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Abridgment

Selection of Work Zone Channelizing Devices Using the Value Engineering Approach

STEPHEN H. RICHARDS and CONRAD L. DUDEK

ABSTRACT

The use of value engineering for selecting work zone channelizing devices is investigated. For illustration, the approach is used to select devices for a lane closure taper at a rural freeway work zone. The results of the investigation indicate that value engineering can be a useful and practical work zone traffic management tool. It provides an objective means of evaluating any number of alternative channelizing devices using whatever performance and cost data are available. Most important, it encourages the selection of low-cost devices that are safe and effective under the prevailing work zone conditions.

There is a wide variety of channelizing devices currently available for use in highway work zones. The Manual on Uniform Traffic Control Devices (MUTCD) (1) presents basic design standards for these devices and general guidelines for their use; however, it is left up to the highway agency to decide where and when to use particular devices or sets of devices.

Typically, work zone channelizing devices are chosen on the basis of one of the following practices:

1. Select the device with the lowest initial cost,
2. Select a device that is normally used by the agency,
3. Select a device already in stock, or
4. Select the "very best" device just in case.

Each of these approaches has drawbacks, and collectively they have resulted in inflated job costs, unnecessarily large inventories, lack of uniformity, and, in some cases, improper device use.

VALUE ENGINEERING APPROACH

The selection of the most appropriate channelizing device for a work zone situation is a critical task. It requires an objective consideration of several factors including cost, safety, maintainability, availability, uniformity, project life, and work zone conditions. Because there is currently no widely accepted, objective means for selecting work zone channelizing devices, the need for a proven approach like value engineering is well founded.

Value engineering is a formalized problem-solving approach directed at analyzing the function of an item with the purpose of achieving the required function at the lowest overall cost (2). Two features of value engineering set it apart from other formal problem-solving techniques. First, it is concerned with function (i.e., identifying the desired function of an item or service). Second, it attempts to establish the relative value of alternatives for accomplishing a function.

The relationship between value (or worth as it is often called) and function is expressed in the following equation (3):

Value = Functional performance/Cost

From this equation, it is seen that value may be increased by (a) reducing costs, if performance is maintained or (b) increasing performance, but only if increased performance is needed and wanted and the user is willing to pay for it, or both (a) and (b).

The intent of value engineering is to find solu-

tions that achieve the required function at the lowest overall cost. Value engineering does not strive to save dollars; dollar savings are automatic and maximum (4). In emphasizing function, value engineering lessens the chance that existing hardware limitations or established practices will confine creative thinking. Thus value engineering promotes objective and innovative problem solutions (2).

APPLICATION OF VALUE ENGINEERING

The selection of work zone channelizing devices using the value engineering approach involves 7 steps:

1. Determine the intended purpose (function) of the devices.
2. Identify available alternative devices.
3. Select appropriate measures of device performance (i.e., a means of evaluating how well a device performs its intended function).
4. Determine the performance of the alternative devices on the basis of selected performance measures. (If it has not already been done, alternatives that do not meet minimum performance criteria should be excluded.)
5. Estimate the total cost of each acceptable alternative.
6. Calculate the relative value of each acceptable alternative, where value = performance/cost.
7. Select the alternative with the greatest value.

Instead of describing each of these steps, the following sections will demonstrate how they are performed in selecting taper devices for a lane closure work zone. For the purpose of the illustration, data from NCHRP Report 236 (5) are used.

WORK ZONE SCENARIO

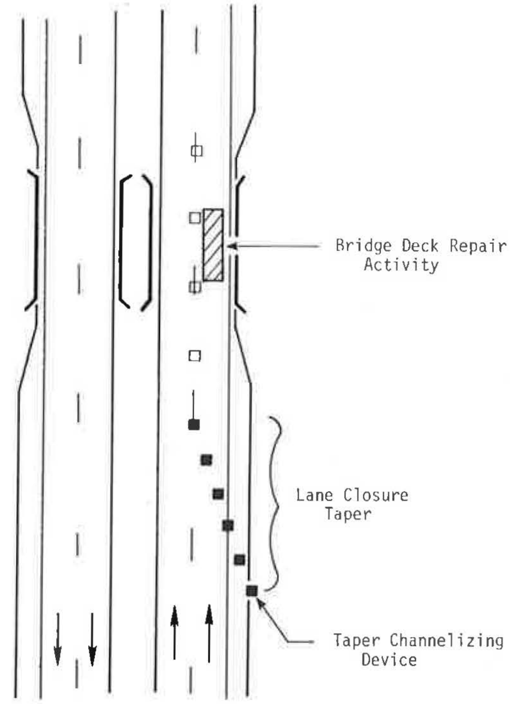
Bridge deck repair work is planned for the northbound, right lane of a rural freeway (Figure 1). The four-lane divided freeway carries low traffic volumes, and speeds are generally high (e.g., 55 mph). In the area of the work, sight distance is excellent and there are no ramps.

