of Public Safety (DPS) Licensing Office. Response was strictly voluntary in the mall—potential respondents were not approached randomly. However, respondents at the licensing office were asked to participate in the study. The result was that 115 respondents were interviewed at the DPS licensing office and 90 respondents were interviewed at Willowbrook Mall.

Survey participants were first asked to respond to questions about work zone signs and other forms of traffic control devices presented in a booklet of photographs. This set of questions was followed by a series of photographs or signs and scenes from the FM 1960 reconstruction project with corresponding questions. The third segment of the interview was a discussion with the respondent about his or her opinion on various aspects of the reconstruction project. A brief set of biographical questions concluded the interview. The interview took an average of 10 min. The work zone signing questions are shown in Figure 2.

RESULTS

As anticipated, the survey revealed that drivers have some difficulty interpreting both word and symbol messages on signs. Response percentages for each of the sign questions are presented and discussed by category.

Road Construction 500 FT

Two-thirds (66.0 percent) of the survey respondents correctly interpreted the sign shown in Figure 3 to indicate an advance warning of construction 500 ft ahead. However, one-fourth

What does this sign mean?

1. A. Road construction ahead
   B. Flagger ahead
   C. Guard for school crossing ahead
   D. Not Sure

2. A. Median narrows
   B. Right lane ends
   C. Right turn lane marker
   D. Not Sure

3. A. Leave room for traffic crossing at intersection
   B. If your car stalls, move it out the of intersection
   C. Move through the intersection quickly
   D. Not Sure

4. A. Divided road ahead
   B. Obstacles in the road ahead
   C. Merging traffic ahead
   D. Not Sure

5. A. Drive in the center, the lane is not marked
   B. Drive in the right lane only
   C. Be alert for cars stopping to turn left
   D. Not Sure

6. A. Low shoulder
   B. Uneven pavement
   C. Bumpy road
   D. Not Sure

7. A. Left turn lane marker
   B. Left lane ends
   C. Median narrows
   D. Not Sure

8. A. Drive in the outside lane only
   B. You cannot go straight at the next light
   C. A Lane for Left Turns is not provided
   D. Not Sure

9. What do the orange and white striped signs mean?

   A. Do not turn between these signs
   B. Pay special attention to signs on these posts
   C. Drive to the right of these signs
   D. Not Sure

10. What does the green sign mean?

    A. Crossover here
    B. Crossover at the next signal
    C. Emergency vehicle cross here
    D. Not Sure

11. What do the orange and white posts on the right tell you?

    A. Hazardous area to the right, drive to the left of posts
    B. Shows the right edge of the pavement
    C. Park between these posts
    D. Not Sure

12. What does the second yellow sign mean?

    A. Obstacles in the road ahead
    B. Merging traffic ahead
    C. Divided road ahead
    D. Not Sure

13. Are you permitted to turn left in front of the barrel with the crossover sign?

    ____ yes ____ no
    ____ not sure ____ other

14. Are you permitted to turn left behind the barrel with the crossover sign?

    ____ yes ____ no
    ____ not sure ____ other

15. Do you think signs like the Auto Tint sign should be allowed in the construction area?

    ____ yes ____ no
    ____ not sure ____ other

16. Are you permitted to turn right at this intersection?

    ____ yes ____ no
    ____ not sure ____ other

17. Why are these signs different colors?

18. You are driving the pickup, what should you do at this intersection?

19. What is your opinion of these red signs?

FIGURE 2 Sign questionnaire summary.

(25.2 percent) of the respondents interpreted the sign as the beginning marker for a construction area that would continue for 500 ft.

Respondents viewed the same sign in a photographed segment of FM 1960. In the context of the construction area, the percentage of correct interpretations did not increase. In response to the sign shown in Figure 4, 33 percent of those surveyed said that the next 500 ft of roadway are under construction, and 58.3 percent said construction would be encountered 500 ft ahead.

Advance Flagger Symbol Sign

The Flagger Ahead symbol sign was interpreted correctly more often in the construction context, presented by photograph, than out of context. Figures 5 and 6 show the signs as presented to the survey respondents. The symbol sign of context was correctly interpreted by 77.5 percent of the respondents. In context, correct interpretation increased to 85.1 percent. Most of those who misinterpreted this sign said that it indicated road construction ahead.

