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Developing Traffic Control Strategies

Users Handbook

National Highway Institute

DEVELOPING TRAFFIC CONTROL STRATEGIES
FHWA CONTRACT NUMBER DTFH61-93-C-00092

Participant's Notebook

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I. Introduction

The aging of our highway infrastructure has been accompanied by the realization that various preservation and enhancement activities will be increasingly commonplace well into the future. Because these activities must be carried out despite the presence of vehicular traffic, efforts are necessary to minimize the effect on traffic and roadway safety. Lacking such efforts, normal traffic flow may be unnecessarily disrupted, resulting in long delays which in turn may contribute to increased traffic accidents and worker safety risk. Proper planning of work zone traffic control, along with strategies which improve construction efficiency and minimize congestion, are essential elements of the traffic control plans and project specifications/requirements. There is a need for training on the development of traffic control strategies to ensure adequate consideration of state-of-the-art practices and procedures in maximizing safety while minimizing traffic disruption in work zones. The course "Strategies for Work Zone Traffic Control" is a two-day course aimed at providing such training.

There are often several ways to handle traffic in relation to highway work. Each alternative offers specific advantages and disadvantages. These methods of controlling traffic can include special layouts, additional devices, phasing work, night work or contractual restrictions. They are the strategies of work zone traffic control.

Strategies in planning work zone traffic control activities become increasingly important and sophisticated as the size, type of work, and time to do the work increase. For simple jobs, such as repairing a pothole, the only strategy involved is selecting the appropriate layout from those available. On large or more complicated projects, the TCP isn't just chosen based on the work and highway type, but work efforts are developed around traffic control requirements. On these projects, special traffic control details, layouts, restrictions, operational phases, and operations need to be developed.

Traffic control strategy selection can sometimes be a difficult task. Often, the requirements and interests of construction and traffic management can be in conflict. Figure 1-1 shows such a scenario. The contractor specified a 10-mph speed that flaggers were to enforce in order to keep vibration on the bridge from vibrating concrete away from reinforcing bars. This strategy selection resulted in a very difficult (if not impossible) traffic management task. Was there a better way?

The complexity of the final traffic control plan is dependent on the strategy chosen. A well-chosen strategy will minimize the sum of construction costs and user costs. There is need for guidance on the degree of effort necessary and strategies available when developing traffic control plans for specific projects.

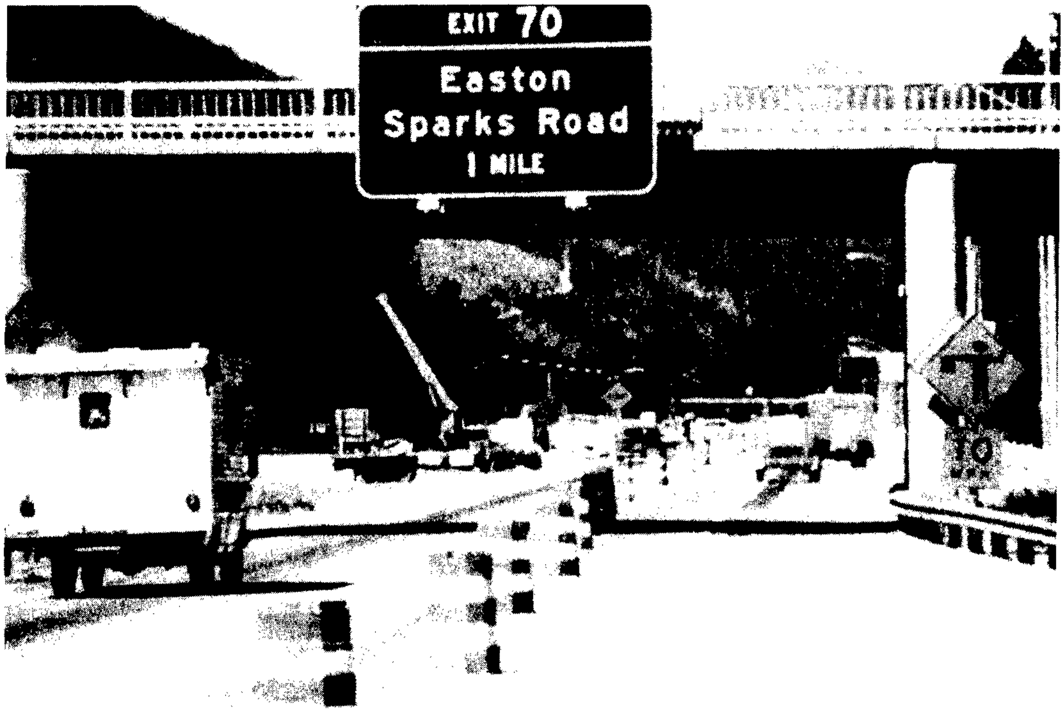


Figure 1-1. Conflict between construction and traffic management.

Course Objectives

This course is for state and local personnel responsible for the development of traffic control plans. It develops technical skills in work zone strategies, which is the science (or technical ability) to plan and develop large highway projects that optimize the relationship between project cost, societal cost (costs to the community), highway safety, and traffic management. The curriculum includes state-of-the-art traffic control and management strategies and discussion of the advantages and disadvantages of each concerning safety and traffic management. Potential operational problems associated with specific strategies when applied to common activities are identified along with suggested mitigations. Suggested specifications and/or special provisions to contract for innovative strategies are also included.

Participants are expected to be familiar with the basics of work zone traffic control by experience or by attending the National Highway Institute (NHI) training course "Design and Operation of Work Zone Traffic Control" or equivalent.

Upon completion of the course, each participant should:

1. Be familiar with current work zone traffic control standards and policies and recognize the importance of providing a safe and efficient temporary traffic control zone.
2. Be familiar with a logical, sequential process for choosing a traffic control strategy which maximizes safety, minimizes traffic disruption, and recognizes the degree of effort necessary for specific categories of work zones.

3. Be familiar with state-of-the-art strategies for routing traffic through or around specific types of highways and work zones, the advantages and disadvantages of each strategy, the effect each strategy has on safety and congestion, and the contracting requirements for innovative strategies.
4. For common highway activities, be aware of the problems which are likely to be encountered when typical traffic control strategies are applied and recognize the possible solutions.
5. Have workshop experience in developing traffic control strategies for specific categories of work zones.

Course Scope

Part VI of the MUTCD (1988, Rev. 3, September 3, 1993) divides work zones into five categories according to the duration of the work. These duration categories are:

1. Long-term Stationary (more than 3 days).
2. Intermediate-term Stationary (overnight up to 3 days).
3. Short-term Stationary (daytime, 60 minutes to 12 hours).
4. Short-duration (up to 60 minutes).
5. Mobile (work that moves intermittently or continuously).

This training course presents information on the most common work activities associated with intermediate and long-term projects.

The training material includes the following:

1. Introduction to the course scope and structure.
2. Current standards and policies concerning traffic control strategies.
3. Discussion of a logical process for selecting a traffic control strategy.
4. Traffic control strategies for the basic types of highway work including discussion of pros and cons of each in relation to safety and congestion.
5. Specifications, special provisions, coordination, and administration of selected strategy.
6. Workshops on traffic control strategies and writing special provisions.

Course Structure

The general outline for the course is shown in Table 1-1. The course first discusses principles of traffic control management, considerations in developing a TCP, then essential information that is needed to develop a strategy. A substantial portion of the course will cover strategies. Traffic control strategies for basic types of work will be presented in the following order:

1. Lane/shoulder work on two-lane, two-way highways (overlay, rehabilitation, shoulder upgrading, realignment, and widening).
2. Lane/shoulder work on multilane divided highways (overlay, rehabilitation, shoulder upgrading, realignment, widening, and adding lanes).
3. Bridge work on two-lane, two-way highways (replace deck, replace deck and rail).
4. Bridge work on multilane divided highways (replace deck, replace deck and rail).
5. Urban street work.

Table 1-1. General Course Outline

I. Introduction

II. Fundamental Principles of Traffic Management

III. Considerations in Selecting a Traffic Control Strategy

IV. Essential Information

V. Traffic Control Strategies for Construction Activities

   A. Work on Two-Lane Highways
   B. Work on Multilane, Divided Highways
   C. Bridge Work on Two-Lane Highways
   D. Bridge Work on Multilane, Divided Highways
   E. Work in Urban Areas

VI. Including the Selected Strategy in the Traffic Control Plan

VII. Summary

Introductions

This course is structured to allow a free exchange of ideas in an informal setting. So that we all get to know each other, please stand and share with other participants:

1. Your name (nickname).
2. Agency.
3. Title or position.
4. Responsibilities related to work zone traffic controls.
5. Your definition of "Work Zone Strategies."

II. Fundamental Principles of Traffic Management

Although participants are expected to be familiar with the basic aspects of work zone traffic control, this chapter will review some terms and fundamental principles from Part VI of the Manual on Uniform Traffic Control Devices. This chapter will include definitions of terms used in the course, fundamental principles that relate to strategy selection, and discussion of types of work zones that may be specified as part of a work zone strategy. Other elements of work zone strategies will also be discussed.

Definitions

In the most basic terms, strategies are the different ways to accomplish an objective. Strategies must be selected when there are two or more competing interests. In work zones these two interests are: first, the traffic and how it is handled, and second, the work and how it is done. These both cost time and money. If only the construction was important, the cheapest and fastest manner to build the job is to eliminate the traffic from the work area. Of course if only the traffic was important, then limits on the amount and time work could be performed could maximize efficient and safe movement of traffic. But when both interests are present, what will be the best way to accomplish the objective?

Once the strategy or strategies are selected for a project, they are then translated into traffic control plans and contract requirements. Designers with a good understanding of the common strategies can develop their traffic control plans and contract requirements to optimize the cost and effectiveness of construction, traffic management, motorist convenience, and community/social needs.

On simple projects, the most common strategies are represented by the traffic layouts in Part VI of the MUTCD. (Layouts are plans that show a roadway and the locations of work zone traffic controls on that roadway.) As projects become more complicated and different restrictions or limitations are included in the planning process, the strategies will become more involved and may employ many methods of both traffic control and construction management. This course will discuss strategies.

The following terms contained in FP-96, "Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects," are used in following sections of this course:

Specifications - The written requirements for performing work.

Standard Specifications - The "Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects approved for general application and repetitive use.

Supplemental Specifications - Additions and revisions to the standard specifications.

Special Contract Requirements - Additions and revisions to the standard and supplemental specifications applicable to an individual project.

Plans - The contract plans furnished by the Government showing the location, type, dimensions, and details of the work.

Standard Plans - Detailed plans approved for repetitive use and included as part of the plans.

Contract - The written agreement between the Government and the Contractor setting forth the obligations of the parties for the performance of and payment for the prescribed work.

Contracting Officer (CO) - An official of the Government with the authority to enter into, administer, and/or terminate contracts and make related determinations and findings. The term includes certain authorized representatives of the CO acting within the limits of their authority as delegated by the CO.

Contract Modification - Any written change in the terms of the contract. Contract modifications are of the following forms:

(a) **Administrative change**. A unilateral contract change, in writing, that does not affect the substantive rights of the parties (e.g., a change in the paying office or the appropriation data).

(b) **Change order**. A written order, signed by the CO, directing the Contractor to make a change that FAR Clause 52.243-4 - Changes authorizes the CO to order without the Contractor's consent.

(c) **Supplemental agreement**. A contract modification that is accomplished by the mutual action of the parties.

Contractor - The individual or legal entity contracting with the Government for performance of prescribed work.

Contract Time - The specified time allowed for completion of all contract work.

Meaning of Terms in FP-96. These specifications are generally written in the imperative mood. In sentences using the imperative mood, the subject, "the Contractor," is implied. Also implied in this language is "shall," "shall be," or similar words and phrases. In material specifications, the subject may also be the supplier, fabricator, or manufacturer supplying material, products, or equipment for use on the project.

Wherever “directed,” “required,” “prescribed,” or other similar words are used, the “direction,” “requirement,” or “order” of the Contracting Officer is intended. Similarly, wherever “approved,” “acceptable,” “suitable,” “satisfactory,” or similar words are used, the words mean “approved by,” “acceptable to,” or “satisfactory to” the Contracting Officer.

The word “will” generally pertains to decisions or actions of the Contracting Officer.

The Contract Requirements, Plans, and Standard Specifications are contract documents. A requirement in one document is binding as though occurring in all the contract documents. The contract documents are intended to be complementary and to describe and provide for a complete contract. In case of discrepancy, calculated and shown dimensions govern over scaled dimensions.

The contract documents govern in the following order:

- Special Contract Requirements
- Special Provisions
- Plans
- Standard Specifications

The contract documents represent the agreement reached between the contracting agency and the contractor on the work to be performed and how the work is to be accomplished.

Fundamental Principles

Fundamental principles of work zone traffic control are given in Section 6B of Part VI of the MUTCD. These principles are presented below along with discussion of what they mean in terms of traffic control strategies.

The introductory paragraphs of this section discusses the scope and purpose of temporary traffic control. The main characteristic of these principles is stated as follows:

"Principles and procedures, which experience has shown tend to enhance the safety of motorists and workers in the vicinity of temporary traffic control areas, are included in the following listing. These principles and procedures provide a guiding philosophy of good temporary traffic control used in work zone traffic control for the practitioner. They do not establish specific standards and warrants (individually addressed in the succeeding sections of this part)."

For the traffic control plan designer, these principles give us both a starting point for consideration of a workable traffic control strategy and a checklist of areas that must be considered.

The first fundamental principle states that safety should be an "integral and high priority element of every project." This principle says that the same safety principles used for permanent roadways should also be used to design temporary traffic control zones. This first principle also states that a traffic control plan should be prepared before a site is occupied. Complete wording of the first fundamental principle is as follows:

1. Traffic safety in temporary traffic control areas should be an integral and high-priority element of every project from planning through design and construction. Similarly, maintenance and utility work should be planned and conducted with the safety of motorists, pedestrians, and workers kept in mind at all times. Formulating specific plans for incident management traffic control is difficult because of the variety of situations that can arise. Nevertheless, plans should be developed in sufficient detail to provide safety for motorists, pedestrians, workers, and enforcement/emergency personnel and equipment.

    a. The basic safety principles governing the design of permanent roadways and roadsides should also govern the design of temporary traffic control zones. The goal should be to route traffic through such areas using geometrics and traffic control devices comparable to those for normal highway situations.

    b. A traffic control plan, in detail appropriate to the complexity of the work project or incident, should be prepared and understood by all responsible parties before the site is occupied. Any changes in the traffic control plan should be approved by an official trained in safe traffic control practices.

The second fundamental principle states that traffic movement should be inhibited as little as possible. This principle addresses speed limits, restricted geometrics, work vehicle operation, scheduling, pedestrians, and night work. The specific purpose of this principle is to discourage the use of designs that unduly delay or inconvenience motorists or pedestrians. Specifically this principle says that reduced speed limits should be avoided except where absolutely necessary. The specific wording of the second principle is as follows:

2. Traffic movement should be inhibited as little as practicable.

    a. Traffic control in work and incident sites should be designed on the assumption that drivers will reduce their speeds only if they clearly perceive a need to do so. Reduced speed zoning should be avoided as much as practical.

b. Frequent and abrupt changes in geometrics (such as lane narrowing, dropped lanes, or main roadway transitions requiring rapid maneuvers) should be avoided.

c. Provisions should be made for the safe operation of work or incident management vehicles, particularly on high-speed, high-volume roadways.

d. Roadway occupancy and work completion time should be minimized to reduce exposure to potential hazards.

e. Pedestrians should be provided with access and safe passage through the temporary traffic control zone at all times.

f. Roadway occupancy should be scheduled during off-peak hours and, if necessary, night work should be considered.

The third fundamental principle says that drivers and pedestrians must be guided in a clear and positive way. Positive guidance emphasizes the proper path rather than areas that are to be avoided. Existing traffic control devices should be removed if not appropriate or in short-term work zones other devices should be used that clearly emphasize the intended path. This principle also says that flagging should only be employed when absolutely necessary. Flagging should not be overused due to the danger to flaggers. Text of the third principle is as follows:

3. Drivers and pedestrians should be guided in a clear and positive manner while approaching and traversing the temporary traffic control zone.

a. Adequate warning, delineation, and channelization by means of proper pavement marking, signs, or use of other devices that are effective under varying conditions of light and weather should be provided where appropriate to assure the driver and pedestrian of positive guidance before approaching and while passing through the work area.

b. Signs, pavement markings, channelizing devices, delineators, and other traffic control devices that are inconsistent with intended travel paths through long-term work spaces should be removed. In short-duration and mobile work spaces where retained permanent devices are inconsistent with intended travel paths, attention should be given to devices that highlight or emphasize the appropriate path.

c. Flagging procedures, when used, can provide positive guidance to drivers traversing the temporary traffic control area. Flagging should be employed only when all other methods of traffic control are inadequate to warn and direct drivers.

The fourth principle says that inspection of the traffic controls must be done on a frequent and regular basis. This principle is directed to individuals in the field who are responsible for implementing the TCP. It also implies that accidents and other incidents should be analyzed to determine if changes in the TCP are necessary. Feedback on how the TCP has performed in the field should be available to designers.

The fifth principle refers to measures to be taken to assure a safe roadside. The roadside is of particular concern in work zones because of materials and equipment that is often stored on the roadside, thereby increasing the number of hazards. In some work areas there may also be a greater number of motorists encroaching on the roadside due to lane shifts or backups. There is also a number of traffic control devices that can become hazards if struck. Sidewalks and pedestrian pathways must also be protected. The full text of the fifth principle is as follows:

5. The maintenance of roadside safety requires attention during the life of the temporary traffic control zone because of the potential increase in hazards.

   a. To accommodate run-off-the-road incidents, disabled vehicles, or emergency situations, it is desirable to provide an unencumbered roadside recovery area.

   b. Channelization of traffic should be accomplished by pavement markings, signs, and/or lightweight channelizing devices that will yield when hit by errant vehicles.

   c. Whenever practical, equipment, workers' private vehicles, materials, and debris should be stored in such a manner as not to be vulnerable to run-off-the-road vehicle impact.

   d. Pedestrian paths through the temporary traffic control zone should be protected to minimize pedestrian exposure to errant vehicles.

The sixth basic principle says that all persons involved with the selection, placement, or maintenance of work zones should be trained in safe traffic control practices. This includes designers as well as field personnel.

The seventh principle says that there must be legal authority to provide traffic regulations needed in work zones. It also says that these laws must have sufficient flexibility to be altered to fit changing conditions in a work zone.

The last principle deals with public relations. It says that it is necessary to maintain good public relations. Although public relations is not a primary concern of the TCP designer, special efforts can be required in the contract document, and many agencies have policies hat require a notice in the media prior tobeginning a project.

The principles also state that it is important to coordinate plan preparation with transit and other highway agencies, police and other emergency units, utilities, schools, railroads, and any other public agency that may be affected by the proposed work.

While each of these principles should be of interest to a TCP designer, it is especially important to observe the philosophy of the first, second, third, and fifth principles in the process of plan preparation. The items discussed in these four principles can provide a very good start on a checklist for TCP design.

Work Zone Type

The "work zone type" is the basic layout of a work site. There are eight basic work zone types (work sites which are completely off the roadway and do not disrupt traffic are not considered). A description of each of the eight types is given below. Many of the basic work zone types are illustrated in the typical applications (TA's) of Part VI. The specific TA's that describe each work zone type are also given below.

1. Lane Constriction - This work zone type is configured by reducing the width of one or more lanes to retain the number of lanes normally available to traffic. An example is shown in Figure 2-1. This scheme is the least disruptive of all work zone types, but it is applicable only if the work space is mostly outside the normal traffic lanes and may also depend on the availability of shoulders. When this scheme is applied for long-term work zones, the current lane markings must be obliterated to avoid motorist confusion. Lane constriction zones are illustrated in TA-6 and TA-15.

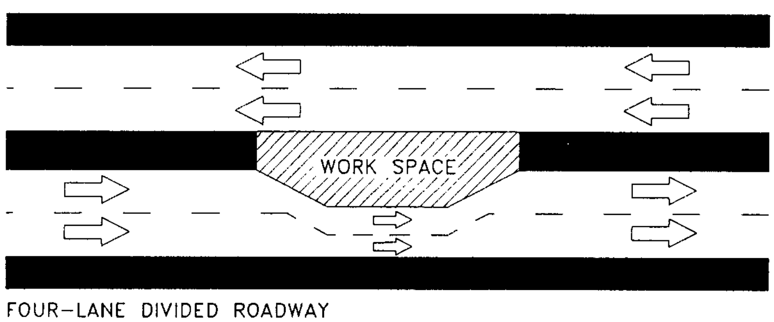


FIGURE 2–1. LANE CONSTRICTION WORK ZONE

2. Lane Closure - This work zone type is configured by closing of one or more normal traffic lanes. An example is shown in Figure 2-2. A capacity analysis may be necessary to determine whether serious congestion will result from lane closure. In some cases, use of the shoulder or median area as a temporary lane will help mitigate the problems arising from loss in capacicty. Shown in several TAs, including TA-21 and TA-33.

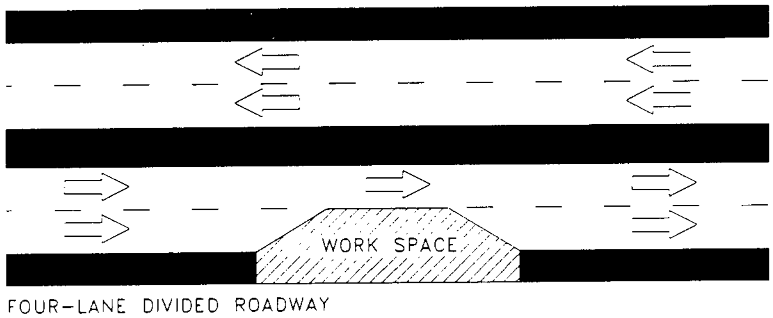


FIGURE 2-2. LANE CLOSURE WORK ZONE

3. **Shared Right of Way** - This work zone type involves utilizing one lane for both directions of traffic. Figure 2-3 illustrates the conditions. For this type of zone a right-of-way control method must be chosen. Flaggers or signals are normally used to coordinate the two directions of traffic. Signing alone may be sufficient for short work zones on very low volume two-lane roads. Examples include TA-10, TA-11, and TA-12.

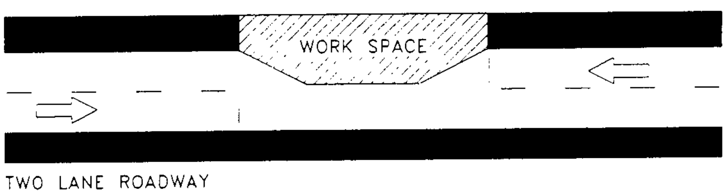


FIGURE 2-3. SHARED RIGHT-OF-WAY WORK ZONE

4. **Temporary Bypass** - This work zone involves total closure of the roadway (one or both directions) where work is being performed and rerouting the traffic to a temporary roadway constructed within the highway right-of-way. An example is shown in Figure 2-4. Obviously, this scheme generally requires extensive preparation of the temporary roadway to withstand the traffic loads and frequent maintenance to ensure a safe roadway. Illustrated in TA-7.

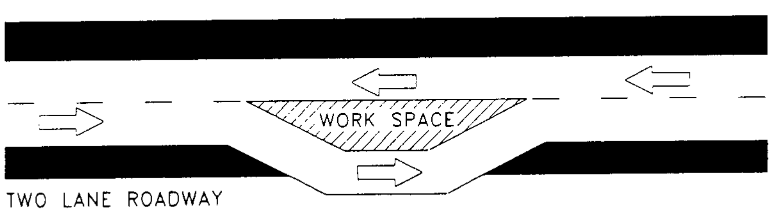


FIGURE 2-4. TEMPORARY BYPASS WORK ZONE

5. **Intermittent Closure** - This work zone type involves stopping all traffic in one or both directions for a relatively short period of time to allow the work to proceed. After a certain time, depending on traffic volume, the roadway is again open and all vehicles can travel through the area. This scheme is normally applicable only on very low volume roadways. Figure 2-5 shows this type of work zone. Illustrated in TA-13.

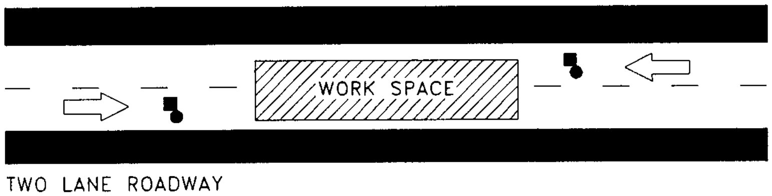


FIGURE 2-5. INTERMITTENT CLOSURE

6.Crossover - This work zone type involves routing a portion or all of one direction of the traffic stream across the median to the opposite traffic lanes. The scheme might also incorporate use of shoulder and/or lane constriction to maintain the same number of lanes. Examples of crossovers are shown in Figure 2-6. When this scheme is used, it is critical that the transition roadways be constructed to equal or better geometric standards than the permanent roadway. Because of the increased head-on accident potential, this scheme shall only be used after careful consideration of other available methods of traffic control. If this procedure is used, opposing traffic shall be separated either with portable barriers (concrete safety-shape or approved alternate), or with channelizing devices throughout the length of the two-way operation.

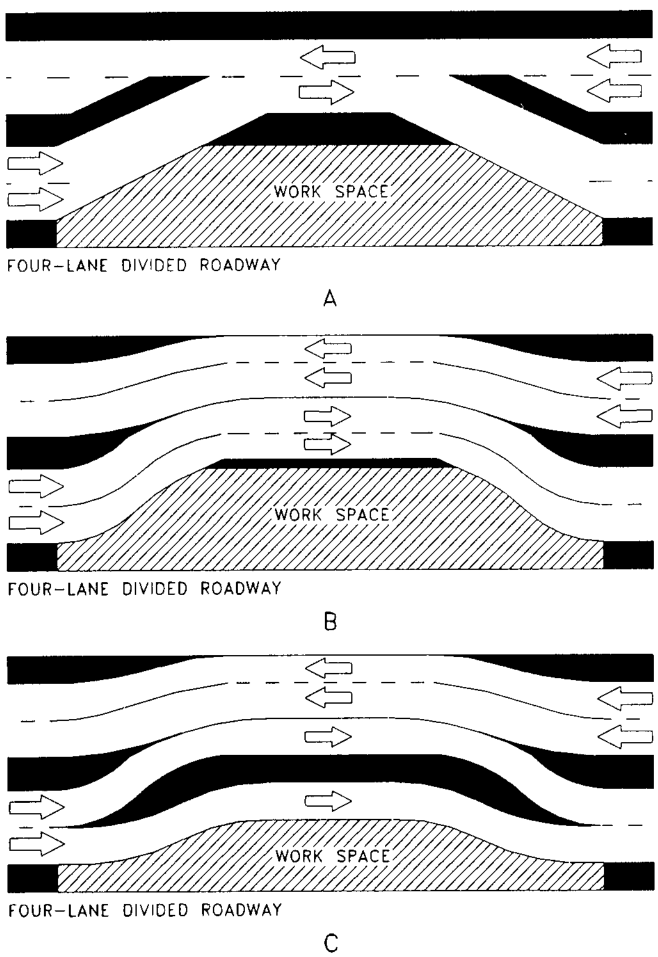


FIGURE 2-6. CROSSOVER WORK ZONES

Positive guidance in the form of pavement markings and high-type delineation is essential. In construction of the crossover roadways, superelevation and transition lengths must be in keeping with the adopted design speed. Shown in TA-32 and TA-39.