The value engineering approach will be used to select the channelizing devices for the lane closure taper. It is anticipated that the right lane will be closed, day and night, for approximately 2 weeks. It is also assumed that the minimum taper length and maximum device spacings recommended in the MUTCD will be used and that only one type of channelizing device will be used in the taper.

FUNCTION OF LANE CLOSURE TAPER

The first step in the value engineering analysis is to identify function. To accomplish this, a functional analysis of the channelizing devices used in a freeway lane closure taper was performed by a team consisting of five traffic engineers and one human factors engineer. The team first identified the various functions performed by channelizing devices in a lane closure taper and then categorized them as either basic or secondary functions.

A FAST diagram, based on the team input, for taper devices was developed. The FAST diagram, shown in Figure 2, indicates that the most basic function of channelizing devices in a lane closure taper is to display color or light, or both, to approaching motorists. The pattern of color or light identifies



Note: MUTCD taper length and device spacing are assumed for evaluating all alternative taper devices.

FIGURE 1 Freeway work zone site layout.

the closure, defines the workspace, and identifies the travel path.

AVAILABLE DEVICES

After device function has been assessed, the next step in the value engineering analysis is to identify alternative channelizing devices that perform the required functions. Data from NCHRP Report 236 (5) provide a basis for selecting appropriate candidate devices. From this report, the following six types of channelizing devices were selected as viable alternatives for a freeway lane closure taper:

1. 3-ft x 12-in. Type I barricades,
2. 3-ft x 12-in. Type II barricades,
3. 12-in. x 36-in. vertical panels,
4. 36-in. cones with reflective strips,
5. 42-in. tubes with reflective strips, and
6. 55-gal. drums with reflective strips.

It is recognized that there are many other possible alternatives, but these six serve the purpose of this illustration.

MEASURE OF PERFORMANCE

The third step is to identify appropriate measures of performance for the alternative devices. From NCHRP Report 236 (5), two measures of performance were selected:

1. Mean array (taper) detection distance and
2. Mean location of lane change relative to the beginning of the taper.

These performance measures were selected because

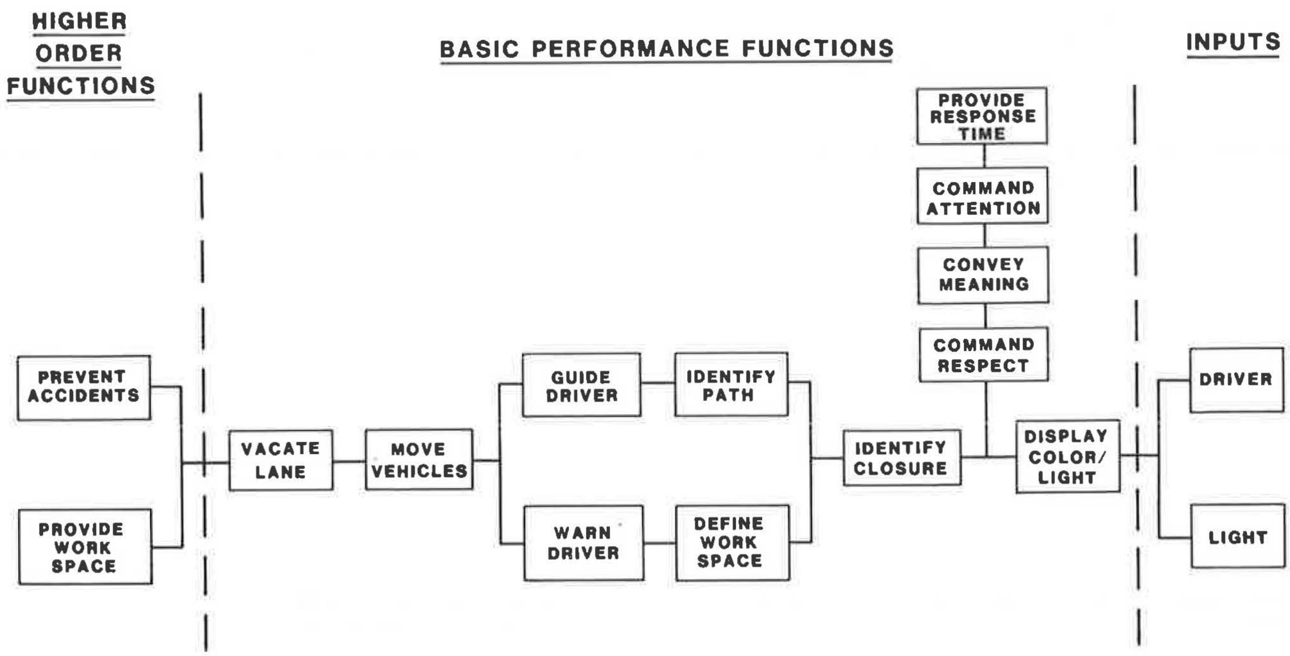


FIGURE 2 FAST diagram illustrating the basic functions of lane closure taper channelizing devices.