FIGURE 3 Sign indicating advance warning of construction.

FIGURE 4 Advance warning sign shown on FM 1960.

FIGURE 5 Flagger Ahead symbol sign.

FIGURE 6 Flagger Ahead sign in construction context.

Low-Shoulder Symbol Sign

The correct interpretation rate of the low-shoulder symbol sign (shown in Figure 7) was very poor. Most drivers (84 percent) thought that this sign indicated uneven pavement, rather than low shoulder.

Lane Ends Symbol Sign

Median Narrows was selected by 15.7 percent of the respondents as the meaning of the symbol sign shown in Figure 8. Right Lane Ends, the correct meaning, was chosen by 78.4 percent of the respondents. In response to the photograph in Figure 9, 9.9 percent thought the sign was a left-turn lane marker. The correct response was given by 79.2 percent of the respondents.

Response to Sign Messages

Respondents were asked to describe the appropriate driving response to several regulatory and informational signs posted

FIGURE 7 Low-Shoulder symbol sign.

FIGURE 8 Right Lane Ends symbol sign.

FIGURE 9 Right Lane Ends sign shown in context.

FIGURE 10 No Center Lane sign.

FIGURE 11 No Center Turn Lane sign.

FIGURE 12 Crossover sign.

FIGURE 13 Crossover sign with ribbon barrier.

in the construction area. The results showed that, for some signs, a clear and single message was not delivered.

No Center Lane and No Center Turn Lane signs (Figures 10 and 11) are used throughout the FM 1960 construction area. These signs were confusing to many respondents. Forty-six percent believed they should drive only in the right lane in response to the No Center Lane sign, and 15 percent thought No Center Turn Lane meant that they should not turn from the center lane. Only 46.1 percent checked the appropriate response—"be alert for cars stopping to turn left."

Green Crossover signs, when posted on a free-standing barrel as shown in Figure 12, do not clearly convey to the motorist where to cross over. Survey participants were asked whether crossing over is permitted before and after the Crossover sign. In response to the situation shown in Figure 12, 55.2 percent said that crossing over was permitted in front of the barrel; 38.4 percent said it was not. Eight percent of the respondents said they were not sure if they would be permitted to turn behind the barrel with the Crossover sign, 43 percent said that they could turn behind it, and 49 percent said that they could not turn behind it. A ribbon barrier attached in front of the barrel as shown in Figure 13 simplified the response. In this case, 82.3 percent of those surveyed said that turning left in front of the Crossover sign was not permitted, and 80.2 percent said that turning left behind the sign was permitted.

Four response choices were provided for the Do Not Block Intersection sign out of context. Response frequencies for each answer were as follows:

1. Leave room for traffic crossing at intersection—73.5 percent,
2. If your car stalls, move it out of the intersection—9.8 percent,
3. Move through the intersection quickly—15.7 percent, and
4. Not sure—1.0 percent.

Figure 14 shows the sign as presented in context. Respondents were asked what they thought they should do if they were the driver of the pickup truck. In this situation, 99.0 percent described in their own words an appropriate driving response. Again, only 1 percent said they did not know what to do in response to this sign.

Color Cues

Results from this survey support other research findings that color coding to distinguish construction signs from other types of signs is not well recognized by the motoring public. When shown two two-way traffic symbol signs, one yellow and one orange, and asked the meaning of the two different colors, over 40 percent said that they did not know. Several respondents remarked that they did not believe they had ever seen orange signs. Only 44 percent knew that orange is the color designated for construction signs.

For some segments of the construction area, orange-and-white hazard markers were used at the pavement edge, as shown in Figure 15. Although 70 percent of the respondents thought these markers indicated a hazardous area to the right, 26 percent thought they marked the right edge of the pavement. In contrast, solid white markers (Figure 16) were used in the construction area as pavement edge markers. The percentage of drivers who recognized these as pavement markers was 58.3, whereas 35.9 percent interpreted them as hazard markers.