7. Use of Shoulder or Median - This work zone type involves using the shoulder or the median as a temporary traffic lane. Examples are shown in Figure 2-7. To use this technique, it is necessary to determine that the shoulder or the median surface will adequately support the anticipated traffic loads and that the traffic can be transitioned to the temporary lane safely. This technique may be used in combination with other work zone types or as a separate technique. In the latter case, it is functionally and in characteristics identical to the Temporary Bypass Type work zone. Examples include TA-36.

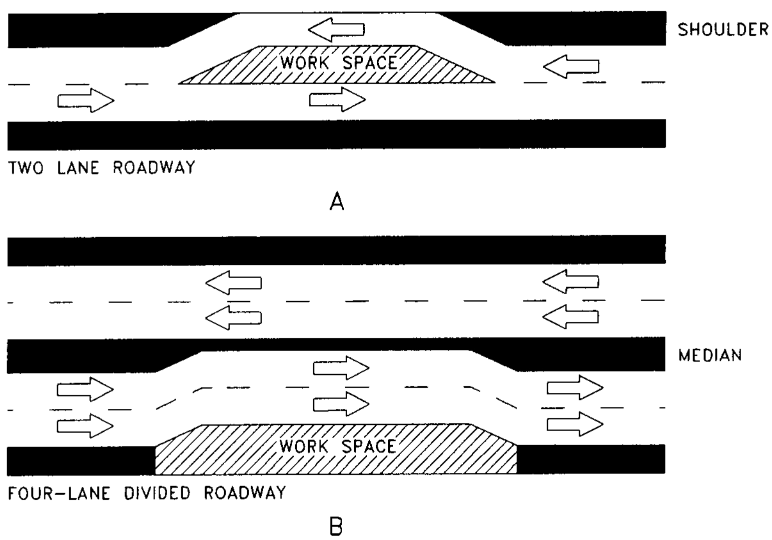


FIGURE 2-7. SHOULDER OR MEDIAN USE WORK ZONES

8. Detour - This work zone type involves total closure of the roadway (one or both directions) where work is being performed and rerouting the traffic to existing alternate facilities. An example of the detour scheme is shown in Figure 2-8. This scheme is particularity desirable when there is unused capacity on roads running parallel to the closed roadway. Examples are shown in TA-9 and TA-20.

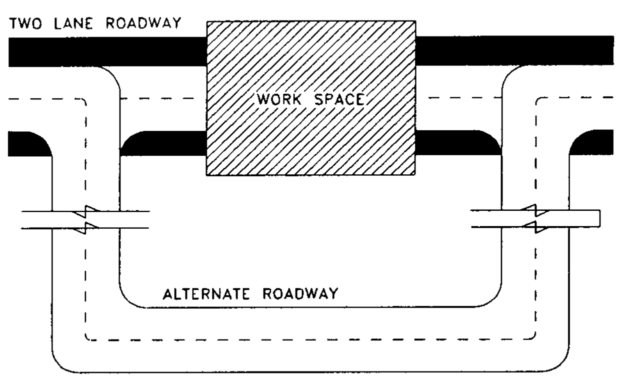


FIGURE 2-8. DETOUR WORK ZONES

Other Elements of Work Zone Traffic Control Strategies

Almost any maintenance, construction or reconstruction activity will require occupancy of some part of the traveled portion of the roadway, except for shoulder and other off-the-road maintenance activities. With any level of roadway space allocated to work activity, the capacity of the roadway will be impacted. In addition, safety considerations both for motorists and workers may require partial or even complete closure of the roadway.

The spatial requirement on the roadway during construction includes:

1. The space required for the work activity, and
2. The space required for safety provisions for workers and motorists.

The extent to which the roadway is occupied for work and safety purposes defines a number of constraints within which the traffic control strategy must be developed. Both spatial requirements of the occupied roadway and time durations of the occupation must be determined. A basic determination of the magnitude of the potential congestion and consequent safety in the work space can be made through a simple evaluation of the work zone traffic carrying capacity that reflects the proposed extent of any roadway occupancy. The analysis would thus focus on the ability of the reduced roadway space (available travel lanes) to accommodate the existing traffic volumes on the facility.

Figure 2-9 displays hourly traffic volumes throughout the day. It can be seen that in case "a", where the capacity through the work zone is 1000 vehicles per hour, there is no deficiency. In case "b" however, where the capacity is reduced to 500 vehicles per hour, peak hour traffic demand will exceed the capacity of the facility resulting in congestion during periods of the day as shown.

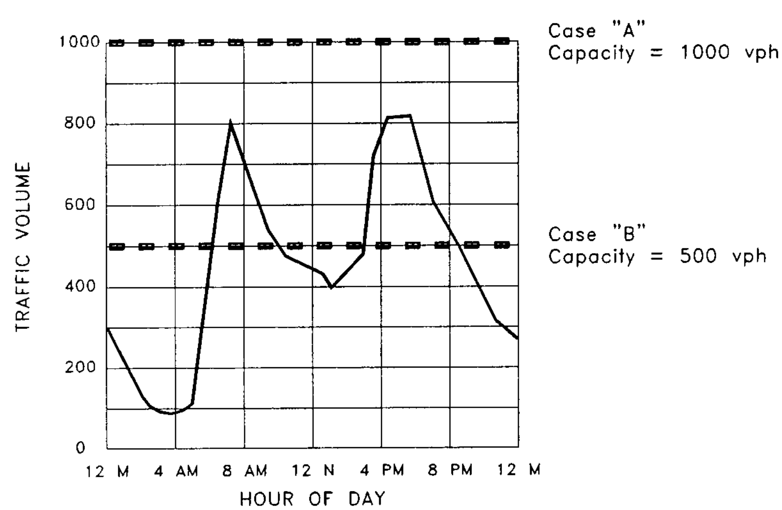


FIGURE 2-9. TYPICAL HOURLY FLOW PATTERN

III. Considerations in Selecting a Traffic Control Strategy

There are always a number of alternative ways to build a project. Generally, one of these alternatives will optimize the competing goals of minimizing construction costs while maximizing traffic safety and operational efficiency. When traffic volumes are low and the type of work has little impact on traffic, then the construction costs may have the primary impact on the decision to use a particular strategy. However, as the volume of traffic grows and the conflict of traffic and construction increases, this decision becomes more difficult and the impact on traffic may become the overriding factor in selecting a strategy.

The process of deciding which is the best strategy involves analysis of many factors. This course discusses a number of factors that may need to be considered. These factors are categorized as traffic management considerations, construction requirements, operational performance, constructibility, emergency planning, and coordination. The factors are presented in checklists to ensure that a strategy is not selected without consideration of an important factor. (See Table 3-1.) In many projects several of the factors mentioned may not apply, and can simply be noted as not applicable and removed from further consideration.

The designer who decides on the best strategy may not be familiar with each type of analysis mentioned in the list of factors. Some types of analysis, such as capacity analysis, require more instruction than what is available in this course. Other types of analysis may be outside one person's field of expertise. It is important that a designer contact a number of other people to determine factors that are needed in the decision process.

The construction department should be contacted early in the design process to discuss constructibility issues. Too many times the designer's theory does not consider the practical order of events in building a job. This is often most difficult for inexperienced designers to understand.

The materials engineer should be consulted on issues such as material strength, cure times, minimum application temperatures, etc. These factors can drive how the project is to be staged, and consequently this impacts the choice of a strategy.

If structures are involved, the type of structure may control how traffic can be handled. On the other hand, problems with traffic may determine the structure type and the staging of the project.

If the project is a gravel-borrow job versus an excavation embankment, traffic control may be entirely different. The traffic control requirements, project completion times, and politics may make the traffic control the key item on which the project revolves.

Table 3-1. Planning Considerations Checklist

TCP CONSIDERATIONS-TRAFFIC MANAGEMENT

1. Capacity analyses- lanes required, length of queues anticipated
2. Time restrictions- peak hours - seasonal peaks
3. Limits to work areas
4. Capacity of detour routes
5. Work vehicle access and worker parking
6. Bicycle and pedestrian traffic
7. Warning sign locations - detours, long queues, intersecting roads
8. Railroad crossings and train schedule
9. Nighttime delineation and illumination
10. Signals, turning lanes, bus stops

TCP CONSIDERATIONS-CONSTRUCTION REQUIREMENTS

1. Phasing of work - length of work zone- project limits
2. Special conditions such as drop-offs, sign bridge installation, etc.
3. Curing time - or any other factor that affects how long the work will take
4. Special contract provisions needed
5. Incentives or disincentives
6. Short duration closures anticipated
7. Temporary drainage
8. Lights for night work
9. Temporary roadway lighting

TCP CONSIDERATIONS-OPERATIONAL PERFORMANCE

1. Speed Management
2. Enforcement (where to stop violators)
3. Start-up procedures and phase changes
4. Barrier installation
5. Geometries of temporary roadways

TCP CONSIDERATIONS-CONSTRUCTIBILITY

1. Structural capacity of bridges, shoulders, and pavement
2. Timing of phases versus probable starting date
3. Will strategy allow contractor to finish project
4. Status of existing traffic control devices - signals, signs, railroad crossings, etc.
5. Wintertime restrictions - snow removal, etc.

Table 3-1. Planning Considerations Checklist (concluded)

TCP CONSIDERATIONS-EMERGENCY PLANNING

1. Incident management plans
2. Emergency medical assistance (EMS)
3. Accidents, breakdowns, tow trucks
4. Snow removal
5. Emergency closures
6. Utility interruptions
7. State police
8. Local law enforcement

TCP CONSIDERATIONS-COORDINATION

1. Local officials - police, fire, hospitals, schools, environmental agencies, utilities, toll facilities, ferries, railroads, airports
2. Public awareness - media, motorist service agencies, local businesses, motor carriers
3. Special events
4. Intra-agency coordination - maintenance crews, permits section, adjacent projects
5. Transit

Many designers feel that two or more initial planning and traffic control review meetings are needed to weigh the options involved in determining how the job is built.

A designer must guard against selecting a strategy without thinking about each area. A great deal of effort can be wasted if later in the design process a different strategy has to be developed.

Table 3-1 is a planning considerations checklist for selecting a traffic control strategy. The following discussion explains the factors to be considered and contains a number of questions that should be answered prior to selecting a traffic control strategy.

TRAFFIC MANAGEMENT

Capacity Analysis - Accommodation of the expected traffic through the work zone without undue delays is a basic requirement of a feasible alternative. If there is insufficient capacity to accommodate the traffic demand over prolonged periods (e.g., a.m. or p.m. peak periods) of several hours then the alternative may be removed from the list. If detours are considered, then the detour routes must handle both the existing and detoured traffic volumes. Where insufficient capacity may exist, alternative strategies are desired.

Determination of the roadway capacity of the alternative work zone strategies can be conducted using analytical or simulation techniques. The level of effort used to determine the work zone impacts depends on the duration and type of traffic control. Analytical methods and techniques are provided in the *Highway Capacity Manual* (1989) and with various simulation programs. Measured capacities of freeway work zones of various configurations are shown in Table 3-2.

A recent report by Krammes and Lopez, "Updated Values for Capacity of Short-term Freeway Work Zone Lane Closures," presented at 73rd Annual Meeting, Transportation Research Board on January 1994, has stated that work zone capacity can be estimated with the following equation, which combines the base capacity value and recommended adjustments used to estimate work zone capacity:

$$c = (1600\ pcphpl + I - R) \times H \times N$$

where,

c = estimated work zone capacity (vph)

I = adjustment for the type and intensity of work activity (pcphpl)

R = adjustment for the presence of ramps (pcphpl)

H = Heavy vehicle adjustment factor (vehicles/passenger car)

TABLE 3-2. Measured Average Work Zone Capacities for Freeways

NUMBER OF LANES		NUMBER OF STUDIES	AVERAGE CAPACITY	
A NORMAL	B OPEN		(VPH)	(VPHPL)
3	1	7	1,170	1,170
2	1	8	1,340	1,340
5	2	8	2,740	1,370
4	2	4	2,960	1,480
3	2	9	2,980	1,490
4	3	4	4,560	1,520

Source: Transportation Research Board, "Highway Capacity Manual, Special Report 209," 1985.

N = number of lanes open through work zone

In review, the recommended values for the base capacity and the various adjustments are as follows:

I = range {-160 to +160 pcphpl} depending on the type, intensity, and location of work activity

R = minimum of {average entrance ramp volume in pcphpl during the lane closure period for ramps located within the channelizing taper or within 500 ft downstream of the beginning of the full lane closure, or one half of the capacity of one lane open through the work zone (i.e., 1600 pcphpl/2N)}

I = given in the Highway Capacity Manual for various percentages of heavy vehicles and passenger car equivalents

A normalized capacity of 1600 vph is recommended.

Based on the expected traffic volumes, estimates of the delay and queuing to traffic can be calculated. Depending on the estimated length and durations of the determined queues, the strategy may have to be eliminated from the list unless additional measures can increase capacity or reduce traffic demand.

There are four basic aspects to be considered in evaluating alternative capacity improvement techniques:

- Impact of likely trip suppression.
- Impact of potential trip diversions.
- Impact of alternative construction scheduling.
- Need for improvements on alternate routes within the corridor.

Computer simulation programs are valuable tools for determining the impacts of each strategy for the long-term projects. Some of the programs to consider are:

For Arterials - TRANSYT 7F family
- NETSIM family

For Freeways - FREQ family
- FRESIM, FREFLO family
- QUEWZ

"QUEWZ" stands for Queue and User Cost Evaluation of Work Zones. It is a software tool for evaluating freeway work zone lane closures. QUEWZ-92 is the most recent version of the program. The program was developed at the Texas Transportation Institute for the Texas Department of Transportation and the Federal Highway Administration.

Two types of output are available from QUEWZ: road user costs and lane closure schedule. An example of the road user cost output is shown in Table 3-3.

The following four points should be determined from the queuing and delay analysis:

- The rapid rise in the total delay to motorists.
- The length of the queue and potential impact on other facilities.
- The length of time required to dissipate the traffic queue.
- The identification of the time periods when congestion occurs.

Limits to Work Areas - What are the natural points to start and end the project? How much space is needed beyond the limits of the work to accommodate traffic control? Are there major intersections or other features that should be included or omitted from the project?

Time Restrictions, Peak Hours, Seasonal Peaks - Is it essential for traffic management to specify that one or more lanes remain open in a certain direction at specific times, or that travel lanes be reopened at certain times? Is the traffic condition such that night work is an appropriate strategy, or that certain operations be allowed only on weekends? Do you need to establish contractual requirements to insure that a minimum number of lanes are open during a peak seasonal period?

Capacity of Detour Routes - If detouring traffic is anticipated, will the alternate route be able to handle detoured traffic? Consider the traffic volume that will be detoured as well as vehicle type. Will the detour route be able to accommodate heavy trucks?

Work Vehicle Access - How will work vehicles be able to enter and exit the work area? Are special measures, such as accel or decel lanes needed? How will public vehicles be discouraged from following work vehicles into the work area? Can materials be delivered during off-peak hours?

Worker Parking - Where are workers going to park their vehicles? Will special provisions need to specify where vehicles can be parked?

Table 3-3. Example QUEWZ Output

SUMMARY OF ADDITIONAL ROAD USER COSTS QUEWZ-92

	ADDITIONAL ROAD USER COSTS ($)		
HOUR	INBOUND	OUTBOUND	TOTAL
0- 1			
1- 2			
2- 3			
3- 4			
4- 5			
5- 6			
6- 7			
7- 8			
8- 9			
9-10	5325.	7852.	13177.
10-11	10688.	14268.	24956.
11-12	15036.	14029.	29065.
12-13	15198.	15158.	30356.
13-14	15364.	16675.	32039.
14-15	15348.	16105.	31453.
15-16	16744.	16919.	33663.
16-17	8395.	3530.	11925.
17-18	517.	0.	517.
18-19			
19-20			
20-21			
21-22			
22-23			
23-24			
	102615.	104536.	207151.

Bicycle and Pedestrian Traffic - What facilities will be available for bicycle and pedestrian traffic during the work? Are covered walkways needed? Will bicycles be able to use the same path as other wheeled traffic? How can conflicts between vehicles, bicycles and pedestrians be avoided or minimized?

Warning Signs - Is there length on the approaches to the work area to place warning signs? Can the signs be placed so that they are only visible to traffic that will be in the work zone? Are there areas on the roadside to mount warning signs? How will the temporary signs affect existing permanent signs? Will duplicate signing be needed at intersections?

Railroad Crossings and Train Schedule - Are there railroad grade crossings that will be affected by the work zone? What is the schedule of trains using these crossings?

Nighttime Delineation and Illumination - What traffic control devices are needed to delineate the path of traffic at night? Is night work or night flagging anticipated? Are there existing street lights? Will floodlights be needed?

Signals, Turning Lanes, Bus Stops - How will signal operations be affected by the work zone? Will turning lanes need to be closed? Will bus stops need to be relocated?

CONSTRUCTION REQUIREMENTS

Phased Work - Will the project require phases of work, such as taking out one-half to one-third of a bridge deck at a time or reconstructing one side of a divided highway while maintaining traffic on the other side?

Work Area Length - Is there a need to specify a maximum length of work area or length of lane closure? (i.e. "During the reconstruction of the traveled way , the length of lane closure shall not exceed 2000 ft".)

Number of Work Areas - For work that requires several "spot" work areas, it is generally desirable to have one long work area rather than several short work areas. In the longer zone work can progress in the direction of traffic as curing time permits. If one long work area is not possible, it is desirable to limit the number of work areas in one direction to five.

Duration of Work - How long is the work expected to last? What factors such as curing time will affect the duration of the overall project or of any one phase of the work?

Special Conditions - Are there construction situations anticipated that should be addressed in a contingency strategy? For example, the following special provision might be used to specify how girders are to be set. " No girders shall be lifted, moved, set or left unsecured over traffic. Girders will be considered secure when

50% of the pins are in place on both sides of the girder. When setting girders over the traveled way, the contractor shall not stop traffic for more than 15 minutes at one time or stop traffic more than one time each hour. If delays of more than 15 minutes are anticipated or necessary, the contractor shall develop and submit a detour plan for rerouting traffic during closure"

Incentives or Disincentives - Incentive/disincentive (I/D) provisions are defined as a contract provision which compensates the contractor for each day that identified critical work is completed ahead of schedule and assesses a deduction for each day that completion of critical work is delayed. The use of I/D provisions is primarily intended for critical projects where it is essential that traffic inconvenience and delays be held to a minimum.

It is essential that a project's suitability for I/D provisions be identified during the early stages of project development. This allows for full deployment of resources needed to properly design and coordinate the project. It must be emphasized that I/D provisions should not be used routinely. Generally, the use of I/D provisions should be limited to those projects that would severely disrupt traffic.

The development of specific criteria for selection of I/D projects will aid in early identification of such projects. The following characteristics are associated with projects appropriate for I/D provisions:

- High traffic volume facilities generally found in urban areas.

- Projects that will complete a gap in a significant highway system.

- Major reconstruction or rehabilitation on an existing facility that will severely disrupt traffic.

- Major bridges out of service.

- Projects with lengthy detours.

The Federal Highway Administration has an initiative to encourage states to use and evaluate promising innovative contracting practices under Special Experimental Project No. 14 (SEP14). Since initiation of SEP14 in 1990, four innovative contracting techniques have been proposed, used, and evaluated by a number of state highway agencies. The four techniques are:

- Cost-plus-time bidding.

- Lane rental.

- Design/build contracting.

- Warranty clauses.

Appendix A, Innovative Contracting Procedures, discusses these techniques, gives example special provisions for them, and gives a progress report on SEP14.

Short Duration Closures Anticipated - Are closures needed for installation of traffic barriers, or for setting beams, etc.? Should the manner in which closures are made be specified in the contract? Are enforcement personnel needed to assist in traffic control?

Temporary Drainage - Are drainage structures being altered, blocked, or added during the work? What provisions are needed for drainage during the work? Is normal drainage going to be affected by traffic control items such as concrete barrier? What erosion control is necessary?

Work Area Lighting - Will lights need to be added for night work? How will glare to drivers be eliminated? Should a lighting plan be prepared by the contractor that shows the position of all lights? (See Appendix B)

Temporary Illumination System - Is permanent highway lighting to remain? Should temporary lighting be provided?

OPERATIONAL PERFORMANCE

Speed Management - Can current legal and driving speeds be maintained safely during construction or are speed limit changes required? Is special approval needed to change speed limits or to put up regulatory signs? Based on speed studies in work zones where the speed limit was reduced from 0 to 30 mph (48 kph), work zones with a 10-mph (16-kph) work zone speed limit reduction had the smallest increase in speed variance from the upstream to work zone locations. See Figures 3-1 and 3-2 from a recent NCHRP research study.

Traffic Enforcement - Will the current levels of police involvement be sufficient or will additional police efforts be required? Will the planned construction interfere with the physical aspects of police enforcement such as eliminating safe pull off areas for traffic violators? A uniform, consistent method of speed limit reduction in combination with police enforcement has been shown to reduce speeds of all vehicles in the traffic stream, improve compliance with work zone speed limits, and also to reduce speed variance and accidents. See enforcement effects on mean speeds and variances in Figures 3-3 and 3-4.

Startup or Phase Change Operations - Do any of the construction operations or phases of work require special enforcement efforts? Will the contractor need to shut down traffic, as when beams are moved or set over the travel lanes?

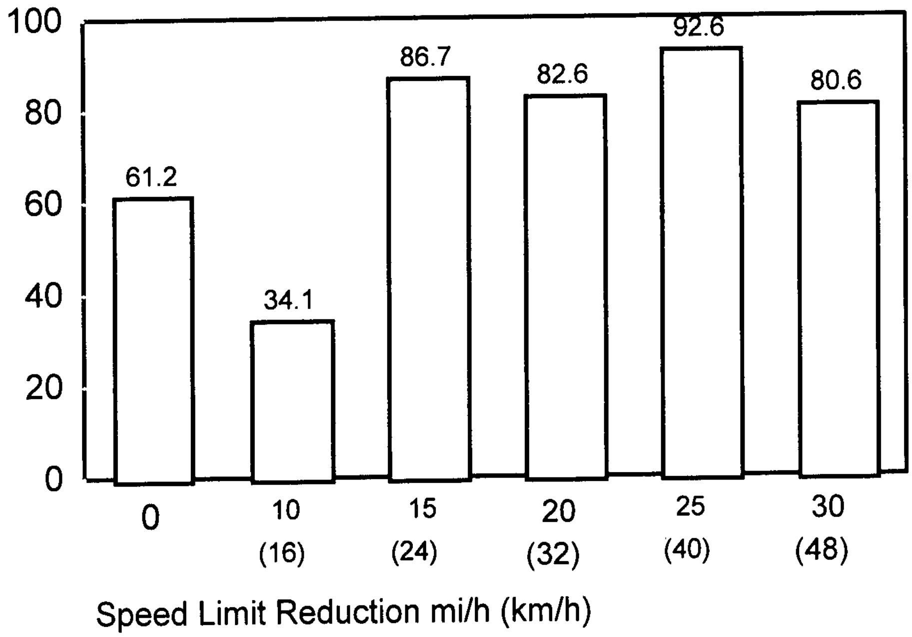
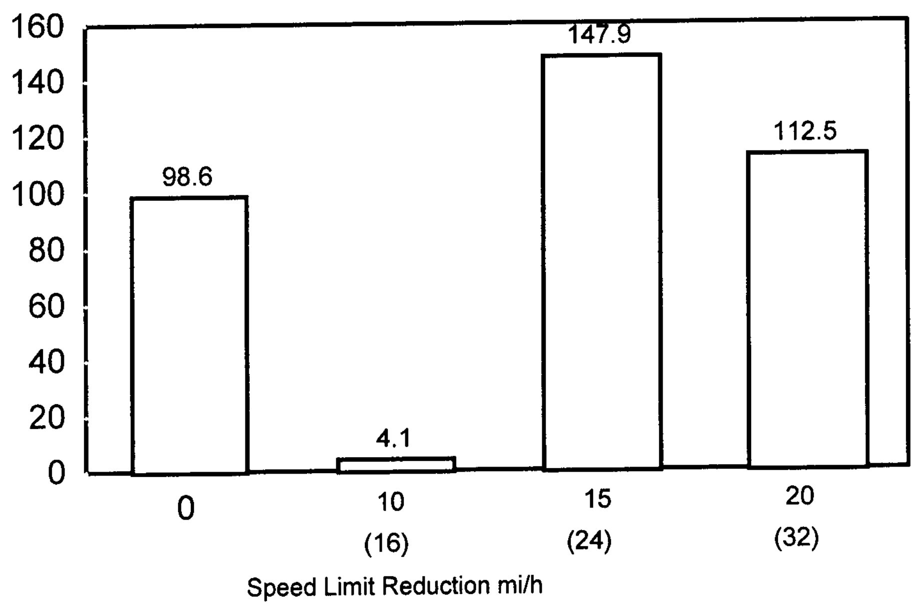


Figure 3-1. Percentage increase in speed variance from upstream to work zone locations.



Traveled way and detour sites on rural freeways.

Figure 3-2. Percentage increase in fatal plus injury accident rate from before to during construction periods.

Source: Effectiveness and Implementability of Procedures for Setting Work Zone Speed Limits, NCHRP Project 3-41(2), 1997.

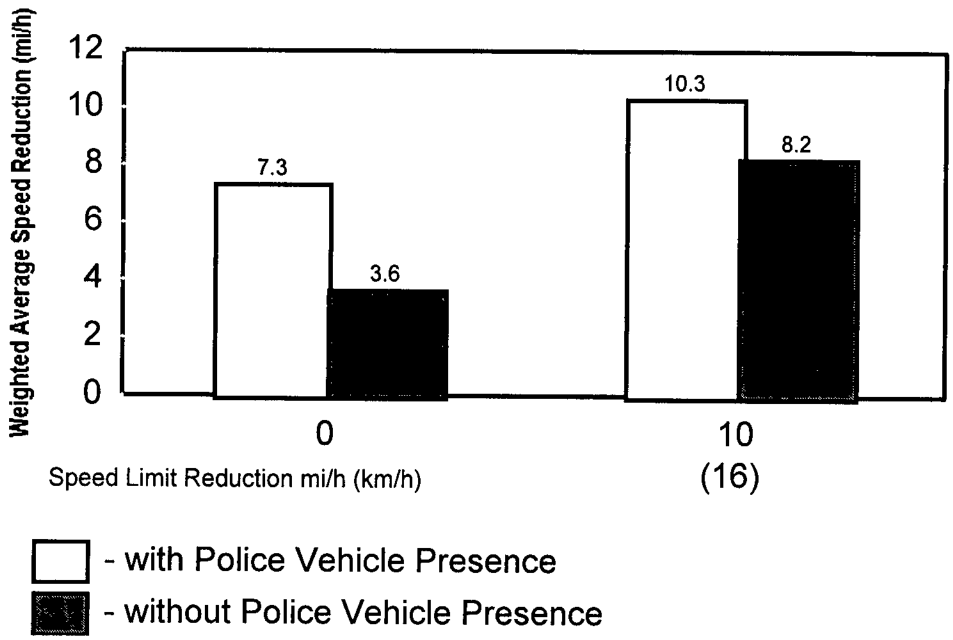


Figure 3-3. Comparison of Reduction in Mean Speeds Between Upstream and Work Locations with and without Police Vehicle Presence.