they correlate with the basic functions of taper channelizing devices (Figure 2) and because there are corresponding performance data available for each alternative device. With respect to the detection distance measure, there also are data available that provide a basis for establishing a minimum level of performance (6).

In addition to performing the basic channelization functions, it is essential that the alternatives perform required secondary functions. Secondary functions might include maintainability, durability, ease in placement and removal, sign support, and the like. It is assumed that the six alternative devices satisfy all the desired secondary functions at the freeway lane closure site.

DEVICE PERFORMANCE

After appropriate measures of performance have been selected, the next step is to determine device performance based on the established measures. Table 1 gives the mean array detection distance and the mean lane change location for each of the candidate device arrays under day and night conditions. These performance data were extracted from the NCHRP Report 236.

With respect to array detection distance, research

TABLE 1 Mean Detection Distances and Lane Closure Locations for Alternative Channelizing Devices *(5)*

	Mean Array Detection Distance (ft)		Mean Lane Change Location Relative to Taper (ft)	
Device Type	Day	Night	Day	Night
Type I barricades	4,250	3,150	640	660
Type II barricades	4,100	2,800	400	810
Vertical panels	4,400	3,300	370	500
Cones	4,400	1,450	460	250
Tubes	3,200	1,900	620	350
Drums	4,200	3,000[a]	540	560

[a]Estimate based on supplemental research by Texas Transportation Insitute.

by Richards and Dudek (6) suggests that the minimum detection distance for a freeway lane closure taper should be 1,000 ft. Types I and II barricades, vertical panels, and drums provide detection distances that greatly exceed this minimum value. However, based on the NCHRP studies, cones and tubes may not fully satisfy the minimum detection distance requirement at night. This limitation should be recognized and considered in selecting an appropriate channelizing device for the 2-week freeway work zone.

A basic assumption in this value engineering analysis is that channelizing device performance has no upper limiting values. In other words, all of the detection distance and lane change distance provided by a device is useful and therefore has value. At other work zones (e.g., on a minor city street or where sight distance is physically limited by geometric features), it might be desirable to establish upper performance limits. For example, devices on a city street may only need to be detected from a distance of 1,000 ft. Any detection distance greater than 1,000 ft provided by a device would not be used and should not be considered in computing value.

DEVICE COSTS

Cost data for the alternative devices were obtained from a traffic control device supplier in Texas. These data were used to generate the relative device costs given in Table 2. It should be noted that the costs in Table 2 were developed on the basis of some simple and general assumptions. They serve the purpose of illustrating the value engineering approach but should not be considered as truly accurate cost estimates.

DEVICE VALUE

Table 3 gives a value summary for the alternative devices. The table shows the relative value of each alternative device based on its ability to provide detection distance and encourage early lane changes under day and night conditions. The values in Table 3 were computed on the basis of the performance data

TABLE 2 Device Cost

Device Type	Cost Per Device ($)
Type I barricades	40
Type II barricades	45
Vertical panels[a]	22
Cones[b,c]	18
Tubes[d,c]	22
Drums[d]	25

[a]Portable vertical panel mounted on stand.
[b]4-in. reflective collar added.
[c]Cost based on 50 percent replacement during 2-week duration.
[d]Two 4-in. reflective collars added.

TABLE 3 Relative Value of Alternative Devices

	Device Cost per 100 ft of Array Detection Distance ($)		Device Cost per 100 ft of Lane Change Distance ($)	
Device Type	Day	Night	Day	Night
Type I barricades	0.94[a] (5)[b]	1.27 (5)	6.25 (5)	6.06 (4)
Type II barricades	1.10 (6)	1.61 (6)	11.25 (6)	5.56 (3)
Vertical panels	0.50 (2)	0.67 (1)	5.95 (4)	4.40 (1)
Cones	0.41 (1)	1.24 (4)	3.91 (2)	7.20 (6)
Tubes	0.69 (4)	1.16 (3)	3.55 (1)	6.29 (5)
Drums	0.60 (3)	0.83 (2)	4.63 (3)	4.46 (2)

[a]Example calculation: Device cost per foot of array detection distance = Device cost/Array detection distance = $40/4,250 ft = $0.0094/ft. Device cost per 100 ft of array detection distance = $0.0094/ft x 100 = $0.94.
[b]Ranking with respect to other devices (1 = best value).

in Table 1 and the cost data in Table 2 using the basic equation: Value = Performance/Cost. However, the values are expressed in inverse form in the table (i.e., device cost per unit of performance).