FIGURE 14 Do Not Block Intersection sign in context.

FIGURE 15 Orange-and-white hazard markers used in construction area.

FIGURE 16 Solid white markers used in construction area to mark edge of pavement.

Turning and Finding Destination

The second major question addressed in the survey was whether motorists were having difficulty locating or getting to their destinations because of the construction or signing in the construction area. After answering the questions with fixed choice responses, survey respondents were interviewed for their opinions on a variety of FM 1960 construction problems (Figure 17). Specifically, they were asked, "Do you have trouble finding certain places you want to go because of the construction?" Half (49.5 percent) of the respondents said yes to this question, and half (50.5 percent) said no.

Subsequently, drivers were asked, "Are there too many, too few, or the right amount of signs that give directions to places alongside the construction area?" The response given most often (48.8 percent) was that the right amount of directional signs is being used. However, 28.9 percent said that too few and 18.4 percent said that too many signs were present.

To optimize the visibility of their businesses and entrances to their businesses, some retail owners adjacent to FM 1960 posted directional signing. In most cases, these signs pictured the business name, logo, and an arrow (as shown in Figure

1. How much did construction delay you in getting to the mall/driver license station today? (3 most frequent response percentages)

10 min. -- 20.7%
15 min. -- 22.2%
20 min. -- 18.5%

2. Was this delay unreasonable?

yes -- 33.3%
no -- 66.0%
other -- .7%

3a. Do you drive on FM 1960 to work or other places during rush hour?

yes -- 45.2% no -- 54.8%

3b. If yes, how much are you delayed by the construction during rush hour? (3 most frequent response percentages)

10 min. -- 12.2%
20 min. -- 17.0
30 min. -- 26.8%

3c. Would you say that amount of delay is unreasonable?

yes -- 46.1% no -- 52.8% other 1.1%

4. Are you using other routes to get where you want to go, because of the construction on FM 1960?

yes -- 85.7% no -- 13.8% other -- .5%

5a. Do you think the benefits of widening this road will be worth the inconvenience now?

yes -- 90.7% no -- 7.3% other -- 2.0%

5b. If no, why not?

6. Do you have trouble finding specific places you want to go because of the construction?

yes -- 49.5% no -- 50.5% other

7. Are there too many signs, too few signs, or the right amount of signs that give warnings and information about how to drive through the construction area?

too many -- 9.4% too few -- 13.8%
right amount -- 73.3% Comments -- 3.5%

8. Are there too many signs, too few signs, or the right amount of signs that give information about how to drive through the construction area?

too many -- 18.4% too few -- 28.9%
right amount -- 48.8% Comments -- 3.9%

9. Should there be more, less, or about the same number of barrels through the construction area?

more -- 4.9% less -- 21.7%
same number -- 70.4% Comments -- 3.0%

10. What is your biggest complaint about the 1960 construction area, if any?

Construction too slow -- 18.1%
Delay -- 12.9%
Signs/Barrels -- 10.5%

11. Do you have any other complaints or comments about the 1960 construction area?

Turning problems -- 14.9%
Too much construction at one time -- 11.9%
Construction too slow -- 10.5%

12. From the list below, what would you say is the biggest problem in the FM 1960 construction area?

12.6% - travel delay
13.7% - the work has taken too long
23.2% - the construction area (in miles) is too long
.5% - signs are confusing
9.0% - too much traffic
17.9% - difficult to turn
1.1% - difficult to find where you're going
11.6% - hazardous road conditions
10.5% - general confusion
- other (please specify)

13. Is there anything you would like to add about construction areas in general, or about the State Highway Department in general?

Compliment to SDHPT -- 28.4%
Work faster -- 13.7%
Too many roads under construction -- 9.2%
Work zones should be shorter -- 9.2%

14. Do you prefer roads to have a continuous left turn lane marked by painted lines on the pavement, or medians with turn lanes cut out of them?

continuous left turn lanes -- 49.5%
medians -- 50.5%

FIGURE 17 Discussion question summary.