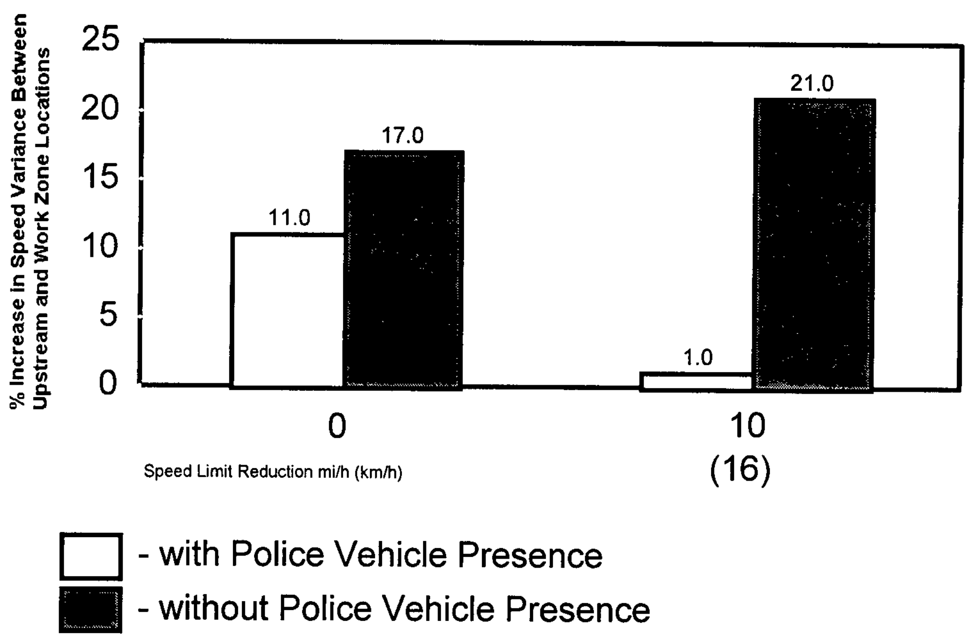


Figure 3-4. Comparison of Speed Variance Increase Between Upstream and Work Zone Locations with and without Police Vehicle Presence.

Source: Effectiveness and Implementability of Procedures for Setting Work Zone Speed Limits, NCHRP Project 3-41(2), 1997.

Barrier Installation - On major projects involving the use of temporary or movable concrete barriers, it is often desirable to develop provisions for delivery, removal, storage, assembly, and movement during phase changes to insure that these activities minimize traffic congestion and maximize safety.

Geometrics of Temporary Roadways - Is right-of-way available for roadways with acceptable design speed?

CONSTRUCTIBILITY

Structural Capacity of Bridges, Shoulders, and Pavement - If traffic is being detoured or shifted to the shoulder, is the detour route or shoulder structurally adequate to carry traffic during the work period? Are bridges and pavement on detour routes wide enough and strong enough to carry trucks, busses or other detoured vehicles?

Phasing of Work Versus Probable Starting Date - Can the project be completed in one construction season? If a Winter shutdown is necessary, which phases should be done prior to the Winter shutdown?

Construction Feasibility - Will the chosen strategy allow the contractor to finish the work? Does the required traffic control severely hamper the progress of the work, such as overly restrictive hours when lanes must be open?

Existing Traffic Control Devices - Which existing traffic control devices can remain during the work? Do any of these devices need to be replaced because of poor condition?

Wintertime Restrictions - Will snow removal be possible without altering the work zone?

EMERGENCY PLANNING

Incident Management Plans - Is there an incident management plan that covers the roadway to be closed? How will the traffic control strategy affect this plan? Should the special provisions contain incident response contingency plans?

Driver Emergencies - Consider the impact of an accident on the project. Can the accident be investigated and cleared quickly? Can drivers of vehicles with mechanical problems pull out of travel lanes safely and without blocking traffic? Can tow trucks move into project areas quickly to remove disabled vehicles?

Emergency Response - Would emergency response personnel and equipment be delayed or restricted by construction activities or materials, such as barriers around a ramp restricting the turning radius and prohibiting access of a hook and ladder truck? Would construction activities restrict emergency services to people and property only accessible through the project?

Snow Removal - Can snow be plowed without destroying or disrupting the work zone traffic control?

Emergency Closures - How would the work zone traffic control be affected if an emergency closure of one of the roadways in the area were necessary?

Utility Interruptions - Will it be necessary to shut off any utility during the work operation? How would traffic control be affected if there was a sudden loss of electrical power?

Law Enforcement - How will local and state police be informed about the project? How will the project affect their planning for emergencies?

COORDINATION

Local Officials - Are city/county officials aware of the planned project? How will they be notified? Are the following services aware of possible coordination problems: police, fire, hospitals, and schools?

Public Awareness - How will the public be made aware of the project? What media can be utilized? Is it desirable to divert some traffic to other routes or to alternate transportation routes?

Special Event Coordination - What events, such as major sports events, Pope's visit, etc., are scheduled during the duration of the project? How may the project affect the planning for this event?

Intra-agency Coordination - What other departments, such as maintenance, should be made aware of the project? Are there other construction projects that will impact this project? Are there any established communication channels between these projects?

Transit Coordination - Have transit companies been alerted to the project? Will the project affect transit facilities, such as bus stops or Park-n-Ride lots?

IV. Essential Information

The factors to be considered in determining a traffic control strategy cannot be determined until some initial information has been gathered. This chapter lists essential information that may be used to determine the factors discussed in Chapter III above. As in Chapter III, the lists in this chapter are meant to serve as checklists. If the data item mentioned does not apply to a specific project, then this information will not need to be collected.

The lists that are presented include essential highway information, essential project information, essential societal information and other essential information.

ESSENTIAL HIGHWAY INFORMATION

1. Roadway/Roadside

    a. Existing road conditions (as builts, aerial photos, survey)

    b. Operational Features (signs, markings, signals, etc.)

    c. Access Points/Business/Land use

    d. Pavement, Shoulder, and Bridge structural condition/limitations

    e. Horizontal and vertical restrictions

    f. Utility location (buried/above ground)

2. Traffic Data

    a. Speed data (design, legal, running)

    b. 24-hour volume counts (hourly or peak hour counts may also be needed)

    c. Alternate routes (site plan, local map)

    d. Daily and seasonal volume variations

    e. Intersection and interchange turning volume counts

    f. Signal timing data

    g. Truck traffic/bus traffic and stops

    h. Accident data

i. Pedestrian and bicycle path (along and across highway such as school or recreational areas)

k. Railroad crossings and train schedule

LIST OF ESSENTIAL PROJECT INFORMATION

1. Description of Type of work (Overlay, shoulder grading, landscaping, rehabilitation of subbase, joint repair, realignment, etc.)

2. Roadway encroachment required (include buffers, storage loading, and unloading areas)

3. Project and work limits

4. Tentative schedule (Time to complete, probable start date, seasonal work through winter or dormant in winter)

5. Project budget and Preliminary budget for traffic control

6. Time periods and days of the week that road will be occupied

7. Location of utilities and how they will be impacted by the Project

8. Work vehicle entrances and exits required

LIST OF ESSENTIAL SOCIETAL (COMMUNITY) INFORMATION

1. Jurisdictions involved

2. Business access and parking areas on street

3. School bus routes and stops and school and recreational crossings

4. Fire districts and location of fire stations

5. Hospitals

6. Transit routes and stations, bus stops, etc.

7. Restrictions on noise or construction lights

8. Policies on worker or motorist safety

9. Incident management plans

LIST OF OTHER ESSENTIAL INFORMATION

1. Possibility of inclement weather (snow, rain, fog, dust)

2. Normal start and end of construction season

3. Need for winter shutdown or dormant workzone

4. Holidays or recreational activities (stadiums, racetracks, etc.)

5. Environmental impacts or constraints

6. Public concerns

7. Property owners

8. Wetlands

9. Archaeological studies

V. Traffic Control Strategies for Construction Activities

When work is to be done on a highway, a basic scheme needs to be developed to handle traffic. This scheme or strategy must be coordinated with the phases of the work. A designer should analyze the essential information by asking, "How can this project be built?" and "How can traffic be handled while the work is underway?"

This chapter will illustrate how to develop a traffic control strategy for the most common types of road and construction activities. A range of possible strategies for each work/highway type will be discussed along with the advantages and disadvantages of using a particular strategy.

One of the most common activities and highway types (lane and shoulder work on two-lane highways) will be discussed first. Strategies of bridge work, multilane highways, controlled intersections, and urban streets will also be discussed. For any type of construction, closing the roadway is normally the first alternative to be considered and usually is the most desirable from the contractors' perspective. Closing the roadway usually lowers construction costs, decreases contract time, and increases worker safety.

Roadway closures can be considered if there are alternate routes available. The alternate route must carry the additional traffic volumes and any weight or height restrictions must be considered. It is also necessary to determine what residences or businesses may be isolated if a road is closed. Will the road closure result in disruption of necessary services such as police, fire, or medical assistance?

For the traveling public, closing the road for a short time may be less inconvenient than having the road under construction for a long time. However, the maximum number of days of closure may need to be written into the special provisions. Incentives for early completion may also be included in the special provisions.

In following sections, warrants are discussed for use of various strategies. **Warrants** are factors or criteria that permit, but do not require, use of a particular traffic control measure.

Strategies for Work on Two-Lane Highways

A number of 4R activities are required on two-lane highways. Probably the most common of these is repaving. Other activities include joint repair, slab replacement, shoulder reconstruction, culvert replacement, and guardrail repair.

A typical priority list of possible strategies for this work/highway type is as follows:

1. Close the road and detour traffic.
2. Close one lane for the entire length where work is required.
3. Advancing limited closure in one lane (expanding or contracting).
4. Leap-frogging limited closure in one lane.
5. Phased full width work.
6. Multiple work areas.

Considerations and warrants for each of these strategies are discussed below.

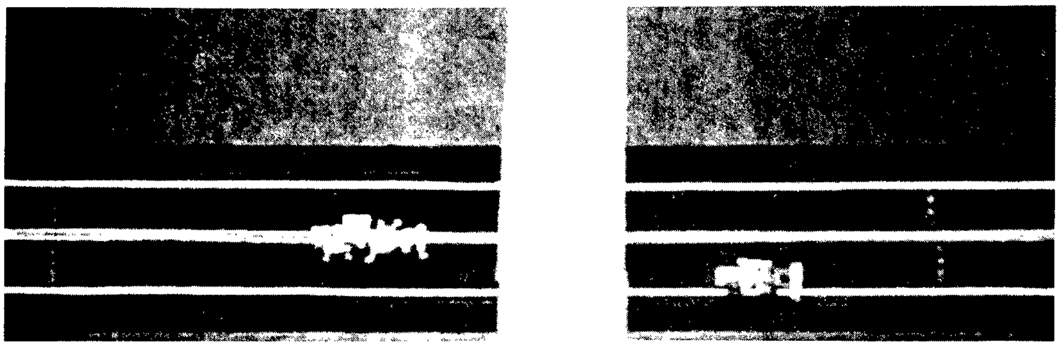


Figure 5-1. Close Road and Detour Traffic

Close road and detour traffic (See Figure 5-1) - The feasibility of closing the road and detouring traffic can usually be assessed by inspection of a site plan, the average daily traffic (ADT) of the road, and the length of road that needs to be worked. How many driveways are covered by the work area? Are these businesses or residences? Are there intersections that would require other closings?

The volume of traffic on the roadway will need to be accommodated on an alternate route or it will become local traffic. A long work zone may cover so many driveways that the local traffic is difficult to accommodate while work is underway.

In the distant past many limited projects, such as overlaying of a rural highway section, could be accomplished by simply closing a section of the highway between two intersections. Drivers were required to find their own route around the work zone or to drive through the work if they needed access to a property in the closed section.

Using this strategy for controlling traffic maximized the advantages to the contractor while putting many motorists at a serious disadvantage. While closing the road was a popular method of traffic control in the mid century, concerns for the public and increased development along most highways has limited the use of this strategy to special situations. There are cases however, where closing a highway, particularly in an area of limited development, can still provide a very safe work zone. Additionally, there are some applications of this strategy that can work well on a limited basis for major highway projects.

This strategy can also include the construction of a detour road which carries traffic temporarily around rather than through the work space. A similar but more common situation is often used for bridge work by using a temporary bypass. (Discussed later in this chapter.)

The basic advantages of closing a highway section to traffic are:

- Generally facilitates construction and traffic control management.
- Little or no interaction in and around the work area between construction personnel and traffic.
- Limited exposure of workers and/or equipment to traffic.
- Limited exposure of motorists to the potential hazards of the work zone, such as drop-offs.
- Reduced number and types of traffic control required.

The basic disadvantages with closing a highway section to traffic are:

- Generally places an additional time/distance burden on the motorists and community along the detour route.
- Detour route must be capable of handling truck traffic.
- Can significantly affect businesses with access from the closed section.
- Detours to local routes may be liability concern.
- Can be confusing and frustrating to the motorist, particularity when they are not familiar with the surrounding highway systems.
- Requires access for construction and local traffic to closed section, including emergency services such as ambulances and fire trucks.
- Requires identification and signing of the detour route.

Information that should be developed before considering closing a highway section to through traffic includes:

- Traffic volume.
- Type and density of land use along section. (How many people need to use this section to get to home, work, or an essential service such as school), businesses that are accessed from this section of highway.
- Intersections and volumes entering access points along the closed section.
- Characteristics of alternative routes available for detours, such as logical detour beginning and ending points, existing traffic volumes, road characteristics, and the increased time/distance that motorists experience.
- Any special considerations, such as truck limitations at posted bridges or overpass restrictions, priority truck routes, RR grade crossings, etc.
- Other highway projects active or proposed on the section to be closed or on detour routes.
- Survey of compatibility of route for attenuation devices, roadside design, etc.

Warrants for closing a two-lane highway section for construction include:

- ADT below 400 to 600 vehicles per day.
- No intersecting highways or limited intersecting highways that can easily be included into the detour plan.
- Limited local traffic, less than 30 families, and no major traffic generators within the closed section.
- No essential services located on the closed section, such as fire fighting facilities, hospitals, highway maintenance yards, etc.
- Ensure that detours provided do not cause travel delays in excess of 15-30 minutes.
- Will not have a significant adverse economic impact on any business.

Steps in developing this strategy and contract specifications for closing a two-lane highway are:

- Highway closures should be coordinated with jurisdictional enforcement officials and fire fighting services personnel. Additionally, when appropriate, coordinate with local hospitals, etc.
- Specific traffic control layouts for closing the highway and establishing detours, including type, size, and location of each sign should be included in the contract.
- The contract should limit the time the contractor can close the highway and, when appropriate, establish the closing and opening dates. The contract should have a penalty clause associated with the contractor's failure to open a safe highway section within the time frame or on the date specified (usually a daily rate appropriate to the societal loss of service resulting from the closure).

Examples of special provisions that would be included in the contract documents for this strategy are shown in Appendix B.

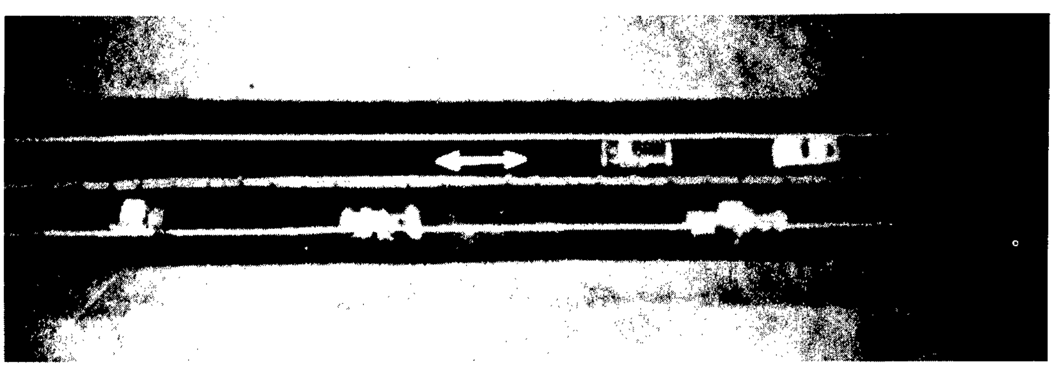


Figure 5-2. Closing One Side of a Two-Lane Highway

Closing One Side of a Two-Lane Highway (See Figure 5-2) - One of the most common approaches to daytime work on two-lane highways is to close one side of the highway and carry traffic on the other side. During nonworking hours the highway is returned to two-way operations. The length of the work area (or more appropriately the section closed to traffic, as the work usually starts at one end and progresses through the closed sections of roadway) is usually determined by what the contractor and the jurisdictional agency consider to be reasonable delay time.

Closing one side of the highway requires alternating traffic flow and a shared right-of-way on the open side. There are three basic ways to control the right-of-way in this type of work zone.

1. Flagger operations - Short-term, short-length work zones - can operate where only a short section of highway (1,000 ft or more, depending on terrain) is closed. These work zones can be closed with flagpersons, desirably in sight of each other, who can alternate the flow of traffic. When the work in one area is complete, the work zone and flaggers can be redeployed further along the highway.

2. Pilot Car Operations - Short-term, long-length work zones where the work requires a curing time, such as asphalt overlays, before the highway can be reopened to traffic. In these cases, longer work zones are to continue operations while curing is taking place at the front of the work zone. These work zones require the use of a pilot car to proceed traffic and reduce the potential danger of an approaching vehicle.

3. Traffic Signal Operations - Long-term, short-length as commonly found with bridge or culvert replacement. Usually the work involves removal of a section of roadway over a short length. The work area remains closed to traffic at night and on weekends. In this situation, temporary traffic signals are used to control the flow of traffic over the one-lane section of highway. Temporary signal installations must be over relatively short sections of highway, preferably where drivers can see the opposing stop area. Generally there should be no intermediate access points. On roads with low ADTs, these work zones may be controlled with stop or yield signs or be self-regulating.

Flagger Operations - Flagger operations have the following advantages:

- The flagger work zone can be set up quickly and moved quickly. This mobility allows the closed section of the roadway to remain short, which minimizes delay.
- Flaggers working as a team can provide more positive, visible control of traffic at a point prior to the one-lane, two-way operation.
- Flaggers are able to react to emergencies and unusual happenings more readily than for temporary signals.

Some disadvantages of flagger operations are:

- There is no control of the speed of vehicles traveling through the work area.
- Flagging is a dangerous job. The flagger is in a very vulnerable position.
- Flagging is especially difficult and dangerous at night. Drivers are normally more accustomed to obeying traffic signals.
- The length of roadway that can be closed is limited by the delay that can be tolerated and the means of communication between flaggers.
- Intersections in the closed section must be controlled to prevent head-on conflicts.
- Motorists may enter the work zone from private driveways.

Warrants for the use of flaggers include:

- Traffic volumes during the work period must be low enough that delays to traffic never exceed 15 -30 minutes. The maximum number of vehicles that can be accommodated using this strategy is about 800 vehicles per hour.
- The closed section of roadway should have no more than 3 or 4 access points. A supplementary flagger must be stationed at each of the access points.
- Normally other strategies should be considered for night operations. If night flagging is necessary, the flagger station must be lighted.

Pilot Car Operations - The basic advantages of using a pilot car are:

- The strategy maximizes the work area available to the contractor when traffic must be maintained through the work area.
- The use of a pilot car provides for the establishment of a relatively long work area and reduces the number of times and the time spent in reestablishing the work zone when there is moving construction activity, such as overlaying a highway.
- The contractor controls the movement of traffic and can adjust traffic flow during the arrival or departure of equipment or materials.
- There is better control of the movement and speed of traffic through the work zone.

The basic disadvantages associated with pilot car operations include:

- There are traffic delays associated with this type of strategy. Traffic must be stopped and stored while opposing traffic is piloted through the open lane and the lane is cleared.

Duration of the work activity is normally limited to an 8- to 12-hour shift. At the end of the shift the road must be in a condition to be reopened to traffic. Pilot car operations are difficult to run on a 24-hour basis.

- Pilot car operations are cost/labor intensive. They require a minimum of two flaggers and a vehicle operator. Additional flaggers are needed at each access point (road intersection) in the work area.
- Drivers may enter work area from private driveways.

Warrants for the use of pilot cars include:

- Traffic volumes during the work period must be low enough that delays to traffic never exceed 15 - 30 minutes. The length of the work area must be short enough to provide a reasonable cycle time/delay time and to insure that there are a sufficient number of cycles per hour to clear all traffic. Generally it is desirable to specify a conservative work area length and adjust this to a longer length depending on field observations of traffic control. The maximum number of cars that can be accommodated using this strategy is about 800 vehicles per hour.

The lengths of the closed sections are generally determined on the basis of what the highway designer and the contractor determine is a reasonable time that the public can be kept waiting while the pilot car makes a down-and-back trip. This cycle time can be estimated as the travel time through the zone for each direction of traffic and adding clearance time for the two platoons of traffic to clear the end points and for the pilot car to return to the head of the waiting platoon of vehicles. The travel time should be based on a pilot car speed of no more than 25 mi/h (40.2 km/h). This will allow vehicles to react to oncoming vehicles without abrupt braking.

For example, say we have a work zone on a two-lane highway with an ADT of 800 vehicles. The length of roadway that needs work is two miles. Can the entire length be worked on without exceeding a 15-minute delay time for any approaching motorist? First determine the peak approaching volume of traffic. If a peak hour count is available, use that. If a peak hour volume is not available, you can estimate a volume by taking a percentage of the ADT. For rural areas the average peak hour volume is about 15 percent of the ADT; therefore, the two-way volume would be 120 veh (800 x .15) or 60 veh approaching from either direction. The travel time will equal the work area length (2 mi) divided by the speed of the pilot car (25 mi/h). So divide 2 mi by 25 mi/h. The travel time is about 5 min (4 min and 48 sec).

During the travel time down and back, about one car a minute will be arriving at the flagger station, or in other words, on average, a 10 vehicle queue will be waiting. Assuming this queue takes 10 sec to clear the end of the work area, and that the pilot car turnaround time is about 30 sec, the total cycle time is about 11 min. (4 min 48 sec + 30 sec + 4 min 48 sec + 30 sec = 10 min 36 sec) Therefore, the entire two-mile work area can be piloted without exceeding a 15-min delay time for any approaching vehicle.

- The work area should have a limited number of access points (no more than 3 or 4, depending on traffic volume). At access points, an uncontrolled vehicle can enter the one-lane section, creating a dangerous head-on conflict with the pilot car. It is usually necessary to station a flagger at each of these access points to control arriving traffic and hold that traffic until it can be crossed safely or joined to a platoon of vehicles operating in the appropriate direction. Pilot car operations are usually suspended at major intersections and flaggers are used until work in the area is completed.

Traffic Signal Operations - The basic advantage of using traffic signals is to be able to maintain two-way traffic on a one-lane section without personnel present. This type of strategy is commonly used on critical highway sections such as bridges when construction activity, and consequently the lane closure, is continuous over night and/or on weekends.

The basic advantages of using temporary traffic signals are:

- Use of signals can be substantially less costly because no personnel are required at the site when there is no work under way.
- The traffic signal is known to drivers and commands their respect. The signals can be enforced by local police.
- Use of signals can provide the contractor greater flexibility in scheduling operations.

The basic disadvantages of using traffic signals to control one lane are:

- The one-lane section cannot have any intermediate access points, driveways, or pullouts.
- The work area available is restricted because opposing traffic signals and queue should be in view of drivers. (When the signal turns green the lead driver must be confident that the shared lane is clear of opposing traffic.)
- Traffic control is basically on the honor system and can be violated when drivers do not see a need to wait.

Warrants for traffic signals on two-lane roads are:

- TA-12 in the MUTCD states, "The maximum length of activity area for one-way traffic signal control is determined by the capacity required to handle the peak hour demand. Practical maximum length is 400 feet."
- ADT and/or traffic volume when signal is in operation must be relatively low. Signal timing (including a long red to allow the lane to clear) must satisfy traffic demand without creating any significant backups.

- Signal timing must be coordinated and controlled through a single system, usually the signals are linked by cable.
- Traffic signals should conform to the requirements of the MUTCD.
- The driver at the stop line should have a clear view of the opposing traffic signal, the work area, and the first opposing stopped vehicle.
- There should be no access points, driveways, or pull-out areas between the traffic lights.

Two figures are presented to use in determining the optimal control for one-lane, two-way alternating traffic. The input information required is the length of the one-lane section, the speed limit, and the volumes on each approach. Figure 5-3 is entered with the length of the one-way section and the speed limit to determine a mean clearance interval. Then Figure 5-4 is entered with the mean clearance interval and the hourly volumes from each approach. This procedure will also specify when approach volumes exceed the capacity of signal control.

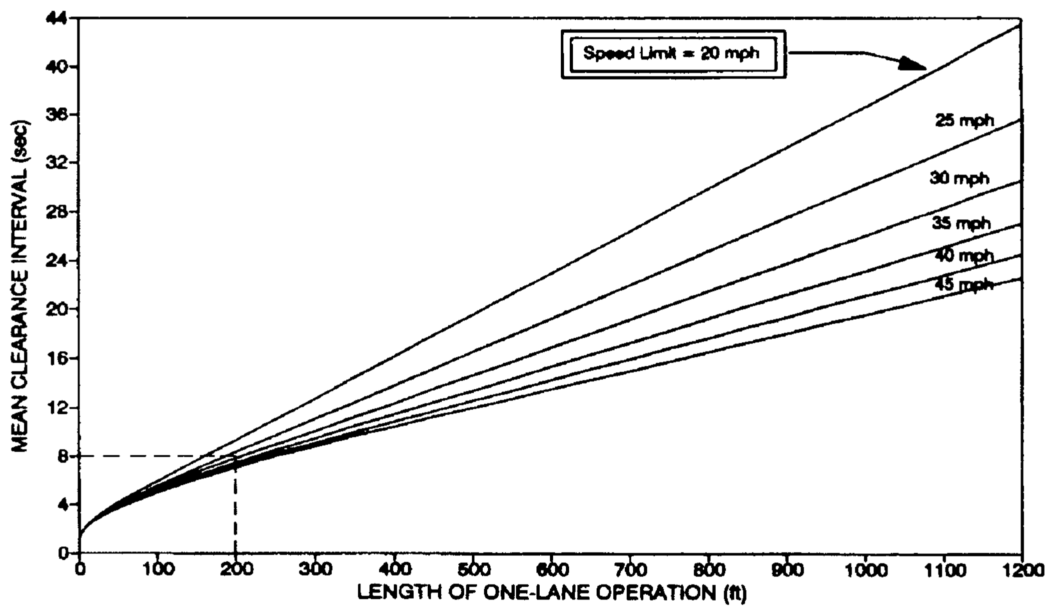


Figure 5-3. Mean clearance intervals for various speed limits and lengths of one-lane segment

For example, a one-lane segment is 200 ft long, speed is 30 mph. Enter Figure 5-3 to obtain a mean clearance time of 8 sec. Volumes are 500 vph for each direction. Signal or flagger control would be selected.