It should be noted again that the minimum taper length and maximum device spacing recommended in the MUTCD were assumed for all the alternatives. Thus each alternative array would contain the same number of devices. For this reason the values in Table 3 are expressed in device cost rather than array cost.

DEVICE SELECTION

From Table 3, vertical panels and drums are "good values" for combined day and night use at the freeway work zone, and vertical panels by a slight margin are the best value. From the table, a vertical panel costs only $0.67 for every 100 ft of nighttime detection distance it provides. This cost is slightly lower than that of drums that cost $0.83 per 100 ft of nighttime detection distance.

Vertical panels also are the best value for encouraging early lane changes at night. For each 100 ft of lane change distance, they cost $4.40. Drums also are a good value at $4.46 per 100 ft of lane change distance.

Both vertical panels and drums have relatively good value in the daytime. Only cones and tubes represent a better daytime value.

Thus, based on the value engineering analysis, vertical panels mounted on portable stands are recommended for the freeway work zone. Drums could be used as an alternate. Both of these devices are relatively low cost ($22 and $25, respectively), and they provide adequate performance, day and night.

CONCLUSIONS AND RECOMMENDATIONS

Value engineering appears to be a useful and practical tool for selecting work zone channelizing devices. It provides an objective means of evaluating any number of alternative devices using whatever performance and cost data are available. Most important, it encourages the selection of low-cost devices that are safe and effective under the assumed conditions.

To be most effective, a value engineering study should be based on comprehensive and accurate information. It is also important to use a team approach in which team members are well trained and diverse in experience and technical background. For these reasons, it is recognized that the value engineering approach is most appropriate for central office use. By pooling central office staff and data-gathering resources, value engineering can be used as an analytical tool for establishing work zone traffic control standards and for planning and allocating resources.

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Abridgment

Potential Impact of Speed Reduction at Freeway Lane Closures: A Simulation Study

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ABSTRACT

The objective of this study was to evaluate the potential impact of reduced speed limits at temporary freeway lane closures at work zones at arbitrarily assumed levels of compliance. Although some transportation engineers prefer to reduce speeds at work zones to protect the working crew, others are hesitant to introduce such a disturbance to the traffic flow. The study approach involved simulation experimentation, using FREESIM, a microscopic, stochastic model. A fractional factorial design was developed for the analysis of three independent variables: two-lane volumes (800, 1,200, 1,500 and 1,800 vehicles per hour); speed limits (55, 50, and 45 mph); and assumed compliance with speed limit (33, 66, and 100 percent). The number of uncomfortable decelerations and the variance of the speed distribution were selected as the dependent variables. These two variables were offered as a measure of the internal friction created by the merging of two-lane traffic into a single lane. It was hypothesized that this internal friction is increased by the introduction of lower speed limits. The results of this simulation study indicate that compliance with reduced speed limits will have no significant impact on the number of uncomfortable decelerations but will reduce variance in speed distribution. These results, therefore, do not support the assumption that effective speed reduction at work zones would create a potentially hazardous disturbance in the flow of traffic.

Freeway lane closures at work zones require properly developed traffic control plans to minimize the disturbance of the traffic flow and provide for the safety of both drivers and working crew. The introduction of reduced speed zones is a somewhat controversial aspect of traffic control. Although, at least intuitively, reduced speed implies greater safety especially for the working crew, it introduces a disturbance that may well have a negative impact on the safety of the traffic flow.

The objective of this computer simulation study was to evaluate the potential safety impacts of speed zones at freeway lane closures at different levels of assumed compliance. The specific configuration selected for analysis was the closure of the median (left or passing) lane on two-lane, rural freeway sections.

It is generally recognized that posted speed limits are not necessarily effective in reducing mean speeds, although there are means by which the effectiveness can be improved. This study, however, was concerned only with the impact of the reduced speed limits at specified levels of compliance on the stability of traffic flow.

SIMULATION MODEL

FREESIM is a microscopic, stochastic simulation model. The model logic is based on a rational description of the behavior of drivers in a lane closure situation. The vehicles are advanced in the system using the classical car-following approach. The model simulates lane changing as well as overtaking. The simulation program is written in SIMSCRIPT II.5 programming language (1).

Verification of the simulation model included operational testing of the simulation dynamics