18). Respondents were asked whether they favored or opposed this type of signing. A majority (53.5 percent) felt that signs showing directions to retail businesses should be allowed in the construction area. Others objected to such signs because they are distracting (14.9 percent), confusing (3.5 percent), not official signs (3.5 percent), and too small (1.0 percent). Several of those who favored the signs suggested that retail owners should be allowed to mitigate the disruptive effect of the construction in terms of visibility and accessibility.

Signs and Messages as Problems

A third objective of the survey was to determine the relative importance of signing and the motorist information system as a source of concern for the users of FM 1960 during the reconstruction activity. Therefore, survey participants were asked if they believed the signing and channeling devices used were adequate. The responses were fairly positive overall—73.3 percent said that the right number of barrels had been placed through the construction area.

Figure 19 shows a type of sign developed by the Houston Northwest Chamber of Commerce. The use of nonstandard signing is occasionally justified by particularly sensitive issues, as in the case of the FM 1960 reconstruction. Because these signs seemed to represent an effort to add a certain lightness to messages given to motorists, their effect was measured. A majority of those surveyed (66.2 percent) said they like the messages on the circular red signs. In general, drivers interpreted them as positive messages. About 20 percent said they did not like them, and 10.8 percent also said they were either distracting or hazardous.

A brief biographical summary concluded the interview. The results are shown in Figure 20.

FIGURE 19 Nonstandard signs used in FM 1960 construction area.

CONCLUSIONS

The survey approach proved to be an effective tool for assessing certain difficulties with sign comprehension in a work zone. The use of a booklet with photographs of various traffic control devices in and out of context produced a sizable number of interpretations in a reasonable time frame with minimal effort on the part of the respondent. One weakness of the approach was that the interpretations given for the survey are not necessarily predictors of behavioral responses to the traffic control devices in the roadway environment. Further, in some cases the incorrect interpretation may be of very little negative consequence. An index that would weigh responses for misinterpretation consequences is recommended for future analyses.

FIGURE 18 Sign showing direction to retail business in construction zone.

The survey of FM 1960 users confirmed previously conducted studies (7) showing that all aspects of signing are not fully understood by motorists. Symbol signs (Advance Flagger, Low Shoulder, and Lane Ends) were correctly interpreted by 77, 13, and 78 percent of the respondents, respectively. Photographs showing the signs in context elicited only slight improvements.

Depending on the situation (in or out of context), from 42 to 33 percent of the drivers surveyed were confused about the meaning of the Advance Construction sign. Further, No Center Lane and No Center Turn Lane are two common signs that do not give the motorist a clear message of the response required.

Inconsistent placement of the Crossover sign (i.e., both in front of and behind the area to be used for crossing over)

Sex	47.0 Male	53.0 Female		
Race	81.3 Anglo	7.0 Black	7.5 Hispanic	4.2 Other
Age	15.2 under 25	76.0 26 - 55	8.8 over 55	

Highest level of education received

8.9 Less than high school	24.1 High school graduate
29.6 Some college	37.4 College graduate

How many years have you been driving?

How many years have you lived in Houston?

What is your zip code?

How often do you travel on FM 1960?

42.1 at least once daily	37.3 at least once weekly
14.7 at least once monthly	5.9 less than once a month

FIGURE 20 Biographical summary of respondents surveyed.

forces the motorist to rely on cues from the roadway environment. An improvement was found in the continuity of responses to the green Crossover sign when it was posted in combination with a ribbon barrier.

However, sign and message interpretation were not primary sources of concern for users of FM 1960. More important issues involved the length of the project, problems associated with turning, and travel delay. The length of the project (in time) was the most frequently cited (18 percent) personal complaint about the construction, while the length (in miles) was most frequently (23 percent) checked from a list of problems. Problems associated with turning and travel delay were checked as the biggest problems by 18 and 13 percent of the respondents, respectively.

The survey instrument focused on problems that might have been encountered by users of FM 1960 during the reconstruction activity. Despite the construction aggravation pointed out in the survey, however, 91 percent of the drivers surveyed believed the long-term benefits will outweigh the short-term inconveniences. In general, the survey respondents indicated a tolerance for construction and its related problems and have positive attitudes toward the Texas State Department of Highways and Public Transportation.

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