An example of the type of specifications for use of traffic signals in a work zone is shown in Appendix B.

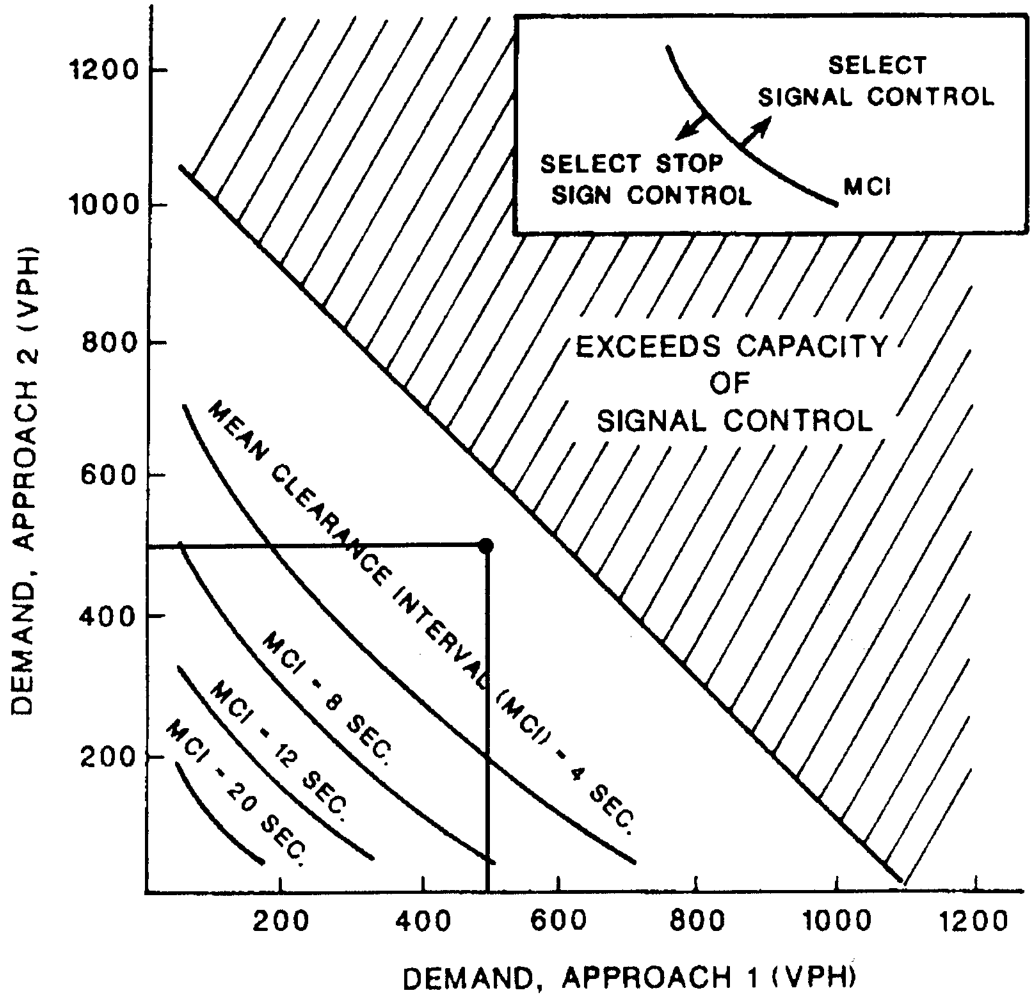


Figure 5-4. Optimal control to minimize total delays for alternating one-way operations

Work or Traffic Management Tactics - Variations on the above traffic control strategies include additional requirements that are placed in the contract to accomplish or provide for specific situations, these include but are not limited to:

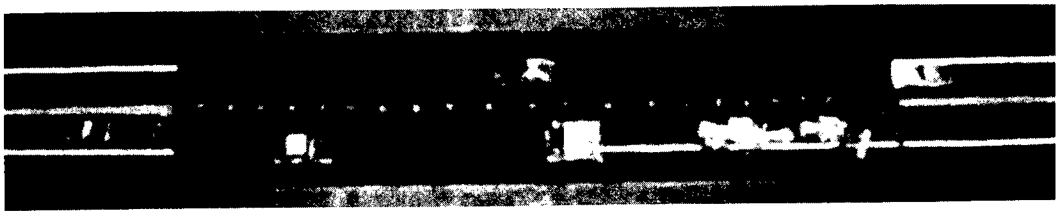


Figure 5-5. The Down and Back Traffic Control Strategy

- The Down and Back (see Figure 5-5) - Requiring the contractor to eliminate any pavement difference by paving down one side of the highway in the morning and paving back up the other side in the afternoon, thus eliminating or reducing the possibility of a centerline dropoff. (Some agencies require that the paver always move downstream.)

Dropoffs or pavement edge differences can cause erratic steering by motorists. Motorcycles are especially susceptible to dropoffs, since they can cause a motorcycle to "trip" when traveling over the pavement edge.

- The Wedge - Contract special provisions may require a contractor to rake out the large aggregate within 1 foot of the traffic side of the freshly placed asphalt, then to roll this 1- foot strip so that a wedge rather than a lip is left next to the unpaved section of highway. The wedge is easier to traverse and can also help reduce centerline reflective cracking.

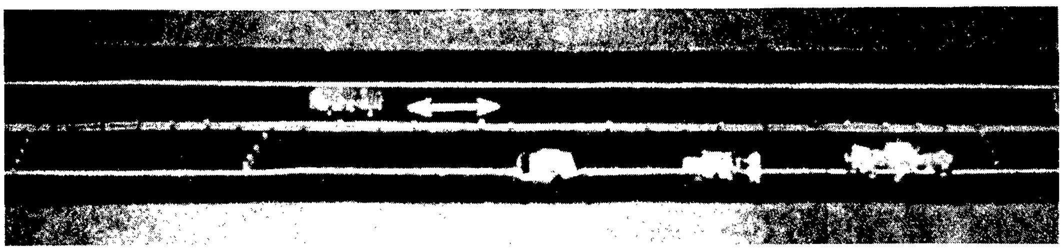


Figure 5-6a. Leap Frogging Traffic Control Devices (Frame 1)

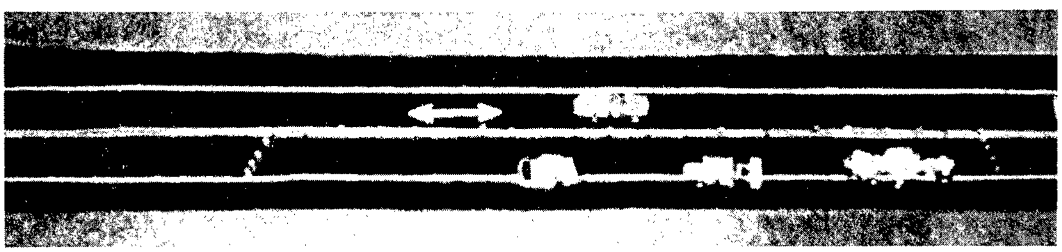


Figure 5-6b. Leap Frogging Traffic Control Devices (Frame 2)

- Leap frogging traffic control devices (See Figure 5-6a and 5-6b) - This variation requires that the contract include sufficient work zone traffic control devices to construct the full area and sufficient additional devices to establish the next work zone closure (including closing taper) downstream from the initial taper, but still within the initial lane closure.

This requirement allows the contractor's personnel to establish new tapers and sign layouts in the relative safety of the existing work area, and reduces the time that traffic control devices are off the roadway. An example of how this work could be specified is shown in Appendix B.

- Night Operations - Specifications require that paving only be done during specific hours, often at night. This requirement is usually accompanied by a contract to provide nighttime work zone illumination during the times the operation occupies the highway.

Traffic management through work areas:

- The decreasing work area - This type operation establishes the maximum feasible work area for the morning traffic condition and decreases the size of the work area as the work progresses and pavement is cured. This type situation is appropriate when the traffic volume (two-way) is low in the morning and increases throughout the day.

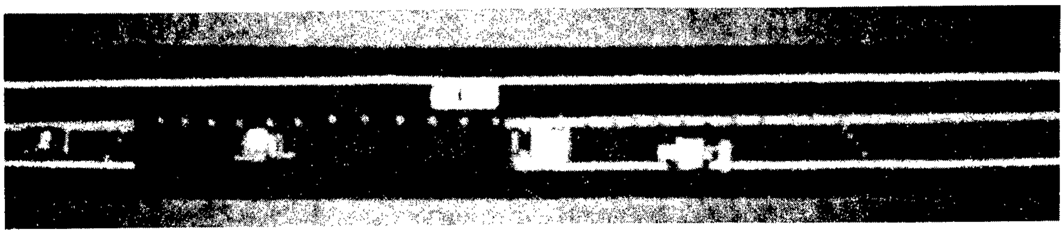


Figure 5-7. The Increasing Work Area Strategy

- The increasing work area (See Figure 5-7) - Opposite of above, the work area is initially limited and as traffic drops off during the midday hours, the work area is extended. The work area can be reduced again by opening the finished area to traffic during the evening rush hours.
- Specifying when work or particular types of work can or cannot be performed. This can include requirements to open the full travel lane by a certain time, allowing certain types of work on weekends only, or requirements to perform certain types of work only during hours of darkness.
- Incentive clauses and disincentive clauses - This includes paying the contractor a fixed rate for every hour that the contractor opens a highway section ahead of schedule, or fining the contractor a fixed amount for every hour that he fails to have the highway open to traffic.

Figure 5-8. Phased, Full-Width Work

Phased, Full-Width Work (See Figure 5-8) - This strategy is used when the entire roadway must be closed, but only for a short time. An example would be to set beams over a road that requires a full road closure for 15 to 30 minutes.

The advantages of this strategy include:

- The entire roadway is available for a short period of time.
- Detours are not necessary.

The disadvantages of this strategy are:

- Traffic may back up through intersections, across railroad tracks, etc.

Warrants for consideration of this strategy include:

- There must be sufficient storage space for vehicles that are stopped. Check upstream for intersections, railroad grade crossings and other features that may be affected by traffic backing up past that point.

TA-13 in Part VI of the MUTCD shows a layout for this strategy. Special provisions should specify when this strategy can be used.

Figure 5-9. Multiple Work Areas

Multiple Work Areas (See Figure 5-9) - For work that takes place at several isolated spots, it may be necessary to use the multiple work area strategy. This strategy is not normally preferred because it calls for a number of sets of traffic control devices. It can also be confusing to drivers because they think they are leaving a work zone only to immediately be introduced to another signing sequence.

The basic advantage of the multiple work area strategy is:

- Traffic control is necessary only where work is taking place.

The basic disadvantages of this strategy are:

- Drivers may not expect several isolated work areas in close proximity.
- Signing needs to be repeated for each work area.

The warrants for consideration of this strategy include:

- Need for work at 3 to 5 isolated spots.
- Short-term or short duration work.

Strategies for Work on Multilane Divided Highways

Like two-lane highways, a number of 4R activities are required on multilane roads including repaving, joint repair, slab replacement, shoulder reconstruction, culvert replacement, and guardrail repair. Since more than one lane is available for each direction of travel, there are more alternative strategies available for multilane roads than for two-lane roads.

A typical priority list of possible strategies for this work/highway type is as follows:

1. Close the road and detour traffic.
2. Close one side of the roadway and operate two-lane, two-way traffic on the opposite side.
3. Close one lane for the entire length where work is required.
4. Advancing limited closure in one lane (expanding or contracting).
5. Alternating lane closures, including reversible lanes.
6. Leap-frogging limited closure in one lane.
7. Phased full width work on one side.
8. Multiple work areas.

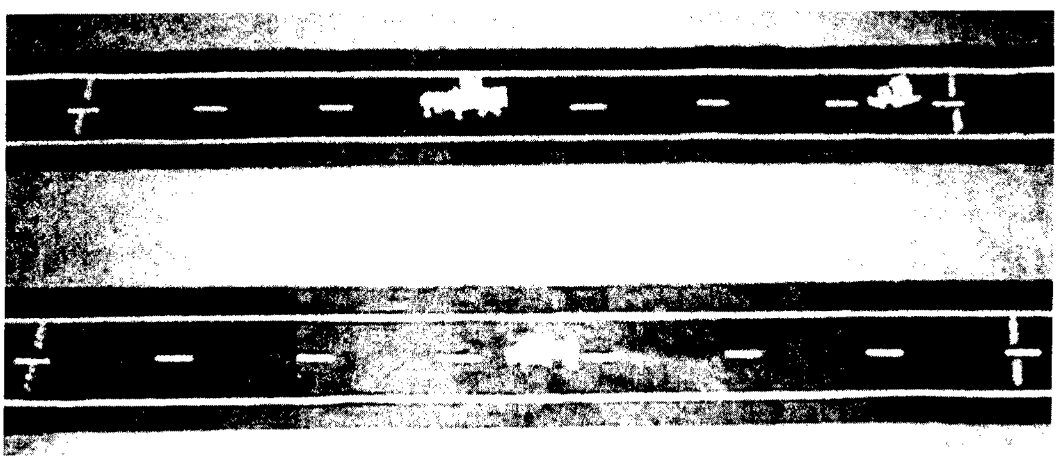


Figure 5-10. Close Road and Detour Traffic

Close road and detour traffic (See Figure 5-10) - The feasibility of closing the road and detouring traffic can be determined in the same manner as for two-lane roads. However, since multilane roads normally have higher traffic volumes and more development than two-lane roads, the use of this strategy is very limited.

The basic advantages of closing a highway section to traffic are:

- Generally facilitates construction and traffic control management.
- Little or no interaction in and around the work area between construction personnel and traffic.

- Limited exposure of workers and/or equipment to traffic.
- Limited exposure of motorists to the potential hazards of the work zone, such as drop-offs.
- Reduced number and types of traffic control required.

The basic disadvantages with closing a highway section to traffic are:

- Generally places an additional time/distance burden on the motorists and community along the detour route.
- Can significantly affect businesses with access from the closed section.
- Can be confusing and frustrating to the motorist, particularity when they are not familiar with the surrounding highway systems.
- Requires access for construction and local traffic to closed section, including emergency services such as ambulances and fire trucks.
- Requires identification and signing of the detour route.

Warrants for closing a multilane highway section for construction include:

- ADT below 2000 vehicles per day.
- No intersecting highways or limited intersecting highways that can easily be included into the detour plan.
- Limited local traffic, less than 30 families, and no major traffic generators within the closed section.
- No essential services located on the closed section, such as fire fighting facilities, hospitals, highway maintenance yards, etc.
- Planned detours provide for travel delays that do not exceed 15 - 30 minutes.
- Will not have a significant economic adverse impact on any business.

Steps in developing this strategy and contract specifications for closing a multilane highway are:

- Highway closures should be coordinated with jurisdictional enforcement officials and fire fighting services personnel. Additionally, when appropriate, coordinate with local hospitals, etc.

- Specific traffic control layouts for closing the highway and establishing detours, including type, size, and location of each sign, should be included in the contract.
- The contract should limit the time the contractor can close the highway and, when appropriate, establish the closing and opening dates. The contract should have a penalty clause associated with the contractor's failure to open a safe highway section within the time frame or on the date specified (usually a daily rate appropriate to the societal loss of service resulting from the closure).

Examples of special provisions that would be included in the contract documents are shown in Appendix B.

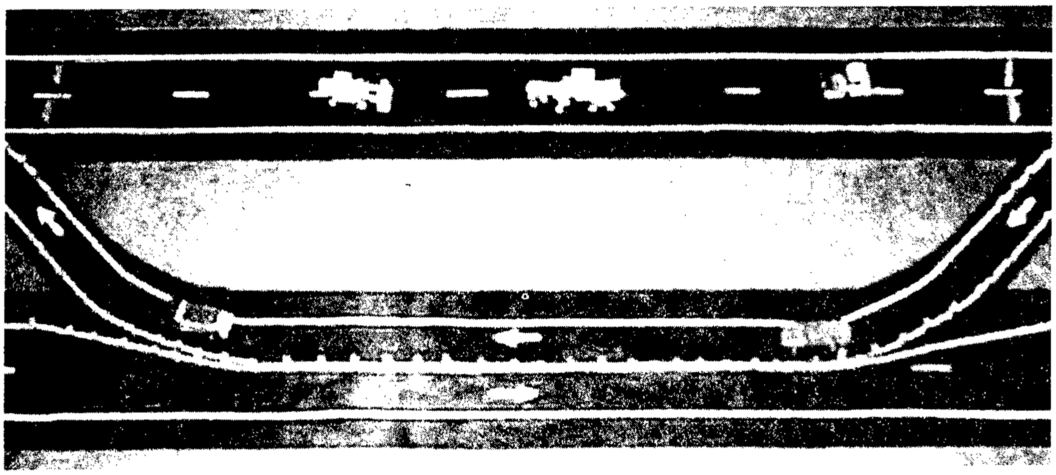


Figure 5-11. Close One Side of Road; Operate Two-Way on Opposite Side

Close one side and operate two-lane, two-way traffic on the opposite side (See Figure 5-11) - In this strategy, median crossovers are constructed to divert one direction of traffic to the roadway normally used by the opposite direction. Traffic then operates like on a two-lane, two-way highway. This strategy is discussed in Section 6G-9 of Part VI of the MUTCD. A typical application for this strategy is shown in TA-39.

The basic advantages of closing one side of a multilane road and operating two-way traffic on the opposing side are:

- The contractor may be able to complete the work quicker because on the closed side there is little interference with traffic.
- Traffic is not exposed to dropoffs or other hazards created by the construction operations.
- Workers are not exposed to nearby traffic.

The basic disadvantages of this strategy are:

- There is an increased risk of serious head-on collisions, and positive separation of the two directions of traffic is required.
- Crossovers must be constructed and additional crossovers may be needed at interchanges.
- Median shoulders may need to be improved since more traffic will be operating on them and these are the only shoulders for crossover traffic. Also, temporary attenuators may be needed where there are bridgerail or guardrail ends exposed to traffic.

Warrants for closing one side of a divided road and operating two-way traffic on the opposite side are:

- Traffic volumes in both directions must be accommodated in one lane. This normally implies that hourly volumes should be below 1600 vph and the ADT should be below 30,000 vehicles.
- No more than one or two interchanges should be included in the work area.
- Work operations that are difficult to accomplish one lane at a time, such as full depth pavement replacement.

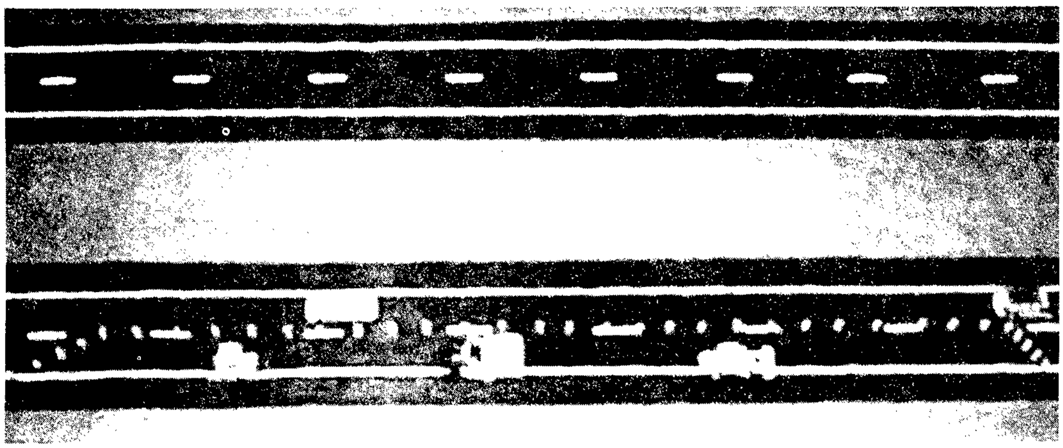


Figure 5-12. Full-Length Lane Closure

Close one lane for the entire length where work is required (See Figure 5-12) - The simplest form of lane closure is to close one lane for the entire length where work is required. The contractor generally has more flexibility in his operations if the entire work area is closed; however, this strategy may penalize the traveling public by making the length of restriction longer than necessary.

The basic advantages of the full length lane closure are:

- The entire roadway to be worked on is available to the contractor.
- Traffic controls do not have to be moved or reinstalled after they are installed.
- Traffic only has to travel through one transition in the entire work zone.

The basic disadvantages of the full length lane closure are:

- In a long work zone, traffic delays due to slow vehicles can be excessive.
- Drivers may see long stretches of lane closure with very little work activity or no work activity.

- If work is halted due to equipment breakdown or other reasons, extra work is done in setting up traffic controls that are not needed.
- This strategy is not easily adapted to heavy directional peaks.
- Disabled vehicles have major impacts on traffic.

Warrants for full length lane closures are:

- Peak hour volumes do not require the traffic controls to be removed or shortened.
- Roadway does not include severe grades that will slow trucks excessively.
- Traffic stream does not include more than 25% trucks. If trucks are a higher percentage, climbing lanes or turnouts should be provided.
- Work should take place throughout the work area.
- Width to move past disabled vehicles is available.

An FHWA study by E. N. Burns, C. L. Dudek and O. J. Pendleton, "Construction Costs and Safety Impacts of Work Zone Traffic Control Strategies," compared the alternative strategies of two-lane, two-way operations versus lane closures on four-lane divided highways with traffic volumes between 10,000 and 30,000 vehicles per day. Table 5-1 shows the recommended traffic control strategy by construction type. The alternative of closing the road and detouring traffic was not considered. It was found that there were no statistical differences in the accident rates for the two alternatives. The report does state that the lane closure strategy is not feasible for some types of construction. The report and accompanying informational guide also include a process for determining the traffic control strategy.

Table 5-1. Suggested traffic control strategies by construction type.

Type of Construction	Traffic Control Strategy
Concrete Pavement Recycling/Overlay	TLTWO
Concrete Pavement Restoration	SLC (analysis)
Asphalt Concrete Pavement Overlay	SLC
Bridge Deck Overlay	SLC
Bridge Deck Replacement/Widening	TLTWO
Reconstruction	TLTWO
New Interchange/Construction	Analysis

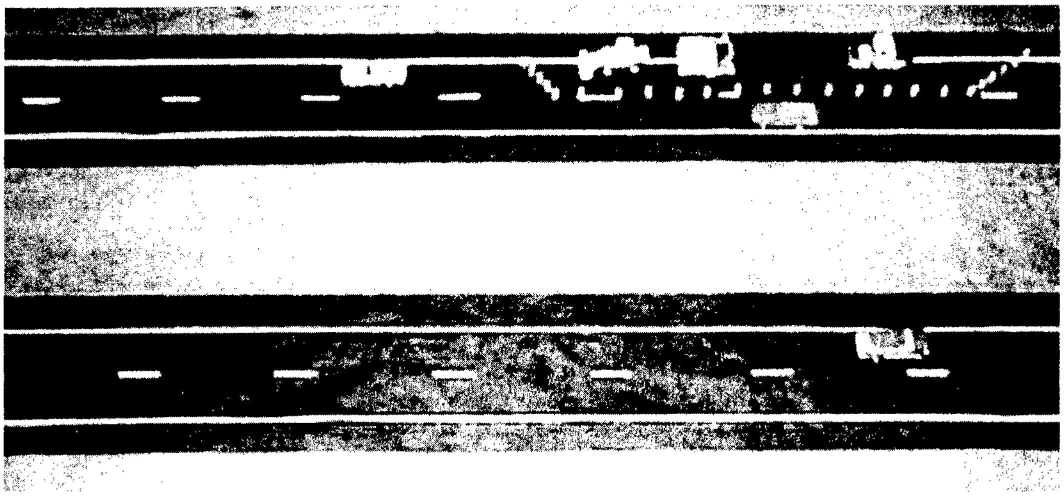


Figure 5-13. Advancing Limited Closure in One Lane

Advancing limited closure in one lane (See Figure 5-13) - For this strategy a lane closure is instituted and then lengthened or shortened according to traffic and the type of construction. One of the most common examples of this strategy is in a paving operation when a short length of lane is closed and then expanded as the paving operation moves downstream.

The advantages of this strategy include:

- Work area can be shortened when traffic is the heaviest.
- This strategy is easier to adjust to breakdowns or schedule changes than a full length lane closure.
- Curing can take place at the front of the work space while work is continuing.

The disadvantages of this strategy include:

- Traffic control devices must be moved frequently as the lane closure expands or contracts.

Warrants for this strategy include:

- Roads where peak hour volumes make it difficult to close entire length of lane at one time.
- Work where curing or set-up time is needed.

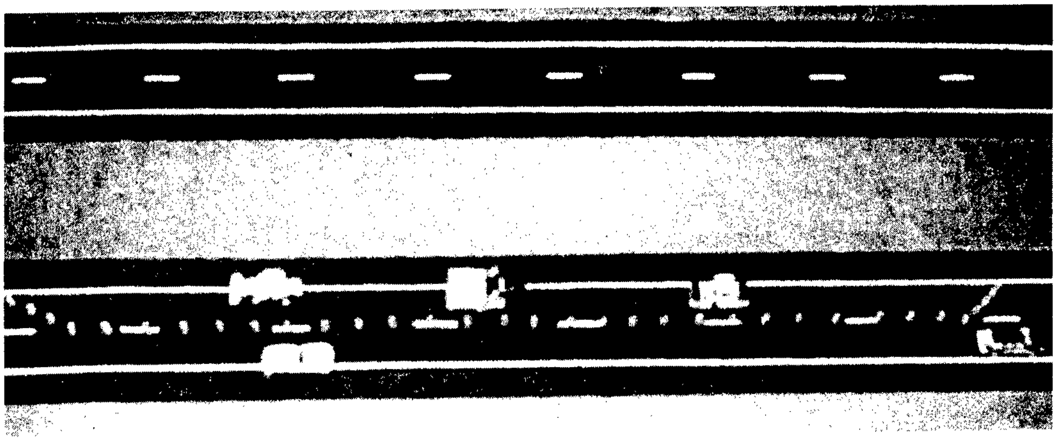


Figure 5-14. Alternating Lane Closures

Alternating lane closures (See Figure 5-14) - In this strategy first one lane is closed then the other. In some cases this strategy is similar to the down-and-back tactic used on two-lane highways.

The advantages of this strategy include:

- It is flexible to adjust to traffic and work.
- This strategy can be scheduled to eliminate drop-offs between lanes. (By paving down one lane in the morning and back the other lane in the afternoon.)

Disadvantages of this strategy include:

- Must be able to open lanes to traffic on same work day.
- Traffic control must change when a lane closure is changed.
- Traffic operates close to workers.
- It is easy to leave up incorrect signs: traffic may be confused by frequent changes.
- In some cases all traffic control may have to be removed and then reinstalled.

Warrants for the alternating lane closure strategy are:

- Work that can be accomplished one lane at a time.
- Areas where the roadway must be open at certain times of the day.

The reversible lane is a type of alternating lane closure where the direction of traffic is reversed based on peak directional volumes. This strategy is useable on multilane divided highways, as well as on urban streets.

Advantages of reversible lanes include:

- Can increase peak hour capacity without widening.
- Can be used for express or high occupancy vehicle lanes.
- May become lateral buffer in non-peak hours when lane is not used.
- May be retained after project.

Disadvantages of reversible lanes include:

- Potential for head-on accidents.
- Access must be carefully planned.
- Can be confusing to drivers, extra signing may be needed.
- Public relations are needed to inform drivers. Use in areas not accustomed to reversible lanes or express lanes may cause great confusion.

Warrants for the use of reversible lanes are:

- Peak direction traffic operates at or near capacity (Level of Service E or F) during peak periods.
- Roadway cannot be widened.
- Construction congestion is expected to be at an unacceptable level.

The reversible lane should be kept clear when not being used. Police car or contractor vehicle should open lane. Barrier is normally used to control access. Urban street reversible lanes may be separated by use of channelizing devices.

An innovative method of accomplishing the alternating lane closure strategy is by using Moveable Concrete Barrier (MCB) to provide reversible or other extra lanes during peak traffic periods. The MCB consists of a set of concrete barriers that are pinned together to form an articulated chain. A special transfer and transport vehicle can move along the chain, lifting and transferring the chain laterally for a distance from 4 to 18 feet.

Identified advantages of the MCB are:

- Construction workers in temporary lane closures are protected behind positive barriers and are better able to concentrate on their work without concern about intruding vehicles.
- The public is better shielded from intrusion into hazardous work zones.
- The barrier can be transferred at speeds up to 5 mph, meaning that a mile of barrier can be transferred in about 12 minutes. Lane closures can be accomplished quicker than with typical channelizing devices and without exposing workers to traffic.
- After an impact, the barrier may be rapidly realigned by the transfer vehicle without the need to place workers on the ground to manually adjust the barrier.

- The transfer vehicle can readily replace damaged units of the barrier thereby reducing maintenance crew effort and time required to repair the barrier.
- The contractors' lane rental costs and/or construction schedule duration may be significantly reduced.

The disadvantages of the MCB are:

- High initial cost.
- The need for personnel to operate the transfer vehicle.
- Problematic amounts of snow and ice can be left behind after each transfer of the MCB.
- In crash tests, the barrier moved 1.25m when impacted with a 2000 kg car at 96km/h at a 15-degree impact angle. (Meets NCHRP 230 Requirements.)

Warrants for the use of MCBs are:

- High AADTs, for example AADTs of 50,000 vpd for four lane facilities and at least 90,000 vpd for six lane facilities.
- Peak direction traffic operates at or near capacity (Level of Service E or F) during peak periods.
- Construction congestion during peak hours is expected to be at an unacceptable level.
- Site constraints preclude temporary or permanent widening.
- No alternate routes with excess capacity exist.
- Traffic flow is highly directional and conducive to use of reversible lanes.
- Nighttime construction conditions warrant the added worker protection of a positive barrier.
- Significant construction quality, efficiency, or schedule benefits can be obtained by widening the work area during off-peak periods.

A memo on a public interest finding and specifications for the QMB are given in Appendix B.

Leap Frogging limited closure (See Figures 5-15a and 5-15b) - This strategy allows workers to set up a lane closure taper within an existing lane closure. The lane closure can then be shortened as work progresses.

Advantages of this strategy include:

- Setting up traffic controls is safer since work can be accomplished inside an existing lane closure.
- This strategy is flexible based on the progress of work and peak hour traffic.

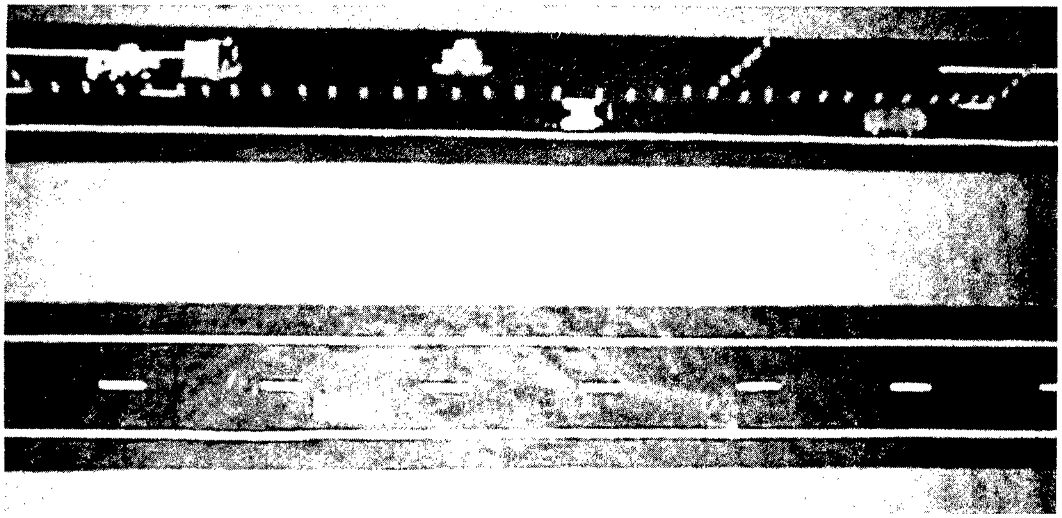


Figure 5-15a. Leap Frogging Limited Closure (Frame 1)

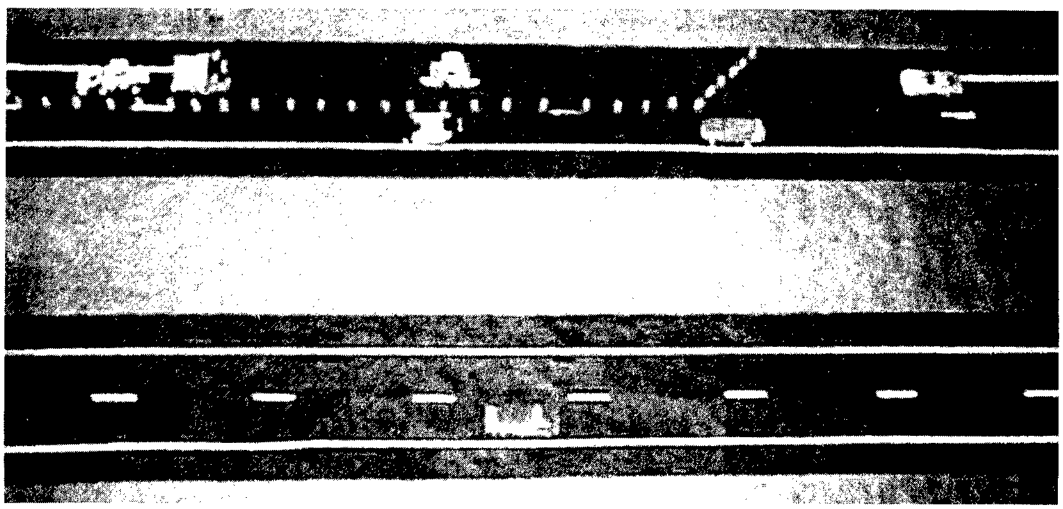


Figure 5-15b. Leap Frogging Limited Closure (Frame 2)

Disadvantages of this strategy include:

- This strategy requires an additional set of traffic control devices.
- Additional labor is involved in setting up traffic controls.

Warrants for this type of work include:

- Work that is progressing in the downstream direction.
- Roads where it is helpful to shorten the lane closure in the afternoon.

Phased full width work on one side of the roadway (See Figure 5-16) - In some cases it may be necessary to close one direction of travel without crossing over any traffic. In this strategy vehicles either back up or divert to other routes.

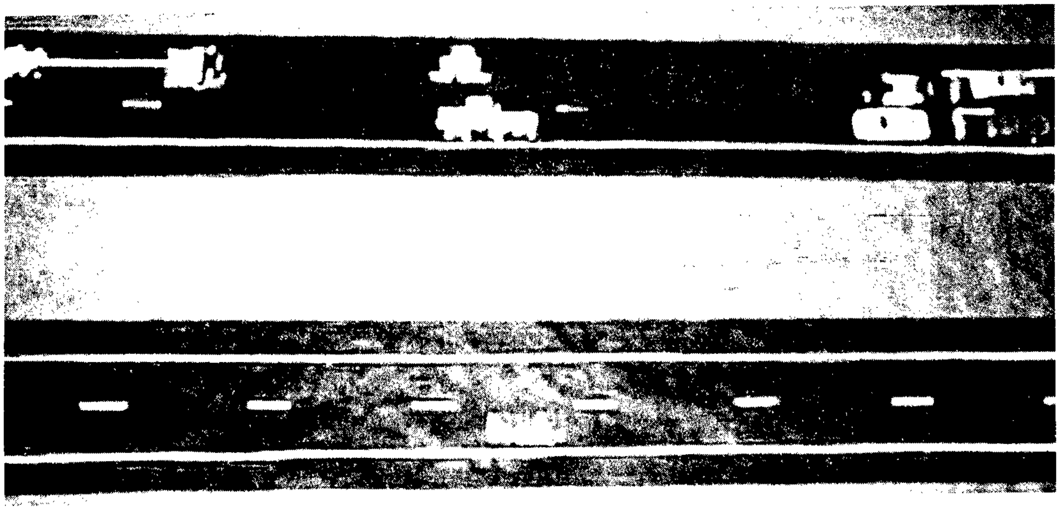


Figure 5-16. Phased, Full-Width Work on One Side of Roadway

The advantages of this strategy include:

- The entire roadway is available for a short period of time.
- Detours or crossovers are not necessary.

The disadvantages of this strategy include:

- Rear-end accidents can occur if drivers are not aware of the queue of stopped vehicles.
- Traffic may back up through intersections, across railroad tracks, etc.

Warrants for this strategy include:

- Short duration work of no more than 15 to 30 minutes.
- Work that requires the entire roadway.

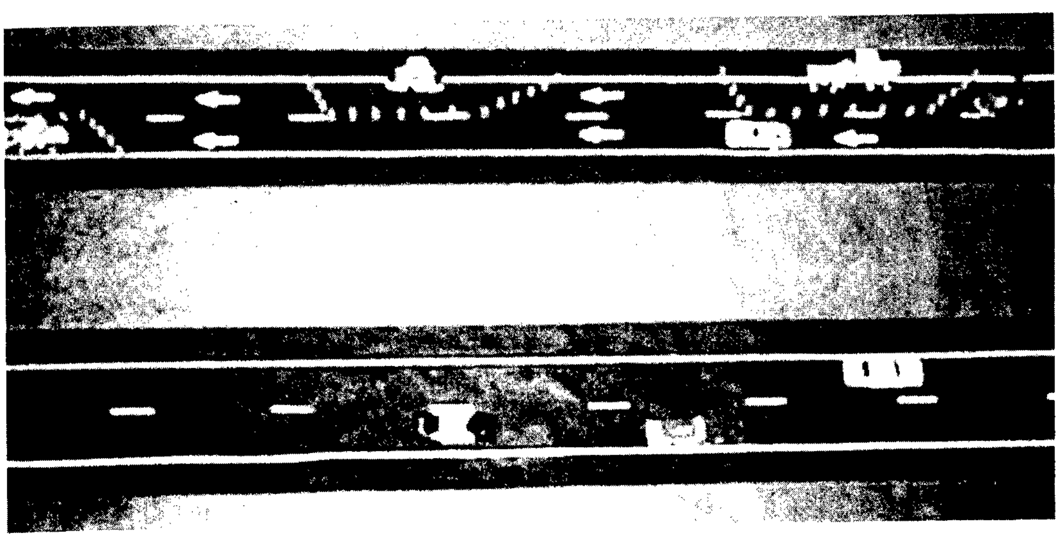


Figure 5-17. Multiple Work Areas

Multiple Work Areas (See Figure 5-17) - For work that takes place at several isolated spots, it may be necessary to use the multiple work area strategy. This strategy is normally not preferred because it calls for a number of sets of traffic control devices. It can also be confusing to drivers because they think they are leaving a work zone only to immediately be introduced to another signing sequence.

The basic advantages of the multiple work area strategy are:

- Traffic control is necessary only where work is taking place.

The basic disadvantages of this strategy are:

- Drivers may not expect several isolated work areas in close proximity.
- Signing needs to be repeated for each work area.

The warrants for consideration of this strategy include:

- Need for work at 3 to 5 isolated spots.
- Short-term or short-duration work.

Bridge Work On Two-Lane, Two-Way Highways

Bridge work, particularly maintaining or restoring an existing bridge, is very common. The type of work often involves the superstructure, the travel surface or bridge rail and requires the development of a traffic control plan that both provides for accomplishing the work and maintaining traffic over and/or through the structure.

The most common factors influencing the selection of a traffic control strategy include the type and complexity of bridge work, the traffic demand, the location of the bridge and how it services the surrounding highway systems, and adjacent roadway or bridges (series of bridges on the same highway) under construction at the same time.

A typical priority list of the common strategies for two-lane, two-way bridges include:

1. Closing the bridge and detouring traffic.
2. Closing the bridge and constructing a temporary structure adjacent to the existing bridge.
3. Reducing or eliminating bridge shoulders and channelizing traffic to a two-lane (minimum width) operation and provide a work area with remaining bridge width (lane constriction).
4. Close one lane and provide for a one-lane, two-way operation (either short-term/during work hours or full time/24 hours a day).
5. In special cases, phased construction where traffic is detoured during low volume periods so that prebuilt parts can be installed and the bridge can be reopened during heavy traffic periods.

Considerations and warrants for each of these strategies are discussed below.

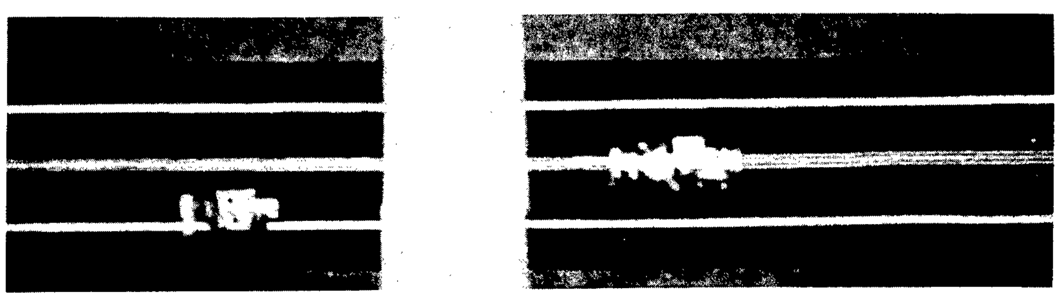


Figure 5-18. Close Bridge and Detour Traffic

Closing the bridge and detouring traffic (See Figure 5-18) - The type and extent of the work required on a bridge may warrant closing the structure to traffic. Work that usually requires closing a bridge includes the replacement of the bridge or bridge superstructure, structural members, the bridge rail, or removal of a major portion of the bridge deck. It is also possible that the materials used in the bridge work may require special traffic consideration, such as the elimination of stresses or vibration in the curing of a portion of a new bridge deck.

Unlike highways (where parallel routes that can service the same area are often common), bridges, particularly those in rural areas, are generally not located in close proximity to other bridges that serve the same function.

This strategy for traffic control maximizes the advantages to the contractor who can work the entire bridge without having to maintain traffic over some portion of the bridge deck. This approach can also have significant societal advantages when it results in quick and efficient completion of the work. Closing a bridge requires detouring through traffic at the nearest practical road intersection while maintaining local traffic on the sections between the bridge and the detour intersection.

Closing a bridge can have significant social impacts when the bridge is on a route between an individual residence or community and fire station, hospital, or other essential business or service. Emergency services, such as ambulances, can be significantly affected when detoured around the bridge closure. Care should be taken not to isolate communities or individuals from essential services when multiple bridges are under construction.

The basic advantages of closing a bridge and detouring traffic are similar to those of closing a highway section and include:

- Generally facilitates construction and traffic control management.
- Provides for maximum work effort, limits interference with work effort, and can expedite construction time.
- Limits exposure to traffic related accidents.
- Can result or contribute to a better product, particularly when redecking in concrete.

The basic disadvantages to closing a bridge are similar to those of closing a highway section and include:

- Places a time/distance burden on both through traffic and local traffic with destinations on the other side of the bridge.
- Reduces the timely response of emergency services when facilities such as hospitals, fire stations, and police can be delayed as a result of the detour.
- Requires that detour signing be established and maintained for the duration of the project.

Warrants for closing a bridge and detouring traffic on the existing highway system include:

- Generally that the type of work being done requires closure or that there is a substantial cost savings in construction costs resulting from closing the structure.
- Relatively low traffic demand; generally rural highways with a low traffic volume.

- Parallel structures that provide for easy return to the closed route; generally detour should be less than 10 miles/fifteen minutes.
- Closure does not deny or significantly reduce the reaction time of emergency services to private and public facilities located off the route.

Often it is essential to close a structure, but the existing highway systems don't provide sufficient and/or timely access for local communities and highway users. In other situations where there is a high volume of traffic using the bridge, it may not be desirable or practical to try to detour this traffic through the existing highway system. In these cases, the design engineer may consider the practicality of using a temporary structure in the immediate vicinity of the bridge.

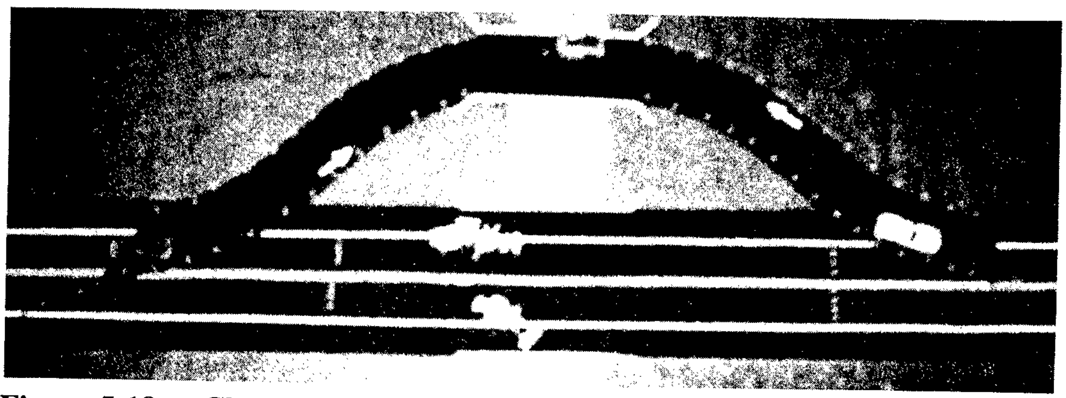


Figure 5-19a. Close Bridge; Provide Structure for Two-Way Traffic

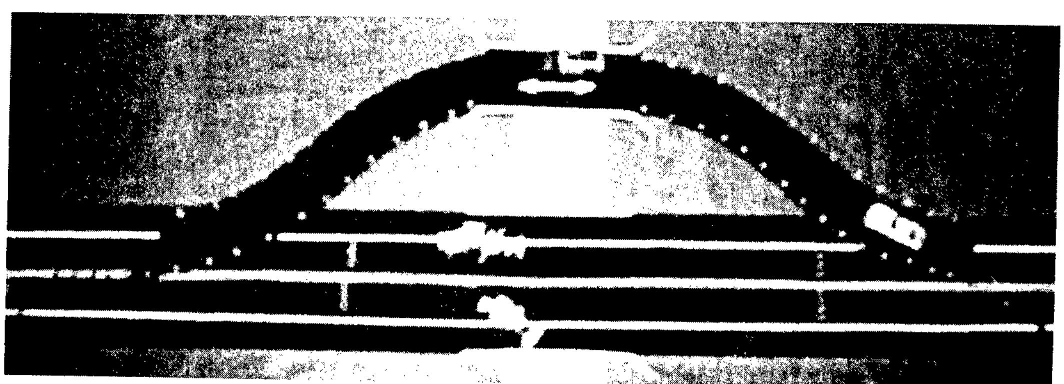


Figure 5-19b. Close Bridge; Provide Structure for Alternating Traffic

Closing the bridge and providing a temporary structure adjacent to the bridge (See Figure 5-19a and Figure 5-19b) - Another of the more common practices for controlling traffic while working on a bridge is to close the bridge and detour traffic over a temporary structure. The typical detail for this type of traffic control is depicted on TA-7 of the Manual on Uniform Traffic Control Devices (MUTCD). The temporary structure is usually located in close proximity to the closed structure to reduce the cost of constructing the temporary bridge approaches.

Temporary structures are often designed or selected to meet the highway needs during the construction period and may include multiple culverts or prefabricated structures. In these cases, the structure may not meet the same design standard as the existing bridge. As an example, multiple culverts which could be overtopped by a five-year storm may be the most practical solution for a four-month project.

When highway traffic is relatively low and the cost of constructing the additional width of a temporary structure is relatively high, the designer can consider a one-lane structure with a traffic light controlling the traffic flow. This approach for low traffic volumes may only be practical where emergency services could be restricted.

The basic advantages to closing a bridge and detouring traffic over a temporary structure include:

- Generally facilitates construction and traffic control management.
- Provides for maximum work effort, limits traffic interference with work, and can expedite construction time.
- Can be developed to limit traffic delays and drivers' confusion and reduce exposure to traffic-related accidents.
- Reduces possibility of delays involving emergency services when an adjacent temporary structure can be provided.
- Can result or contribute to a better product (particularly when redecking in concrete).

The basic disadvantages to closing a bridge and detouring over a temporary structure include:

- Generally increases construction costs significantly because of the cost of temporary structure and approaches.
- Additional planning, efforts, and authority is often required to build temporary approaches and a structure. As an example, right-of-way easements may be necessary for the approaches.
- Temporary structures usually have some limitations over existing conditions (shoulder width, lane width, overtopping, etc.).

Warrants for closing a bridge and constructing a temporary structure include:

- Special situations wherein substantial time delays (5 minutes) cannot be tolerated; for instance, in the case of emergency services such as ambulances and fire fighting equipment.
- Situations in which the available detours require considerable driver delays, have unacceptable restrictions (load or height limits), or cannot accommodate the additional traffic.

- Special situations wherein detouring would result in a significant economic burden to a community. This could be the case where localized businesses rely on traffic and a detour would significantly affect their ability to operate.
- Bridge must be totally replaced and no alternate routes are available.

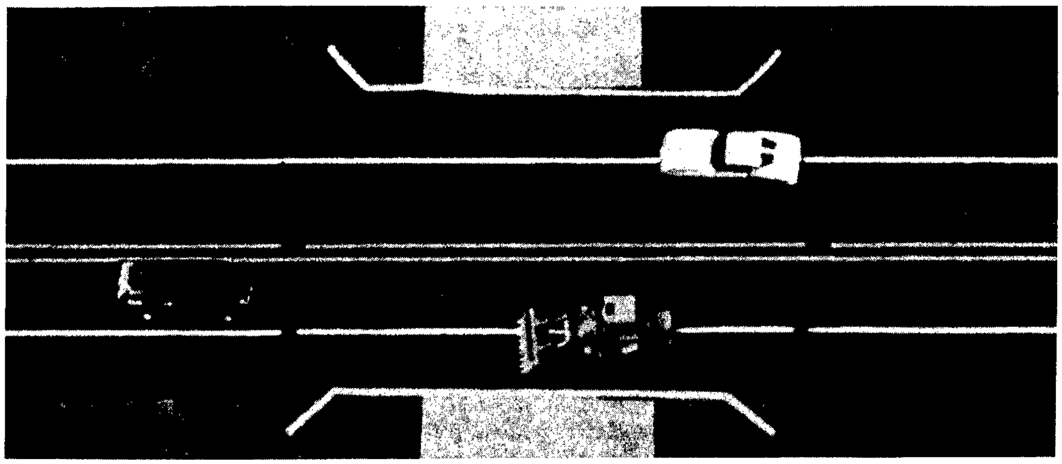


Figure 5-20. Channelize Traffic to Minimum Widths; Eliminate Shoulders

Providing a work area by channelizing traffic, eliminating shoulders and using minimum lane widths (See Figure 5-20) - When work that can be done in phases--such as sand blasting and painting, asphalt overlaying, bridge rail rehabilitation or upgrading, deck and/or expansion, dam repairs, drainage repair or improvement, and various other relative short-term projects--it may be appropriate to consider keeping the bridge open to traffic by channelizing the traffic to provide for a suitable work area.

Attention to both roadway and structural details is essential when considering working on a bridge under traffic.

Traffic control layouts should be developed on the basis of the amount of roadway width available at the most constricted point for each phase of the work. This is to ensure there is sufficient lane width in both directions of traffic and adequate work space for the contractor's equipment, traffic control devices, and any appurtenances that will be required (such as temporary concrete barriers).

Structural analysis is generally not required; however, traffic control plans should be checked against the superstructure support system. As an example, there are structures that have cantilevered decks that were not designed to accept additional dead and live loads in some areas. Some of the older bridge designs for small-single span bridges were developed with bridge rails that also served as support beams. In cases like this it may not be prudent to rebuild the bridge rail under traffic.

This strategy for traffic control usually minimizes the overall inconvenience to the traveling public. It reduces the possibility of drivers getting lost on a detour and, with lower volume roads, can minimize motorist delays.

The basic advantages of maintaining two-way traffic over a bridge during construction include:

- Convenience to motorists that aren't detoured off the highway system.
- Facilitates the maintenance of traffic and traffic control by limiting the section of the highway affected.
- Reduces the burden on adjacent communities in terms of emergency services and businesses.
- Traffic control contract costs are usually significantly less costly than those providing a temporary structure and approaches.

The basic disadvantages of maintaining two-way traffic over a bridge during construction include:

- More time must be provided for construction.
- The construction phasing and traffic control plans are generally more complicated.
- The areas available to the contractor to work and to move equipment are limited and generally require phasing construction operations.
- Generally requires a detailed development of requirements in the contract and a significantly more detailed traffic control plan.
- Generally requires reestablishing different traffic control patterns for each phase of construction.
- Depending on the traffic volumes, the restricted lane widths can result in traffic delays.

Warrants for maintaining traffic over a bridge during construction:

- Relatively low hourly traffic volumes.
- Bridge work is not sensitive to vibrational or deflection loading (curing of a bridge deck).
- If emergency services must be provided across the bridge, then the traffic control plan must provide for those services (such as a fire trucks).

Specifications for maintaining traffic over a bridge during construction:

- Potential misunderstandings can result in this situation where traffic and construction must share a limited space. A detailed traffic control plan, including type, amount, and location of traffic control devices, along with other controlling features such as minimum lane width, is recommended.
- Contract provisions should also allow the contractor to submit for consideration alternative construction phasing plans. The contract or general provisions also allows the contractor to propose alternative construction/traffic control plans.

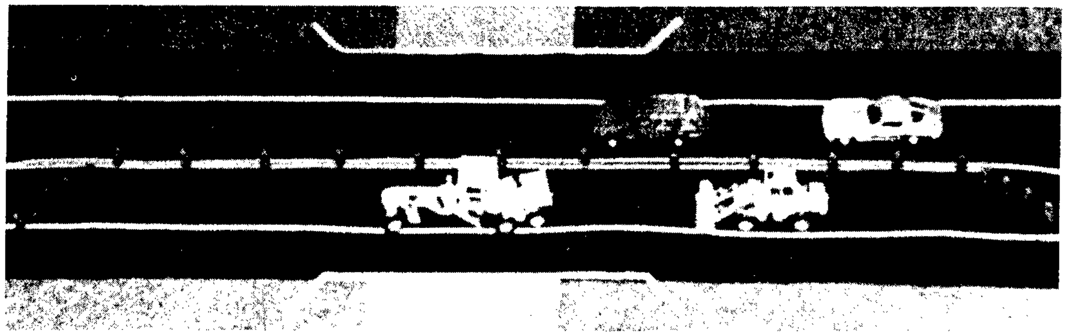


Figure 5-21. Alternating One-Lane, Two-Way Traffic

Providing alternate one-lane, two-way traffic flow across the bridge (See Figure 5-21) - An alternative to carrying two-lane, two-way traffic over a reduced lane width, as discussed above, is a plan using alternate flow over one lane. This strategy was previously discussed under "Strategies for Work on Two-Lane Highways -- Closing one side of a roadway using traffic signals" it may also be used for short-duration projects using flaggers.

Often on older bridges, particularly through trusses, there is a minimum width of roadway available. In this situation it is impossible to provide for two-lane, two-way operations and also have a practical and safe work zone area. As previously discussed, there may be a need to maintain traffic operations over the bridge, such as providing for emergency services. On narrow structures it is often desirable, depending on the type of work required, to maintain one traffic lane and a parallel work site.

This strategy for traffic control usually optimizes the phasing of work and the accommodation of traffic. It reduces the possibility of drivers getting lost or losing time in detours while providing a situation where the contractor can advance the work at his own pace. One of the tradeoffs in this strategy is that more attention to safety is necessary, due to the use of a shared lane that is mechanically maintained by temporary traffic signals.

The basic advantage of maintaining two-way traffic over a single lane on a bridge include:

- Optimizes the cost of traffic management and construction activities.
- Reduces motorists' delays and detouring.
- Provides for emergency services and local businesses.
- Provides the contractor with flexibility in his operations

The basic disadvantages of maintaining two-way traffic over a single lane on a bridge include:

- Requires temporary traffic signals that can be subject to breakdown, vandalism, or power failure (some projects require back up power generators).
- Generally, there is an increased probability of an accident, often because of the uniqueness of the situation where vehicles alternatively share one lane. Drivers are not accustomed to long delay times at traffic signals and may assume that the signal is not functioning.
- Will only operate safely and efficiently with low to moderate traffic volumes and limited peak hour traffic. Potential traffic capacity for an alternating flow condition can be calculated as previously discussed under "Strategies for Work on Two-lane Highways."
- May not be practical or feasible to operate temporary traffic signals when there are other signals, other access points or other potential conflicts, such as railroad grade crossing at or near the bridge terminal.

See Table 5-2 for a summary of one-lane traffic control practices.

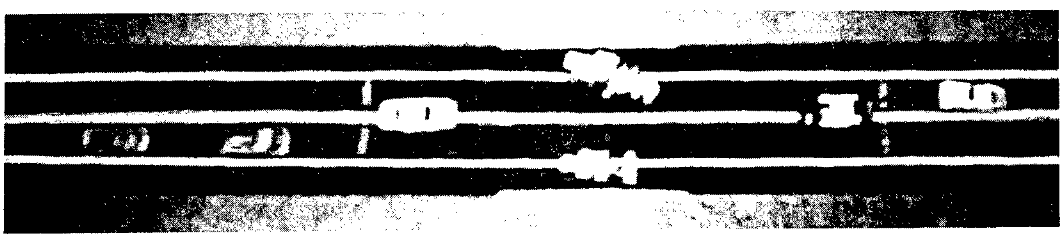


Figure 5-22. Special Cases; Phased Bridge Closure During Construction

Special cases - phased or segmental construction while maintaining traffic during the non construction periods (See Figure 5-22) - In some special situations, bridge rehabilitation or superstructure reconstruction can be done during periods of low traffic volume (usually at night) by removing a section of the bridge superstructure or highway element and installing a prebuilt section in it's place or over short periods of time, such as several days or over weekends, or at preselected and advertised intervals. This type construction requires both a great deal of planning and coordination to ensure that the essential work is accomplished on time.

This type of phased construction may accommodate daily traffic until the necessary material (bridge section) and equipment are available on site and ready for installation. The road is closed during the time it is necessary to remove the exiting section, install the new section, and reestablish all necessary traffic control.

Table 5-2. Traffic control practices for extended/continuous one-lane operations during bridge rehabilitation/reconstruction.

The following was the question posed: What is the criteria which your State uses in determining if traffic control will be by signalization or stop/go controls?

The following is a summary of the responses:

Hawaii
Hawaii does not permit single-lane operation during non-work hours. Contract provisions require a minimum two-lane traffic operation, including use of temporary bridges; i.e., Bailey Bridge, Accro Bridge, etc., to maintain the two lanes. Apparently, their exposure to public liability is a great concern. During construction hours, flagman control is used when only one lane is available. However, in rare instances where the lane closure on a two-lane highway is of significant length or if sight distances along the lane closure is limited, the state may use a pilot car system.

Iowa
The Iowa DOT generally uses traffic signals for extended lane closures on two-lane highways. For low volume facilities (less than 2,000 ADT) stop signs are a permitted alternative, provided the location is not within a no-passing zone or has other sight distance restrictions.

Kansas
All bridge rehabilitation/reconstruction projects either require the use of traffic signals or complete closure of the bridge where an acceptable detour can be used. The only time flaggers are used (stop/go) is when a contractor or KDOT maintenance forces need to work on part of bridge for a short period but plan to open the bridge up to normal traffic flow at the end of the operation.

Minnesota
Minnesota does not have any specific criteria for addressing traffic control requirements on bridge construction projects. Construction traffic control requirements are handled on a case-by-case basis. There is no specific guidance for controls at bridge sites.

Missouri
In Missouri, temporary traffic signals are considered for bridges and other construction work on two-lane roadways which will require one lane, two-way traffic situations in construction work zones for a continuous time period *greater than 15 days*. The following conditions are also considered in the justification of traffic signals:

- Work area is over 90 m long.
- Adequate sight distance is not available.
- Construction year ADT is over 3,000.

Table 5-2. Traffic control practices for extended/continuous one-lane operations during bridge rehabilitation/reconstruction.(Concluded)

New York
Most of our one-way alternating flow work zones are either very short duration (a day or two) or long enough where temporary signals are an obvious choice. There doesn't seem to be any marginal work zones where the choice is not obvious. We are under some pressure from the portable signal industry to allow portable signals as an alternative to flaggers. We will probably allow, but we need to develop specs for their operation. I am not aware of any length variance. Most state highways have high enough volumes that we need positive traffic control. On off-system jobs, a short alternating one-way flow may be more cost effective with flaggers even if a long duration project, but I have never seen such.

Oklahoma
Oklahoma has done several projects that utilized portable signals during bridge rehabilitation projects. These signal systems are only used when a shoo-fly detour or re-routing traffic is not an option. These signal systems are used on state highways only. We have encountered bridges that are so lengthy that a two-phase controller would not allow enough all-red time, and the signal controller had to be increased to a four-phase controller.

Pennsylvania
A stop sign can be used if the length of the one-lane section is not greater than approximately 150 feet and the ADT is not greater than approximately 1500. Traffic signals should be used where the criteria is exceeded.

South Carolina
SCDOT has not used one-lane operations for any extended period of time during construction. The SCDOT maintains a minimum of one lane of traffic in each direction by:

1. Building on new alignment
2. Building ½ of the new bridge adjacent to the old bridge, shifting traffic, and then completing the new bridge.
3. Closing the bridge/roadway and using alternate routes during construction.
4. Building adjacent detour bridge (seldom used).

South Dakota
South Dakota uses traffic volumes and sight distance.

Projects that are developed to maintain traffic through phased or segmental construction are generally complicated and more expensive than other strategies. They often require special equipment, special work, and usually don't provide the contractor the opportunity to maximize his work efforts. Because of the increased cost and complexity of such projects they are often only practical in situations where the need to provide for and maintain traffic or the needs of the local community are critical controlling factors.

The basic advantages of phased or segmental construction are:

- Control of the contractors operations.
- Maximum traffic capacity generally through some major check point.

The basic disadvantages of this type of project include:

- Increased cost and complexity of contractual relations.
- Special attention must be given to planning and contract development, project management and traffic management is difficult.
- Close coordination with local agencies is required, keeping the driving public informed of the traffic situations is difficult.

It may be desirable for planners and designers considering segmental construction under traffic to contact and discuss their proposed operations with other individuals or other agencies with experience in developing and implementing this type of bridge work.

Bridge Work on Multilane Divided Highways

The different strategies for work on two-lane, two-way highways are discussed above. Similar strategies are discussed in this chapter for construction projects on bridges on multilane divided highways (bridge work that affects the flow of traffic on and sometimes under the bridge).

The different common strategies applied to construction projects on bridges on multilane divided highways generally reflect the different ways that traffic can be managed on the existing highway and bridges while they are under construction. Multilane highways generally carry high- speed, high-volume traffic and it is often impractical to detour traffic to alternate routes.

Because of the cost, time, and work involved in managing traffic during bridge rehabilitation, reconstruction, or deck-bridge rail upgrading, frequently it is desirable to group several bridge projects or bridge-highway projects together and develop one common strategy. Grouping the projects together can reduce total inconvenience to the traveling public by eliminating the series of smaller construction projects. Generally project costs, especially those costs associated with traffic management can be significantly reduced.

The most common factors influencing the selection of a traffic control strategy include the type and complexity of bridge work, the number of bridges or highway projects within an area suitable for similar traffic management, the traffic demand, access points and communities serviced by the highway, and the location and size of parallel roadway and bridge systems.

A typical priority list of the common strategies for work on multilane bridges include:

1. Closing the bridge and detouring traffic.
2. Closing the bridge and constructing a temporary structure adjacent to the existing bridge.
3. Providing a work space by channelizing traffic. This can include eliminating shoulders and reducing lane width for a two lane minimum width operation and provide a work area with remaining bridge width.
4. Close one bridge and operate two-lane, two-way traffic on the other bridge.
5. In special cases, phased construction where traffic is detoured during low volume periods so that prebuilt bridge sections can be installed.

Considerations and warrants for each of these strategies are discussed below.

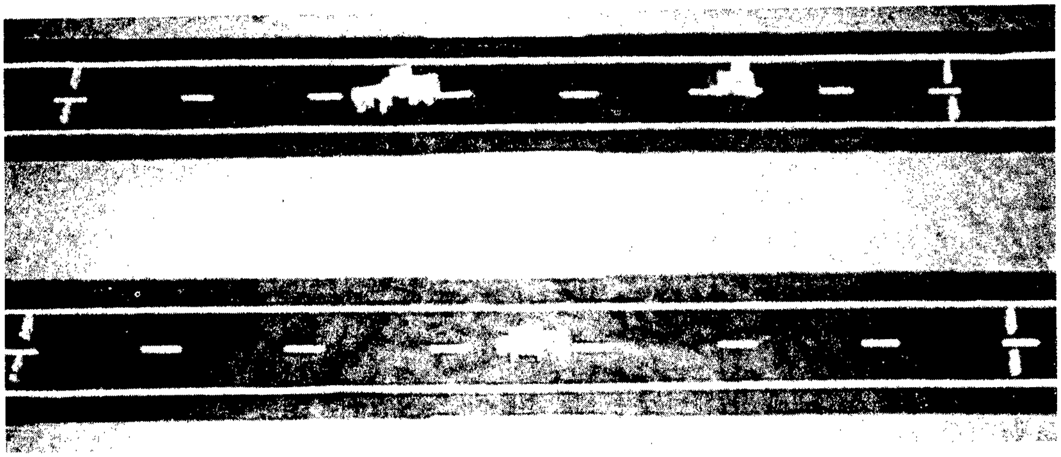


Figure 5-23. Close Bridge and Detour Traffic

Closing the bridge and detouring traffic (See Figure 5-23) - The type and extent of the work required on a bridge may warrant closing the structure to traffic. Work that usually requires closing a bridge includes the replacement of the bridge or bridge superstructure, structural members, the bridge rail, or removal of a major portion of the bridge deck. It is also possible that the materials used in the bridge work may require special traffic consideration, such as the elimination of stresses or vibration in the curing of a portion of a new bridge deck.

Unlike highways, where parallel routes that can service the same area are often common, bridges, particularly those in rural areas, are generally not located in close proximity to other bridges that serve the same function.

This strategy for traffic control maximizes the advantage to the contractor who can work the entire bridge without having to maintain traffic over some portion of the bridge deck. This approach can also have significant societal advantages when it results in quick and efficient completion of the work. Closing a bridge requires detouring through traffic at the nearest practical road intersection while maintaining local traffic on the sections between the bridge and the detour intersection.

Closing a bridge can have significant social impacts when the bridge is on a route between an individual residence or community and fire station, hospital, or other essential business or service. Emergency services, such as ambulances, can be significantly affected when detoured around the bridge closure. Care should be taken not to isolate communities or individuals from essential services when multiple bridges are under construction.

The basic advantages of closing a bridge and detouring traffic are similar to those of closing a highway section, these include:

- Generally facilitates construction and traffic control management.
- Provides for maximum work effort, limits interference with work effort and can expedite construction time.
- Limits exposure to traffic related accidents.

- Can result or contribute to a better product (particularly when redecking in concrete).

The basic disadvantages to closing a bridge are similar to those of closing a highway section and include:

- Places a time distance/burden on both through traffic and local traffic with destinations on the other side of the bridge.
- Reducing the timely response of emergency services when facilities such as hospitals, fire stations, and police can be delayed as a result of the detour.
- Requires that detour signing be established and maintained for duration of project.

Warrants for closing a bridge and detouring traffic on the existing highway system:

- Generally that the type of work being done requires closure or that there is a substantial cost savings in construction costs resulting from closing the structure.
- Relatively low traffic demand. Generally rural highways with low volume of traffic.
- Parallel structure that provides for easy return to the closed route. Generally detour should be less than 10 miles/fifteen minutes.
- Closure does not deny or significantly reduce the reaction time of emergency services to private and public facilities located off the route.

Often it is essential to close a structure but the existing highway systems do not provide sufficient and/or timely access for local communities and highway users. In other situations where there is a high volume of traffic using the bridge, it may not be desirable or practical to try to detour this traffic through the existing highway system. In these cases, the design engineer may consider the practicality of using a temporary structure in the immediate vicinity of the bridge.

Closing the bridge and providing a temporary structure adjacent to the bridge (See Figure 5-24) - Another of the more common practices for controlling traffic while working on a bridge is to close the bridge and detour traffic over a temporary structure. The typical detail for this type of traffic control is depicted on TA-7 of the Manual on Uniform Traffic Control Devices (MUTCD). The temporary structure is usually located in close proximity to the closed structure to reduce the cost of constructing the temporary bridge approaches.

Temporary structures are often designed or selected to meet the highway needs during the construction period and may include multiple culverts or prefabricated structures (they are not typically designed to 25- or 50-year flood

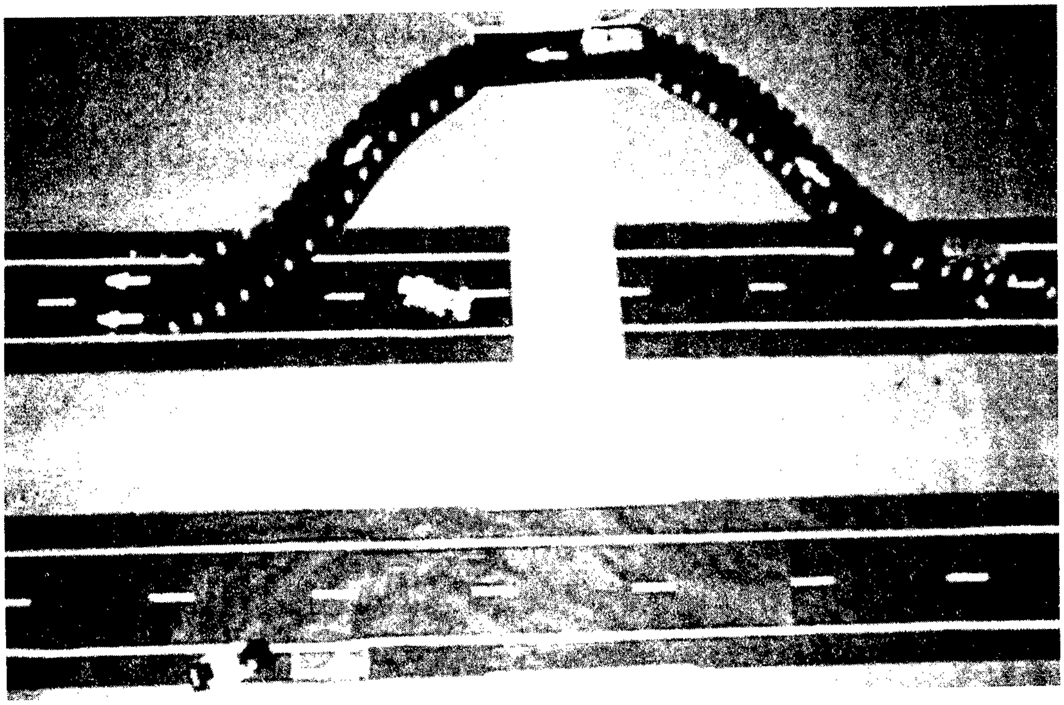


Figure 5-24. Close Bridge; Provide Temporary Adjacent Structure

cycles). In these cases the structure may not need to meet the same design criteria as a permanent structure. As an example, multiple culverts which could be overtopped by a 5-year storm may be the most practical solution for a 4-month project.

When highway traffic is relatively low and the cost of constructing the additional width of a temporary structure is relatively high, the designer can consider a 1-lane structure with a traffic light controlling the flow of traffic. This approach for low traffic volumes may only be practical where emergency services could be restricted.

The basic advantages to closing a bridge and detouring traffic over a temporary structure include:

- Generally facilitates construction and traffic control management.
- Provides for maximum work effort, limits traffic interference with work and can expedite construction time.
- Can be developed to limit traffic delays and drivers' confusion and reduce exposure to traffic related accidents.
- Reduces possibility of delays involving emergency services when an adjacent temporary structure can be provided.
- Can result or contribute to a better product (particularly when redecking in concrete).

The basic disadvantages to closing a bridge and detouring over a temporary structure include:

- Generally increases the construction costs significantly because of the cost of the temporary structure and approaches.
- Additional planning, efforts, and authority is often required to build temporary approaches and a structure. As an example right-of-way easements may be necessary for the approaches.
- Temporary structures usually have some limitations over existing conditions (shoulder width, lane width, overtopping, etc.).

Warrants for closing a bridge and constructing a temporary structure include:

- Special situations where substantial time delays (5 minutes) cannot be tolerated. As in the case of emergency services such as ambulances and fire fighting equipment.
- Situations where the available detours require considerable driver delays, have unacceptable restrictions (load or height limits), or cannot accommodate the additional traffic.
- Special situations where detouring would result in a significant economic burden to a community. This could be the case where localized businesses rely on traffic, and a detour would significantly effect their ability to operate.

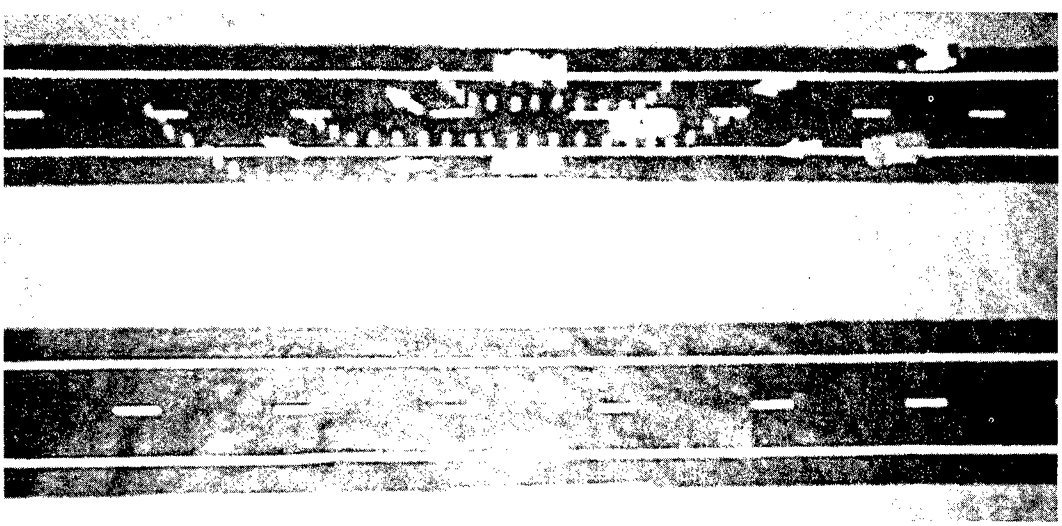


Figure 5-25. Channelize Traffic to Minimum Widths, Eliminate Shoulders

Providing a work area by channelizing traffic, eliminating shoulders, and using minimum lane widths (See Figure 5-25). - Work (such as sand blasting and painting, asphalt overlaying, bridge rail rehabilitation or upgrading, deck and/or expansion dam repairs, drainage repair or improvement, and various other relative short term projects that can be done in phases) may be appropriately done under traffic conditions. This requires keeping the bridge open to traffic by channelizing the traffic to provide for a suitable work area.

Attention to both roadway and structural details is essential when considering working on a bridge under traffic.

Traffic control layouts should be developed on the basis of the amount of roadway width available at the most constricted point for each phase of the work. This insures there is sufficient lane width in both directions of traffic and adequate work space for the contractors equipment, traffic control devices, and any safety appurtenances that will be required (such as temporary concrete barriers). Structural analysis is generally not required; however, the traffic control plan should be checked against the superstructure support system. As an example, there are structures that have cantilevered decks that were not designed to accept additional dead and live loads in some areas. Some of the older bridge designs for small-single span bridges were developed with bridge rails that also served as support beams. In cases like this, it may not be prudent to rebuild the bridge rail under traffic.

This strategy for traffic control usually minimizes the overall inconvenience to the traveling public. It reduces the possibility of drivers getting lost on a detour and, with lower volume roads, can minimize motorists delays.

The basic advantage of maintaining two-way traffic over a bridge during construction include:

- Convenient for motorists because they are not detoured off highway system.
- Facilitates the maintenance of traffic and traffic control by limiting the section of the highway affected.
- Reduces the burden on adjacent communities in terms of emergency services and businesses.
- Traffic control contract costs are usually significantly less costly than providing a temporary structure and approaches.

The basic disadvantages of maintaining two-way traffic over a bridge during construction include:

- More time must be provided for construction.
- The construction phasing and traffic control plans are generally more complicated.
- The areas available to the contractor to work and to move equipment are limited, which generally requires phasing construction operations.
- Generally requires a detailed development of requirements in the contract and a significantly more detailed traffic control plan.
- Generally requires reestablishing different traffic control patterns for each phase of construction.
- Depending on the traffic volumes, the restricted lane widths can result in traffic delays and accidents.

Warrants for maintaining traffic over a bridge during construction:

- Relatively low hourly traffic volumes.
- Bridge work is not sensitive to vibrational or deflection loading (curing of a bridge deck).
- If emergency services must be provided across the bridge, then the traffic control plan must provide for those services (such as fire trucks).

Specifications for maintaining traffic over a bridge during construction:

- Potential misunderstandings can result in this situation where traffic and construction must share a limited space. A detailed traffic control plan, including type, amount, and location of traffic control devices, along with other controlling features such as minimum lane width is recommended.
- Contract provisions should also allow the contractor to submit for consideration alternative construction phasing plans. The contract or general provisions also allows the contractor to propose alternative construction/traffic control plans.

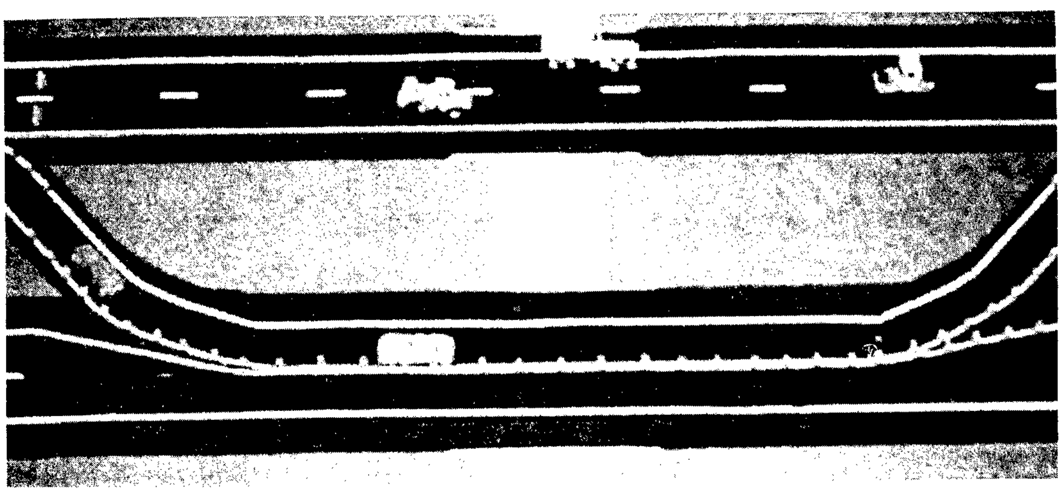


Figure 5-26. Close One Bridge; Operate Two-Lane, Two-Way Traffic on Other Bridge

Close one bridge and operate two-lane, two-way traffic on the other bridge (See Figure 5-26) - In this strategy, median crossovers are constructed to divert one direction of traffic to the roadway normally used by the opposite direction. Traffic then operates like on a two-lane, two-way highway. This strategy is discussed in the multilane section above. A typical application for this strategy is shown in TA-39.

The basic advantages of closing one side of a multilane road and operating two-way traffic on the opposing side are:

- The contractor may be able to complete the work quicker because on the closed side there is little interference with traffic.
- Traffic is not exposed to dropoffs or other hazards created by the construction operations.
- Workers are not exposed to nearby traffic.

The basic disadvantages of this strategy are:

- There is an increased risk of serious head-on collisions, and positive separation of the two directions of traffic is required.
- Crossovers must be constructed and additional crossovers may be needed at interchanges.
- Median shoulders may need to be improved since more traffic will be operating on them and these are the only shoulders for crossover traffic. Also, temporary attenuators may be needed where there are bridgerail or guardrail ends exposed to traffic.

Warrants for closing one side of a divided road and operating two-way traffic on the opposite side are:

- Traffic volumes in both directions must be accommodated in one lane. This normally implies that hourly volumes should be below 1600 vph and the ADT should be below 30,000 vehicles.
- No more than one or two interchanges should be included in the work area.
- Work operations that are difficult to accomplish one lane at a time, such as full depth pavement replacement.

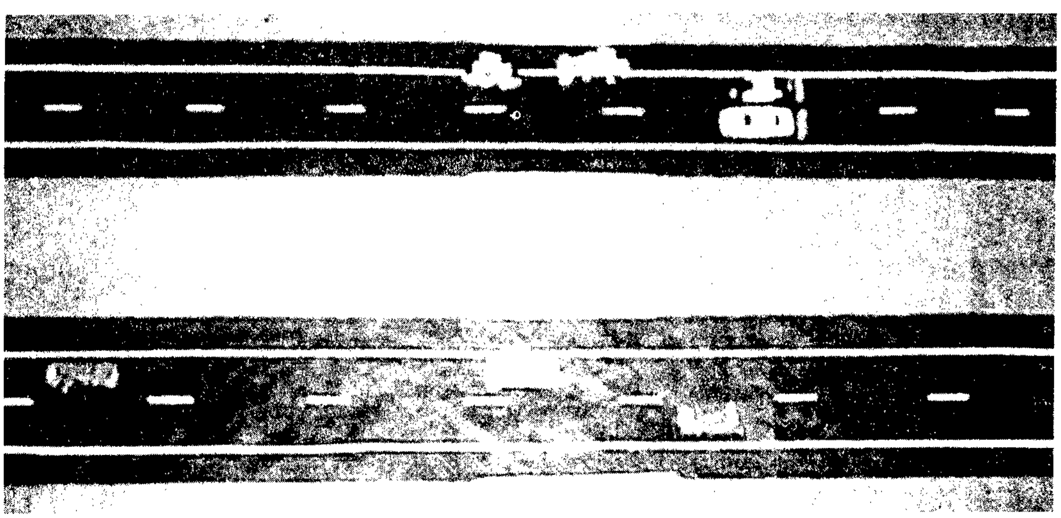


Figure 5-27. Special Cases; Phased Construction

Special cases - phased or segmental construction while maintaining traffic during the nonconstruction periods (See Figure 5-27) - In special situations, bridge rehabilitation or superstructure reconstruction can be done by removing a section of the bridge superstructure or highway element and installing a prebuilt section in its place. This can be done during periods of low traffic volume (usually at night) or over short periods of time, such as several days or over weekends or at preselected and advertized intervals. This type construction requires both a great deal of planning and coordination to ensure that the essential work is accomplished on time.

This type of phased construction may accommodate daily traffic until the necessary material (bridge section) and equipment are available on site and ready for installation. The traffic is restricted during the time it is necessary to remove the existing section, install the new section, and reestablish all necessary traffic control.

Projects that are developed to maintain traffic through phased or segmental construction are generally complicated and more expensive than other strategies. They often require special equipment and special work and usually do not provide the contractor the opportunity to maximize his work efforts. Because of the increased cost and complexity of such projects, they are often only practical in situations where the need to provide for and maintain traffic or the needs of the local community are critical controlling factors.

The basic advantages of phased or segmental construction are control of the contractors operations and maximum traffic capacity generally through some major check point.

The basic disadvantages of this type of project include:

- Increased cost and complexity of contractual relations.
- Special attention to planning and contract development, project management and traffic management is difficult.
- Maintaining close coordination with local agencies, public awareness or keeping the driving public informed of the traffic situations is difficult.

It may be desirable for planners and designers considering segmental construction under traffic to contact and discuss their proposed operations with other individuals or other agencies with experience in developing and implementing this type of bridge work.

Work in Urban Areas

One of the most difficult areas to develop and maintain traffic control in is the urban street system. Projects in these areas must be developed to consider and accommodate not only vehicle traffic volume, but turning movements at intersections, pedestrian traffic, access to businesses, parking, bus routes and stops, school children and their busses, emergency services, and other traffic related operations common to the urban area.

Unlike rural highways, the range of alternative strategies for urban areas is very limited. This is primarily true because of the density of public and private activities that are serviced by urban highways and streets. The urban highways and streets serve more as an origin/destination for a vehicular trip than as a link between origin/destinations that many rural trips represent. While strategies, such as closing a street, may have to be applied in special cases in the urbanized area, the economic hardship and burden caused by some of the previously discussed strategies often make their application impractical. The defining characteristic of work zone activities in the urban area is often the short-term traffic control approach to longer-term projects.

Different methods of applying traffic control may enhance both work and traffic operations.

Rather than using the term strategies, it is probably better to refer to the different possible methods available to control traffic during construction and maintenance operation on urban streets. Unlike their rural counterpart, urban street networks usually provide several close alternative routes for detouring traffic. The primary factors involved in developing a traffic control plan for urban streets may include the following information:

- Traffic volumes and traffic distribution.
- Traffic mix, including trucks and transit busses and the areas they service.
- Location of access to businesses, type of business and traffic generated, and private and public parking.
- At controlled intersections in and around the work areas - Traffic signal timing, traffic counts including turning movements, any restrictions, pedestrians counts.
- Roadway width, traffic regulations in effect (signs and markings), other signing, parking restrictions, fire hydrants.
- Proximity of residential areas and noise restrictions.

Some or all of the following traffic control methods may be used:

- Modifying traffic patterns by restricting turning movements, changing signal times, using temporary one-way street couples, or other traffic control methods to reduce or eliminate traffic from selected work areas.
- Closing one or more blocks of a street to traffic, generally for limited periods of time, and modifying the surrounding traffic patterns.
- Eliminating either shoulders and/or parking to provide for existing traffic while having adequate room for a work area.
- Closing a highway section or street at night and restoring traffic operations, possibly on a temporary or milled surface during peak traffic periods.

Strategy Workshop

INSTRUCTIONS

Participant team assignments will be announced. A team captain will be named. It is the captain's responsibility to see that the assigned task is completed and that one member of the team is appointed to present the team solution to the class.

The course Participant Notebook is the basic reference. The instructor may be called upon to answer questions. Do not confer with members of other teams.

For the sample situations, apply the strategy selection process and select a favorable work zone strategy. Prepare notes on the group discussions and use the notes as a basis for each group's presentation. Each team is provided with a single situation. Data will need to be assumed. Document assumptions. Extra blank sheets will be provided for work purposes.

VI. Including the Strategy in the Traffic Control Plan

The selected strategy is implemented via the contract documents including the traffic control plan (TCP), the special provisions, and the contract. Development of the TCP, special provisions, and contracts are discussed in this chapter.

Purpose of the Traffic Control Plan

The purpose of a traffic control plan for construction activities is to guarantee that motorists and construction workers are provided with safe and efficient highway conditions during the activity. To guarantee this objective is met requires that good practices in temporary work zone traffic control are designed and adhered to. The primary tool to verify and assess this condition is the traffic control plan. It serves as a record of the planned conditions for the activity as well as permits a view of the field conditions and the traffic control needs to provide and maintain control of traffic.

The design activities for a traffic control plan will vary by the planned duration of the construction or maintenance activity. While the traffic control needs for a shorter duration activity may not require the level of sophistication in the plan, the presence of physical activity within the traveled portion (or nearby) requires that proper planning and review of field conditions will be necessary to assure a favorable plan will result and that motorists adhere to the plan.

Based on the planned activity and its duration, the form of the traffic control plan will vary. For example, where a moving operation (striping) is planned along a highway section and the activity may extend over many miles in a short period of time, several key traffic controls may be needed (e.g. advance warning signing, warning lights on paint trucks, etc.) The use of a traffic control 'typical' modified for the general field condition (grades, horizontal curves, driveways, etc.), however, may be sufficient for the given condition. However, in the case of a multi-stage construction project involving several shifts to traffic patterns, significant detail is involved and the traffic control plans will require significant detail to reflect those needs. Detailed traffic control plans defining the staging needs as well as the specific traffic control devices required under each stage will be required. Varying levels of effort exist between these levels. A key issue at this point is to understand that, while the plan format is important, the assurance that the plan meets the traffic conditions and the traffic control needs of the situation is critical.

Elements of the TCP

The design of a traffic control plan requires that field conditions are reflected. Field conditions such as curves or grades, presence of intersecting roadways, presence of driveways, etc. require adjustments to the 'typicals' which serve as a "base" for beginning the TCP. The TCP must reflect the field conditions.

The design of a new traffic control plan is normally initiated by the preparation of a base plan. It is termed as a base plan as it initially defines the general geometric characteristics of the location. Ultimately, it forms the basis for the construction plan and the sequencing plan, if needed.

- The base plan may be a drawing drafted from field survey data or may be an aerial photo map. With today's CADD systems, this plan is often a file obtained from survey data and plotted onto an electronic file. The information on the plan represents the field conditions at the time of planned construction of the project work. The information normally displayed includes:
- Roadway alignment
- Angles of intersecting streets and roadways
- Right-of-way and property lines
- Roadway widths
- Physical features (curb and gutter, sidewalks, shoulders)
- Corner radii
- Driveways or other roadway entrances in the study area
- Physical obstructions or facilities within the ROW (e.g. utility poles, mailboxes, controller cabinets, fences, etc.)
- Lane usage
- Parking restrictions
- Existing signs and signals
- Existing pavement markings
- Existing speed limits
- Bus stops and loading zones
- Building lines
- Alternative routes (where traffic diversion may be used)
- Others

The focal point of the base plan is the physical layout of the study area and surrounding conditions. While much of the data is available from the construction records (either 'as-built' plans or design records), additional data may be obtained from field visits. As a key check, the primary data used in the base plan should be field-verified to assure its general accuracy and current status.

Phasing/Staging Review

Utilizing the base plan, a check of the appropriateness of any planned construction staging should be made. This step may be accomplished by reviewing each phase of construction, defining the specific work to be accomplished, and describing the specific traffic patterns and movements required. Specific items to be examined at this time include:

- Does appropriate roadway width exist to adequately provide the needed number of traffic lanes?

- Are lane widths appropriate to service the vehicle type needs, i.e. trucks, recreational vehicles, etc.?
- Is appropriate clearance from objects or devices provided (e.g. 2-foot clearance from portable concrete barrier or 1-foot clearance from a Type I or II barricade)?
- Does sufficient work space exist to adequately perform the necessary work in an effective manner?
- Is construction vehicle access adequate?
- Is proper traffic control provided to permit safe access for construction traffic to merge or diverge with the highway traffic?
- Are all required traffic control devices and their placement included in the plan?
- Is sufficient construction space/area permitted to allow safe and efficient use of the available traffic lanes as shown under each phase?
- Are all items to be removed from traveled portions of the roadway actually removed prior to the needed phase?
- Where traffic is diverted or re-routed, are the diversion routes accessible and does sufficient capacity exist to service the demand increase?

Where deficiencies exist in response to these questions, the construction or construction staging should be revised to fit the needs of the construction work and to permit safe and efficient operations through the study area.

Plan Preparation

The format for the preparation of traffic control plans should follow the guidelines set by the agency leading the work activity. These formats may vary significantly throughout an area depending on the specific agency requirements, the complexity of the planned work activity, the duration of the work activity, and the impact of the activity on the study area and the adjacent highway system.

In general, traffic control plans should be provided for every work or maintenance activity which may occur within the highway ROW. While the detail provided in the plan may be significantly less for minor projects than major projects, development and review of a traffic control plan will guarantee that the situation has been reviewed and that the traffic control needs are being addressed. In some cases, a sketch of a typical may meet the project needs (given that the field conditions are comparable to the typical). However, in most cases, greater detail is required to assure the traffic control needs meet the needs of the construction activity. <u>A site-specific traffic plan is required</u>.

Most traffic control plans utilize scaled drawings depicting the study site and local conditions. Common scales are 1"=50' or 1"=100', depending on the length of the study area and the complexity of the highway situation. Symbols are also used to denote the various physical elements along the study area. The trend toward uniformity has progressed significantly although variations are inevitable. It is, however, critical to define the symbols used in a legend on the face of the plan or in the plan set.

The size of the plan sheet is normally 22" X 34". This size allows a 50% reduction to 11" X 17" for an easily used document in the field. Wherever possible, the original size should be proportional to either 81/2 X 11 or 11 X 17- inch final page size.

Plan Layout

The normal layout of the traffic control plan layout should follow the leading agency's guidelines. Generally, each sheet should contain a title block for appropriate review signatures and a sheet numbering plan. A sample list of plan sheets is as follows:

- Cover Sheet- identifies the project limits and defines the work overview.
- Table of Contents- lists the sheets and sheet numbers contained in the plans.
- General Notes- states the general notes used in the project.
- Phasing Overview- highlights the work to be done, the traffic patterns, and the general traffic control needs of the project. Often, a shaded depiction of the work by phase is included to highlight the work on a phase basis.
- Detailed Traffic Control Plan by Phase- details the traffic control plan for each phase of construction.
- Standard Details- contains standard drawings used by the specific agency.
- Quantities by Phase- lists the quantities planned to be used (per the traffic control plan) on the project.
- Specifications

Title/Cover sheet - The Title/Cover sheet is the lead sheet in the plans. Basically, it is used to identify the plan, and type of work intended. It may identify the area on a location map and the specific site on a vicinity map. The location map covers a major portion of the area and the vicinity shows the immediate surroundings of the project site.

Table of contents - This sheet displays an index of sheets contained in the plan.

General Notes - The General Notes should contain notes relating to the overall project. The notes may relate the use of standard specifications, overall equipment needs, general traffic control requirements, contact names for review purposes, and general requirements. The notes provide information that cannot easily be communicated by the drawing alone. The primary requirement of the notes is that they be clear, concise, specific, complete, and as carefully worded as if they were to appear in the specifications.

Phasing Overview - This sheet serves as a one-page overview of the construction and traffic control plans of the activity. It highlights the work done under each construction phase and the traffic flow patterns under each phase. Review of this sheet and the staging assists in guaranteeing that all needed work for a subsequent phase has been accomplished in the previous phase(s). Often, to assist in this effort, the phases of construction and the traffic control plans are shaded in different patterns to display the phasing at a single glance. Or, if multiple displays are provided, they are shown on the same sheet to provide an easier review of the phasing/staging and its appropriateness.

Traffic Control Plan by Phase - The traffic control plan sheets are the heart of the plan set. Different agencies elect to include various items of information on the design plan sheet and other more detailed information on the detail sheets or in the specifications. The major consideration should be clarity and completeness. While traffic control detail is a prime requisite, little is gained by cluttering a sheet with too much information. The major objective of the design plan is to graphically depict the traffic control needs of each construction phase. This includes the work area, advance warning sign area and needed traffic control devices, the termination area and needed traffic control devices, buffer space and needed traffic control devices, blow-ups of key areas (for greater clarity and definition), symbol legend, and phase-specific construction and traffic control notes.

Standard Details - The detail sheets usually consist of previously developed standard plans or drawings for items of equipment or construction detail common to most traffic control plans. Detail sheets are also used for special features not covered by standard drawings. These usually involve the specifics of a different type of installation or special equipment unique to an individual location. These drawings provide dimensions, configurations, locational factors, and explicit installation details. This type of detail generally could not be easily included in a single design sheet because of space and scale limitations. In addition, since the items detailed are common to many installations, the use of standard drawings eliminates unnecessary and repetitious drafting work. Example standard details may include: portable concrete barrier, sandbagging techniques, special sign stands, special lighting devices, and portable traffic signals.

Quantities by Phase - This sheet, if used, contains a tabulation of line items and the estimated quantities needed for the project. The quantity summary is used primarily as a basis for the bid proposal. The quantities may be listed by project as a whole or by specific phase. For check purposes, the phase details are desirable. Materials that are to be provided by the agency to the contractor must be clearly defined or listed separately from those items to be supplied by the contractor.

Specifications - Standard specifications, approved and adopted by a particular state or local jurisdiction are customarily bound in a separate document and can be obtained for use on a multitude of different types of projects. Specific sections for traffic control needs are normally addressed in this document. It serves as the basic reference for this information. In addition to the standard specifications, special provisions may be required to supplement the traffic control plans. The special provisions prescribe revisions or additions to the general provisions contained in the standard specifications or general notes. Special provisions may relate to legal or administrative matters or to technical requirements. In most cases, the special provisions have legal precedence over the standard provisions. As such, they should be used with care. A number of example special provisions are shown in Appendix B.

In addition to these needs, an Engineers Cost Estimate should be developed as part of the plans. The estimate will determine if the cost of the project is within the budget limits set, will assure that all considerations are accounted for, and will be useful in planning for future traffic control projects and their needs and budgets.

Quality Control

In the plan preparation and the plan review, significant effort needs to be extended in the quality control activity. A strong quality control program needs to be in-place or developed as part of any agency's standard operating procedures. This program should contain steps for: verifying field data; checking plans for accuracy, clarity, and reliability; back-checking plans; correcting; verifying; and finalizing a plan set. The end result will guarantee a functional and effective set of traffic control plans and contract documents.

Process Review

Federal Aid Policy Guide 630J, "Traffic Safety In Highway and Street Work Zones" specifies that each agency shall annually review randomly selected projects to assess the effectiveness of its procedures. The appropriateness of the selected work zone strategy and the effectiveness of the TCP should be determined for each project.

Each agency should have a process where designers receive feedback on how their TCP actually performed in the field. One of the best methods to accomplish this review is for designers to spend time on field assignments reviewing their TCPs.

VII. Summary

1. A project designer should consider a number of elements in selecting the best strategy. For complicated projects, this may involve collection of extensive initial information. (See Chapter 4 and checklist on Page 3-2.)

2. A designer may need to consult with a number of others to select the best strategy, including construction, structures, and materials representatives.

3. A designer should look at the range of feasible alternatives rather than just relying on past plans and provisions.

4. Coordination with outside agencies is necessary. Check with these agencies in regard to incident management, EMS, utilities, local agencies, police, HP, fire, schools, transit, special events, motor carriers, railroads, AGC, local businesses, etc. (See checklist, Page 3-3.)

5. Capacity is a key to any successful strategy.

6. Chapter 5 contains a list of alternative strategies. These should be reviewed and assessed.

7. The best strategy is usually a compromise between competing interests, especially the contractor and the traveling public.

INDEX

APPENDIX A

INNOVATIVE CONTRACTING PROCEDURES

U.S. DEPARTMENT OF TRANSPORTATION

FEDERAL HIGHWAY ADMINISTRATION

SUBJECT	FHWA TECHNICAL ADVISORY
INCENTIVE/DISINCENTIVE (I/D) FOR EARLY COMPLETION	T 5080.10 February 8, 1989

1. PURPOSE. To provide guidance for the development and administration of incentive/disincentive (I/D) provisions for early completion on highway construction projects or designated phase(s).

2. DEFINITIONS

a. Incentive/disincentive for early completion - a contract provision which compensates the contractor a certain amount of money for each day identified critical work is completed ahead of schedule and assesses a deduction for each day the contractor overruns the I/D time. Its use is primarily intended for those critical projects where traffic inconvenience and delays are to be held to a minimum. The amounts are based upon estimates of such items as traffic safety, traffic maintenance, and road user delay costs.

b. Liquidated damages - the daily amount set forth in the contract to be deducted from the contract price to cover additional costs incurred by a State highway agency (SHA) because of the contractor's failure to complete all the contract work within the number of calendar days or workdays specified or by the completion date specified.

c. Contract time - the total time (calendar days or completion date) established to complete the project.

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d. Incentive/disincentive time - the time (calendar days or completion date) established for the contractor to complete critical work on identified roadway(s) and/or structure(s). This time begins when traffic is impacted by the project and normally ends when unrestricted traffic is permitted on the identified roadway(s) and/or structure(s). This is the time upon which the I/D payment will be based. The I/D time and contract time may be the same in situations where traffic impact exists for the full duration of the project or I/D time may be for a shorter period when traffic is impacted only during a certain phase or phases of contract work.

3. BACKGROUND

a. The FHWA policy which prohibited participation in bonus payments for early completion was rescinded effective July 13, 1984. The policy prohibiting bonus payments goes back to a 1927 interpretation of a statute that limited the Government's share of project costs to the value of labor and materials. In the 1970's the policy was based on the belief that FHWA should not have to pay "extra" just to have a project completed early. The present FHWA policy on bonus payments is based in part on the evaluation of National Experimental and Evaluation Program (NEEP) Project #24 which showed that I/D provisions are a valuable cost-effective construction tool.

b. Present FHWA policy allows for approval of I/D provisions which are in compliance with the intent of the FHWA program. This may include, but is not limited to: (1) provisions for early completion of critical improvements which result in significant savings and/or positive benefits to the traveling public and (2) provisions which allow for product acceptance with pay adjustments. This Technical Advisory will only address I/D for early completion on highway construction projects. In accordance with Mr. Willetts' memorandum of January 22, 1988, to Mr. Leon Larson, I/D provisions are not to be used in Federal-aid participating consultant service contracts.

c. In discussing I/D, a clear distinction needs to be made between the intent of I/D provisions and liquidated damages. Although they have similar mechanisms, the purpose or function of each is different. The liquidated damages policy has as a prime function the recovery of construction engineering (CE) and/or additional costs associated with the contractor's failure to complete the project on time. The I/D provision is intended to motivate the contractor so that work will be completed on or ahead of schedule. Liquidated damages provisions apply to all projects; however, I/D provisions apply only to special projects.

d. The regulation change to 23 CFR Part 630 of August 20, 1987, concerning the assessment of liquidated damages allowed the SHA's to include costs of project-related delays or inconveniences to them or the public, in addition to CE costs, in their liquidated damages provisions. If an SHA includes delay related costs in its liquidated damage rate, those delay costs should be excluded from the disincentive amount on an I/D project so a contractor is not subjected to a double assessment for the same costs.

4. GUIDANCE

a. The approval of I/D provisions will be reserved only for critical projects or phases of projects where traffic inconveniences and delays must be minimized. States should develop guidelines for selection of projects.

b. The determination of I/D amount and time should be documented and retained in the project records. The I/D amount and time determination with supporting data should be submitted and concurred in by the FHWA Division Administrator prior to the State's request for approval of the plans, specifications, and estimate and authorization to advertise.

c. Project time should be established on either a calendar day or completion date basis. Contractors should have an approved critical path method (CPM) schedule prior to starting work on the project.

d. For those States with an approved Certification Acceptance Plan, the procedure for developing I/D projects should be covered under the State's plan, or the projects should be handled as an exception and developed with the Division Administrator's approval.

5. PROJECT SELECTION. I/D provisions provide an effective method to motivate the contractor to complete projects or portions of projects faster than normal. However, it is recommended that I/D provisions not be used routinely. Generally, I/D provisions should be limited to those projects whose construction would severely disrupt highway traffic or highway services, significantly increase road users' costs, have a significant impact on adjacent neighborhoods or businesses, or close a gap thereby providing a major improvement in the highway system.

a. The selection of projects during the early stages of project development is essential. This will allow for full deployment of resources needed to properly design and coordinate the project.

b. The development of criteria for possible projects will aid in early identification of projects. The following characteristics have been associated with projects appropriate for I/D provisions:

(1) High traffic volumes generally found in urban areas.

(2) Work that will complete a gap in the highway system.

(3) Major reconstruction or rehabilitation on an existing facility that will severely disrupt traffic.

(4) Major bridges out of service.

(5) Lengthy detours.

c. The project should be such that the I/D phase(s) can be completed in one construction season or less.

6. PROJECT DEVELOPMENT

a. Experience has shown that engineering time spent during project development pays dividends during construction and in obtaining a successful project. A field change to correct mistakes in plans can be very costly in time and money on an I/D project. The plans and specifications must be complete and accurate to permit a common and clear understanding of what is to be constructed.

b. During the development of I/D projects, extra effort should be made to ensure that the design, specifications, schedule, etc., are compatible since all must be modified to fit the project. Any omission or error in the plans and specifications may result in a claim from the contractor. The plans and specifications should indicate any unusual condition or any restriction the contractor may be required to work under, such as restrictions prohibiting jack hammering or pile driving during the night due to noise problems.

(1) Available right-of-way and utility relocation work are two variables that play a very important role in I/D projects. If the right-of-way is not clear, then I/D provisions should not be used on the project. Utility work by other than the contractor should be limited to only work that will not interfere with the I/D phase(s) of the contract.

(2) The contract must clearly define what constitutes the start and the completion of the I/D phase(s). Either or both may differ from the start or completion of the project. The I/D time may be delayed until traffic is impacted, thus allowing the contractor time to fabricate steel, obtain mix design, etc. However, it is necessary to define in detail what is expected of the contractor. This can be done through the plans for stage construction or detailed description in the special provisions. Bid items to be completed should be referenced.

Completion of items such as signing, lighting, signals, striping, curb, shoulder, and cleanup should be addressed. Liquidated damages can be assigned for completion of work after the I/D phase has been accomplished.

c. During the preconstruction phase of the project, all parties (local officials, police, local traffic engineers, and construction engineers) should become involved in the project development. A prebid meeting may be necessary to cover the I/D phase(s) and any unusual features of the project.

d. Predesign field reviews are essential since "as built" plans or old construction plans have not proven reliable due to maintenance operations or field changes not being recorded on the plans.

e. The development of I/D provisions must be related to each State's specifications. To assist in preparing I/D provisions, a checklist (formulated by Region 7) of items to consider when preparing contract provisions is included as Attachment 1.

7. DETERMINATION OF INCENTIVE/DISINCENTIVE AMOUNT. The major area of concern expressed on the use of I/D provisions is determination of the appropriate dollar amount per day for I/D provisions for early completion of projects. To be effective and accomplish the objectives of I/D provisions, the dollar amount must be of sufficient benefit to the contractor to encourage his/her interest, stimulate innovative ideas, and increase the profitability of meeting tight schedules. If the incentive payment is not sufficient to cover the contractor's cost for the extra work, then there is little incentive to accelerate production, and the I/D provisions will not produce the intended results.

a. A daily I/D amount is calculated on a project-by-project basis using established construction engineering inspection costs, State related traffic control and maintenance costs, detour costs, and road user costs. Costs attributed to disruption of adjacent businesses should not be included in the daily I/D amount. Engineering judgment may be used to adjust the calculated daily amount downward (not upward) to a final daily I/D amount that:

(1) provides a favorable benefit/cost ratio to the traveling public where the cost is the daily I/D amount and the benefit is the calculated daily savings in road user and SHA costs.

(2) is large enough to motivate the contractor. If a favorable benefit/cost ratio cannot be realized and/or the resulting daily amount is not high enough to motivate a contractor, the project should not be further developed as an I/D project.

b. Currently, accepted SHA procedures for estimating road user costs may be used, or one of the following references may be used for estimating road user costs.

(1) A manual entitled "User Benefit Analysis of Highway and Bus--Transit Improvements," 1977, AASHTO, Washington, D.C.

(2) Participant Notebook: "Traffic Control for Streets and Highway Construction and Maintenance Operations," FHWA, 1978.

(3) "Planning and Scheduling Work Zone Traffic Control," Report #FHWA IP-81-6, FHWA, October 1981.

c. The vehicle operating costs should be based on the most recent information available. The 1982 FHWA study entitled "Vehicle Operating Costs, Fuel Consumption and Pavement Type and Condition Factors" (NTS PB 82-238676) may be used to supplement costs for the methodologies listed above. Caution should be exercised in using the data as some items included may not be applicable to costs incurred due to the construction activity, i.e., insurance, parking, tolls, taxes, etc.

d. Generally, the incentive daily rate should equal the disincentive daily rate. If different rates are selected, the incentive daily rate should not exceed the disincentive daily rate.

e. A cap of 5 percent of the total contract amount has been recommended as the maximum incentive payment. The 5 percent was based on the NEEP study average of incentive payments made on experimental I/D projects. In a survey by the Office of Program Review, "50 percent of the completed projects paid the maximum incentive." The placement of a cap on the incentive payment limits the funding requirements that may result if the time analysis was not realistic for an accelerated project time. With experience, the SHA may feel comfortable in not setting any maximum on the number of days for which an incentive can be earned. No cap should be placed on the maximum disincentive amount.

8. INCENTIVE/DISINCENTIVE TIME DETERMINATION. The determination of I/D time is one of the major problems facing an SHA when developing an I/D project. It must answer the question: to what extent and at what cost can construction be compressed from a normal construction time to an accelerated time?. If the contractor feels that the completion date is impossible to meet, he/she will not even try. In fact, unreasonable completion dates may well discourage potential bidders. However, the use of a normal computed time may allow the contractor to earn the maximum amount without making an increased effort. This would also penalize the public since the I/D phase(s) would not be completed as soon as possible. Most highway agencies will normally use either past performance or a CPM schedule to determine time.

a. Determination of I/D time based on past performance will require engineering judgment in determining to what extent the time can be compressed from normal construction time. Normal construction time is generally based on an average contractor working 5 days a week, 8 hours a day. To convert this to I/D time, the time should be based on the performance of a good contractor working extended shifts with extra workers for 6 or 7 days a week.

However, the use of a continuous 7-day workweek is cautioned against unless provisions can be made through shift assignments for days off. Extended periods of work with no days of rest has resulted in high turnover rates with contractor and inspection personnel.

b. The use of a CPM schedule is based on breaking down the project into the separate operations or processes necessary for its completion. These separate operations can then, through a network analysis, determine a completion time for the project. By supplying additional incremental resources of manpower and equipment, a further evaluation can be made as to the effects of accelerating the project.

c. The use of calendar days or completion date has proven to be most effective in controlling contract times. The dates for beginning and completion of the I/D work are then readily understood. The use of working days has not been effective in having projects completed by a specific date. The use of working days has placed the project engineer under undue pressure in determining whether the contractor should be charged a working day. In addition, it has created unnecessary conflict between the contractor and the project engineer.

d. The season of the year in which the project will be constructed should also be considered in determining the I/D time for calendar day projects. Weather days and legal holidays should be included for calendar day projects.

9. CONTRACT ADMINISTRATION. Cooperation and coordination between the contractor and the SHA is essential. The delay in approval of a field change or working drawings can be costly in time. Decisionmaking and approval authority should be promptly provided at all times that I/D work is in progress. If nighttime or weekend work is allowed, all offices that have decisionmaking and approval authority should designate a contact person with authority to make decisions for the agency represented. Several projects have been set up with

periodic meetings of all decisionmaking personnel to discuss project development during design and construction. These discussions should consider future critical operations and potential problems.

a. The contractor should be required to submit a CPM schedule for review and approval prior to commencement of work. This schedule will be the basic document to gauge and analyze the contractor's progress, determine time adjustments, and evaluate claims. Regularly scheduled job site progress meetings should be held for the purpose of updating the CPM schedule. Attachment 2 is a sample specification that is included in the "Construction Contract Claims" training manual. The reference to the Associated General Contractors of America CPM may be replaced by any other CPM the SHA has approved.

b. Extension of time on an I/D date should not be given unless extraordinary circumstances occur. The burden of proof to extend the I/D date must be on the contractor. The contractor must fully justify why concurrent operations, additional manpower, additional shifts, overtime, 24-hour workdays, 7-day workweeks, etc., cannot be used to keep the project on schedule. The SHA should consider all alternatives, including additional CE cost, to keep the project on schedule.

c. The I/D time adjustments shall be limited to only major work items affecting completion of items on the critical path and should be so identified in the contract. The effect of field changes and how field changes will be evaluated for time adjustments must be clearly spelled out in the project documents. The percentage of underrun or overrun should be substantial enough to warrant contract time changes.

(1) Extra and additional work should be expected by both the contractor and the SHA when establishing the I/D dates. Both parties should fully understand that the SHA is willing to pay for extra work, but it is to be absorbed within the current CPM schedule without any adjustment in the I/D dates.

(2) Because I/D projects are normally limited to one construction season. extensions of time will often extend into periods of adverse weather, resulting in further delays and cost to both the contractor and the traveling public. Moving an I/D date should only be done when all other avenues have failed.

(3) Time limits for certain actions should be included in the contract -- for example, 7 days for review and approval of shop drawings and 3 days for review and approval of unforeseen problems, etc., after notification by the contractor to the engineer.

d. Flow charts have proven very beneficial in establishing lines of communication and ensuring that all parties that have involvement in reviewing plans and shop drawings are contacted. Flow charts may include number of copies needed for submission, distribution of approved copies, and method of transmittal. Shop drawings may require handcarrying between contractor, reviewers, and approval authorities. However, the mail may be sufficient for transmitting copies for information or for files.

10. ROAD USER COSTS IN LOW BID DETERMINATION

a. The use of road user costs in low bid determination was approved for use on an experimental basis by the Federal Highway Administrator's memorandum dated May 20, 1985. This procedure allows the State to award a project to the low bidder based on a combination of the aggregate bid of individual contract items and a "bid" for the total time the contractor will use on the project. Each bid submitted shall consist of two parts:

(1) The dollar amount for all work to be performed under the contract.

(2) The total number of calendar days required to complete the work.

b. The lowest and best bid is then determined by the State according to the following formula: (A) + [(B) X road user cost per day]. This formula shall only be used to determine the lowest and best bidder and shall not be used to determine payments to the contractor.

c. Approval for the use of road user costs in low bid determination should be given on an experimental project basis in accordance with Mr. Rex Leathers' memorandum of May 30, 1985. As a minimum, both an interim report and final report shall be submitted to the Washington Headquarters Contract Administration Branch (HHO-32). The interim report of bid information and problems encountered by the contractors in the development of bids, if any, should be submitted after concurrence in award of the contract.

Thomas O. Willett
Acting Associate Administrator
for Engineering and Program
Development

Attachments

INCENTIVES/DISINCENTIVES (I/D) CHECKLIST ITEMS

When using I/D for early completion to minimize public inconvenience, maximize public safety, and reduce total costs to the traveling public, the following items should be considered when preparing contract special provisions.

1. Clearly define the beginning and ending dates for the critical work elements that are to be accomplished.

2. The use of calendar day or completion date contracts have proven most effective in controlling contract times. The dates for beginning and completing the I/D work are fully understood.

3. State the time the contractor is permitted to work, such as multiple shifts, weekends, holidays, etc., or conversely, when work should not be permitted.

4. Describe what working operations the contractor may or may not perform during nighttime hours.

5. Include the pay schedule for I/D:

   a. The pay schedule should relate money and time.

   b. Incentive payments should have a specified maximum time.

   c. Disincentive payments should be charged continuously until the critical elements have been completed.

6. List approved staging areas the contractor may use if this is a critical item.

7. Address underruns and overruns:

   a. Contractor time adjustments should be limited to only major work items and should be so identified in the contract.

b. The percent underrun or overrun should be substantial enough to warrant contract time changes.

c. Values and formulas can be specified that advise the contractor of the relationship between underruns and overruns and time extensions or time deletions.

8. The subject of strikes should be addressed as it relates to approving time extensions.

9. The contractor should be encouraged to stockpile materials, and the contract should specify which materials will be paid for as stockpiled materials.

10. All I/D projects shall require that the contractor have an approved critical path method (CPM) prior to starting work on the project.

    Regularly scheduled job site progress meetings should be held for the purpose of keeping the CPM on schedule. If the contractor should fall behind the CPM schedule, extra work measures should be prescribed until the contractor is back on schedule.

11. Identify what work is considered preparation, fabrication, and clean-up that may be outside the critical time path for fully opening a project to traffic.

12. Consider having legal counsel review the "language" of the contract provisions to avoid possible future claims.

13. Contracts involving bridge construction should take into account the time factor associated with shop drawing and erection procedure reviews and approvals. These two items can be an important factor in measuring and assessing contract time.

14. Incentive/Disincentive can be considered for specialty items within a contract (for example, erecting steel over another roadway that carries high traffic volumes and would require lane closure).

SUGGESTED STATE HIGHWAY ADMINISTRATION SCHEDULING SPECIFICATION

The construction of this project will be planned and recorded with a conventional critical path method (CPM) schedule based on the principles defined by the 1976 issue of "The Use of CPM in Construction" published by the Association of General Contractors. The schedule shall be used for coordination and monitoring of all work under the contract including all activity of subcontractors, vendors, and suppliers.

CONTRACTOR is responsible for preparing the initial schedule in the form of an activity on arrow diagram. All costs incurred by the CONTRACTOR in preparing the schedule shall be borne by the CONTRACTOR as part of its responsibility under this contract.

A. Preparation of Initial Schedule

Within 30 calendar days after the issuance of "Contract Award" prior to the "Notice to Proceed," CONTRACTOR will complete development of its initial schedule and present to the OWNER two copies of an activity on arrow diagram, an I node-J node computer sort and a Total Float Computer sort.

Following review of the initial submission and within 15 calendar days of its submission prior to "Notice to Proceed," OWNER and CONTRACTOR shall meet for joint review, correction, and adjustment of the schedule if required. The construction time, as determined by the schedule, for the entire project or any milestone shall not exceed the specified contract time. In the event that any milestone date or contract completion date is exceeded in the schedule, logic and/or time estimates will be revised.

After this meeting but within 15 calendar days after any changes in the logic and/or time estimates have been agreed upon, another submission of the schedule, including five copies of an activity on arrow diagram, an I node-J node computer sort, and a Total Float Computer sort, will be transmitted to the OWNER. If necessary, this process will be repeated; however, the schedule must be finalized within 30 days after "Notice to Proceed." Failure to finalize the schedule by that date will result in withholding all contract payments until the schedule is approved. Note that time charges shall begin no later than the time stipulated in the "Notice to Proceed."

No contract work may be pursued at the site without an approved CPM schedule.

B. Schedule Requirements

All activity on arrow diagrams provided by CONTRACTOR shall include:

1. activity nodes,

2. activity description, and

3. activity duration.

The activity on arrow diagram shall show the sequence and interdependence of all activities required for complete performance of all items of work under this contract, including shop drawing submittals, approvals, fabrication, and delivery activities. All network "dummies" are to be shown on the diagram.

No activity duration shall be longer than 20 workdays without OWNER'S approval.

OWNER reserves the right to limit the number of activities on the schedule to between 50-500 activities.

The activities are to be described so that the work is readily identifiable and the progress on each activity can be readily measured. For each activity, CONTRACTOR shall identify the trade or subcontractor performing the work, the duration of the activity in workdays and the location of the work.

CONTRACTOR shall also provide the following information: workdays per week, holidays, number of shifts per day, number of hours per shift, and major equipment to be used.

C. Schedule Updates and Progress Payments

Job site progress meetings will be held monthly by OWNER and CONTRACTOR for the purpose of updating the project work schedule. Progress will be reviewed to verify finish dates of completed activities, remaining duration of uncompleted activities, and any proposed logic and/or time estimate revisions. It is CONTRACTOR'S responsibility to provide OWNER with the status of activities at this progress meeting and with the process schedule updates based on this information once it has been verified.

Each month of the project, the CONTRACTOR will submit five copies of an updated I node-J node and Total Float Computer sort illustrating verified progress. Included shall be a written narrative describing the critical path and logic revisions or modifications to the schedule, including, but not limited to, changes in the method or manner of the work, changes in specifications, extra work, changes in duration, etc.

CONTRACTOR will further submit two copies of revised activity on arrow diagrams for the following: delay in completion of any critical activity; actual prosecution of the work which is, as determined by OWNER, significantly different than that represented on the schedule; the addition, deletion, or revision of activities required by contract modification; or any logic revisions. The contract completion time will be adjusted only for causes specified in this contract.

As determined by CPM analysis, only delays in activities which affect milestone dates or contract completion dates will be considered for a time extension.

If CONTRACTOR does seek a time extension of any milestone or contract completion date, it shall furnish documentation as required by OWNER to enable OWNER to determine whether a time extension is appropriate under the terms of the contract.

It is understood by OWNER and CONTRACTOR that float is a shared commodity.

Memorandum

U.S. Department of Transportation

Federal Highway Administration

Subject: **ACTION**: Special Experimental Project No. 14 Date: MAY 4 1995

From: Director, Office of Engineering Reply to Attn of: HNG-22

To: Regional Federal Highway Administrators
Federal Lands Highway Program Administrator

By previous memorandums you have been informed of the Federal Highway Administration's (FHWA) initiative to encourage States to use and evaluate promising innovative contracting practices under Special Experimental Project No. 14 (SEP 14). The purpose of this memorandum is to provide you updated information on SEP 14 activities, to advise you of several recent decisions, and to request your support in expanding the experimental use of innovative contracting practices.

Since initiation of SEP 14 in 1990, four innovative contracting techniques have been proposed, used and evaluated by a number of State highway agencies (SHA's). These techniques had previously been identified in Transportation Research Circular No. 386, *Innovative Contracting Practices* and/or the 1990 European Asphalt Study Tour report as having potential for successful use on Federal-aid highway projects. The techniques are:

- Cost-plus-time bidding,
- Lane rental,
- Design/build contracting, and
- Warranty clauses.

Attachment "A" contains a brief discussion of each technique.

The SEP 14 has been operational for over 5 years and approximately 65 percent of the SHA's have, on at least one occasion, participated. Attachments "B" and "C" list the States that have participated and the technique(s) they have chosen to use and evaluate. The participation of these SHA's in SEP 14, and the reports developed, have provided the information necessary to make a number of decisions for the future. These include:

- The cost-plus-time bidding approach, with its widespread successful use, has demonstrated definite beneficial application to the Federal-aid highway program to reduce construction time for critical projects that have high road user delay impacts. The use of lane rental can similarly be an effective technique to significantly reduce these impacts. Although lane rental has not been as widely used and evaluated as cost-plus-time bidding, it is not difficult to administer and its use does not compromise any existing FHWA policy. For these reasons, we have determined that these techniques (cost-plus-time and lane rental) have proven their suitability for use as nonexperimental, operational practices. The SHA's are encouraged to consider the use of these techniques for future projects with high road user impacts.

- The use of warranty clauses should be a permissible practice on Federal-aid projects. We have begun a rulemaking effort to revise the presently prohibitive warranty regulation (23 CFR 635.413) to permit States to use warranty clauses in Federal-aid highway contracts. However, the regulation will contain general criteria to ensure that contractors will not be required to be responsible for items not under their control.

- Although there is support from some SHA's to use and evaluate the design/build contracting method, a large portion of the industry has expressed strong disapproval. Due to lack of support from the highway community, we have decided that no special emphasis, beyond the SEP 14 initiative, should be made to promote the design/build/warrant concept at this time. We will continue to approve use and evaluation of design/build contracting under SEP 14.

A review of Attachments "B" and "C"* reveals that a number of SHA's have participated in multiple SEP 14 projects. The use of SEP 14 to test and report on new promising techniques, that have the potential to improve the quality of highway construction, is highly beneficial to our industry. As concepts are successfully evaluated and made operational (i.e., cost-plus-time bidding and lane rental), others are being proposed for evaluation to take their place (i.e., indefinite delivery contracting and cost-plus-quality bidding). All SHA's should be encouraged to identify and evaluate at least one technique that is new to that State.

If you have any comments or questions regarding SEP-14 or would like to discuss any specifics of a proposed innovative contracting practices concept, please contact Mr. Allan Rockne of the Contract Administration Branch at (202) 366-1562.

William A. Weseman

3 Attachments

* Attachments B and C are not included in the "Developing Traffic Control Strategies" Notebook.

INNOVATIVE CONTRACTING TECHNIQUES

Cost-Plus-Time Bidding:

Cost-plus-time bidding, also referred to as the A+B method, involves time with an associated cost, in the low bid determination. Under this method, each bid submitted consists of two components:

- The cost or "A" component is the traditional bid for the contract items and is the dollar amount for all work to be performed under the contract.
- The time or "B" component is a "bid" of the total number of calendar days required to complete the project, as estimated by the bidder.

The bid for award consideration is based on a combination of the bid for the contract items and the associated cost of the time, according to the formula:

$$(A) + (B \times \text{Road User Cost} / \text{Day})$$

This formula is only used to determine the lowest bid for award and is not used to determine payment to the contractor.

A disincentive provision, that assesses road user costs, is incorporated into the contract to discourage the contractor from overrunning the time "bid" for the project. In addition, an incentive provision is usually included to reward the contractor if the work is completed earlier than the time bid. The value of the road user cost is predetermined by the contracting agency and specified in the proposal. It is based on costs such as road user delay time, any detour costs, construction engineering costs, etc.

Lane Rental:

Like cost-plus-time bidding, the goal of the lane rental concept is to encourage contractors to minimize road user impacts during construction. Under the lane rental concept, a provision for a lane rental fee assessment is included in the contract. This fee rate is based on estimated cost of delay to the road user during the rental period. The fee is assessed for the time that the contractor occupies or obstructs part of the roadway and is deducted from the monthly progress payments.

The rental fee rates are stated in the bidding proposal in dollars per lane per time period, which could be daily, hourly or fractions of an hour. Neither the contractor nor the contracting agency give an indication as to the anticipated amount of time for which the assessment will apply and the low bid is determined solely on the lowest amount bid for the contract items.

The intent of lane rental is to encourage contractors to schedule their work to keep traffic restrictions to a minimum, both in terms of duration and number of lane closures. This concept has merit for use on projects that significantly impact the traveling public; major urban area projects are prime candidates for this approach.

Design/Build Contracting:

With the design/build approach, the contracting agency identifies the end result parameters and establishes the design criteria minimums. The prospective bidders then develop design proposals that optimize their construction abilities. The submitted proposals are rated by the contracting agency on factors such as design quality, timeliness, management capability and cost.

By allowing the contractor to optimize his/her work force, equipment and scheduling, the design/build concept opens up a new degree of flexibility for innovation. However, along with the increased flexibility, the contractor must also assume greater responsibility. Extended liability insurance or warranty clauses may be used to ensure that the finished product will perform as required.

From the contracting agency's perspective, the potential time savings is a significant benefit. Since the design and construction are performed through one procurement, construction can begin before all design details are finalized. Also, because both design and construction are performed under the same contract, claims for design errors or construction delays due to redesign are not allowed and the potential for other types of claims is greatly reduced.

The Office of Chief Counsel reviewed the design/build concept for compatibility with current Federal laws and regulations. It is their position that Federal-aid funds may participate in design/build contracts when approved under SEP-14 and awarded using competitive bidding procedures. However, the approach should only be applied to those projects for which the end product or facility can be well defined.

Warranty Clauses:

Warranties have been successfully used in other countries and by some States on non-Federal projects to protect investments from early failure. Currently there is a regulation (23 CFR 635.413) that restricts the use of warranties on Federal-aid projects to electrical and mechanical equipment. The rationale for the restriction is that such contract requirements could indirectly result in participation in maintenance costs, and the use of Federal-aid funds for normal maintenance purposes is prohibited by law.

However, an exception to this restriction was made possible as a result of the 1991 Highway Act, the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). The Act provides certain program flexibilities for Federal-aid projects off the National Highway System (NHS) when a State chooses to request an exemption. Under these conditions, warranty clauses may be used in accordance with State procedures.

Under SEP 14, the FHWA has approved warranty concepts with the objective of encouraging improved quality and contractor accountability without shifting the maintenance burden to the contractor. Ordinary wear and tear; damage caused by others, and routine maintenance remain the responsibility of the State.

APPENDIX B

SAMPLE SPECIAL PROVISIONS

1. Road Closure and Detour
2. Moveable Concrete Barrier - Special Provisions and Letter of Public Interest Finding
3. Leapfrogging
4. Night Work - Washington State DOT
5. A + B Bidding
6. Lane Rental - Daily Basis
7. Lane Rental - Hourly Basis
8. FP-96 Traffic Signal Installation

Road Closure Special Provision

FP96

635.03 Supplement

In addition, the work will consist of closing Route A from Point X to Point Y. Establish a detour route on Route B from Point X to Point Y in accordance with the contract, TCP, MUTCD, Section 635, and this section. Provide access to Route A.

Item 11619.3810

D256067

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MOVEABLE CONCRETE TRAFFIC BARRIER TRANSFER AND TRANSPORT VEHICLE

DESCRIPTION. This item shall consist of furnishing a Moveable Concrete Traffic Barrier Transfer and Transport Vehicle (Vehicle) the requirements noted herein, and providing the maintenance of the Vehicle during the work. The item shall also include training Vehicle operators and supplying operation/maintenance manuals.

The Vehicle is a patented and patent-pending product and may be obtained from [redacted] through [redacted] (914) 636-1000.

MATERIALS. The Vehicle shall be self propelled and in good working condition.

The Vehicle shall be capable of performing the following functions:

(1) Lateral transfer of continuous lengths of Moveable Concrete Traffic Barrier (MCTB) from four (4) to eighteen (18) feet in one (1) inch increments;

(2) Pick-up and transport of a minimum of fifty (50) feet of MCTB at one time;

(3) Operation under all the restrictions of the contract (i.e. rough pavement);

(4) Maintaining a forward speed of at least five (5) miles per hour while making lateral transfer moves of the MCTB.

The Vehicle shall be equipped with a Capstan Drive and an engine block heater.

CONSTRUCTION REQUIREMENTS.

(1) General

The Vehicle designated for use under this item is to be used in conjunction with the handling of traffic through work areas as indicated under the provisions for maintenance and protection of traffic provided in this contract, as shown on the detailed plans or, as directed by the Engineer.

(2) Maintenance.

The Vehicle shall be stored, when not in use, in an approved, storage area. The Contractor shall be required to perform all maintenance operations recommended by the manufacturer of the Vehicle. 237

The Vehicle shall be kept in good repair at all times. The Contractor shall expedite repairs necessitated by malfunction of or damage to the Vehicle. Maintenance shall include the periodic cleaning of the Vehicle along with the repair of damage to the protective coating of the Vehicle.

The Contractor shall have on hand at all times sufficient spare parts and necessary, trained personnel to insure that the lane configurations are available at the required times. Failure to move or to be able to move the MCTB at the proper time will be regarded as a substantial deficiency in compliance under the item for Basic Maintenance and Protection of Traffic and will result in a day's non-payment thereof and additionally may result in the assessment of liquidated damages in accordance with §619-5 Basis of Payment General.

At the completion of the project the Vehicle will not be retained by the State.

MEASUREMENT. Measurement shall be by each individual Vehicle.

PAYMENT. The Vehicle specified under this item, measured as provided for under "Measurement", shall be paid for at the contract unit price bid for "Moveable Concrete Traffic Barrier Transfer and Transport Vehicle", which price shall be full compensation for furnishing the Vehicle to the project, for the use of the Vehicle during the project and for maintenance and operation of the Vehicle during the project. This price shall also include all equipment, tools, labor, services, supplies and incidentals necessary to keep the Vehicle in functional state. Payment shall also include the cost of training Vehicle operators by the manufacturer or its representative.

Payment will be made at the lump sum price bid for Moveable Concrete Traffic Barrier Transfer and Transport Vehicle as follows:

Eighty (80) percent when the vehicle is on the job site and operational and operator training is completed and twenty (20) percent when the vehicle is permanently removed from the job site.

ITEM 11619.3611

LATERAL MOVEMENT OF MOVEABLE CONCRETE TRAFFIC BARRIER

DESCRIPTION. This item shall consist of the lateral movement of the Moveable Concrete Traffic Barrier (MCTB) from the storage position to the deployed position and from the deployed position to the storage position as shown on the plans or as ordered by the Engineer.

MATERIALS. None.

CONSTRUCTION REQUIREMENTS. Prior to the each daily lateral movement of the MCTB the Contractor shall give the Engineer ample notice as to the when such movement will begin.

MEASUREMENT. Measurement will be the number of linear feet of MCTB moved per relocation.

PAYMENT. The price bid per thousand linear feet per movement shall cover the cost of furnishing all labor and necessary incidentals required to position the MCTB in either the storage or deployed position. This price shall also include the cost of placing or removing individual barrier sections as may be required. Incidental movement of the barrier to achieve proper alignment or to realign barrier sections disturbed by traffic shall be included in the price bid.

ITEM 11615.2612

D256067

MOVEABLE CONCRETE TRAFFIC BARRIER
(SUPPLY AND REMOVE)

DESCRIPTION. Under this work the Contractor shall furnish, assemble, maintain and remove the Moveable Concrete Traffic Barrier (MCTB) at the locations designated in the contract documents or as directed by the Engineer.

MATERIALS. MCTB shall be fabricated from materials conforming to the following specifications:

Reinforcing Bars	§709-01 or §709-03;
Steel Plates for Hinges	ASTM A36, ASTM A588, ASTM A441 or ASTM A572;
Through Bolts (Fully Threaded)	ASTM A449;
Nuts	ASTM A563, Grade DM;
Washers	ASTM F944.

Precast concrete barrier units for MCTB shall conform to the requirements of §704-05 Precast Concrete Median Barrier except that NYSDOT approved materials and epoxy coated reinforcement are not required unless specified otherwise. The precast concrete barrier units for MCTB shall conform to the details shown herein.

CONSTRUCTION DETAILS. Each run of MCTB shall be placed at the locations indicated in the contract documents or where directed by the Engineer. The individual units of the barrier shall be fastened together, as specified by the manufacturer, to form a continuous chain to facilitate movement and placement by the transfer and transport vehicle.

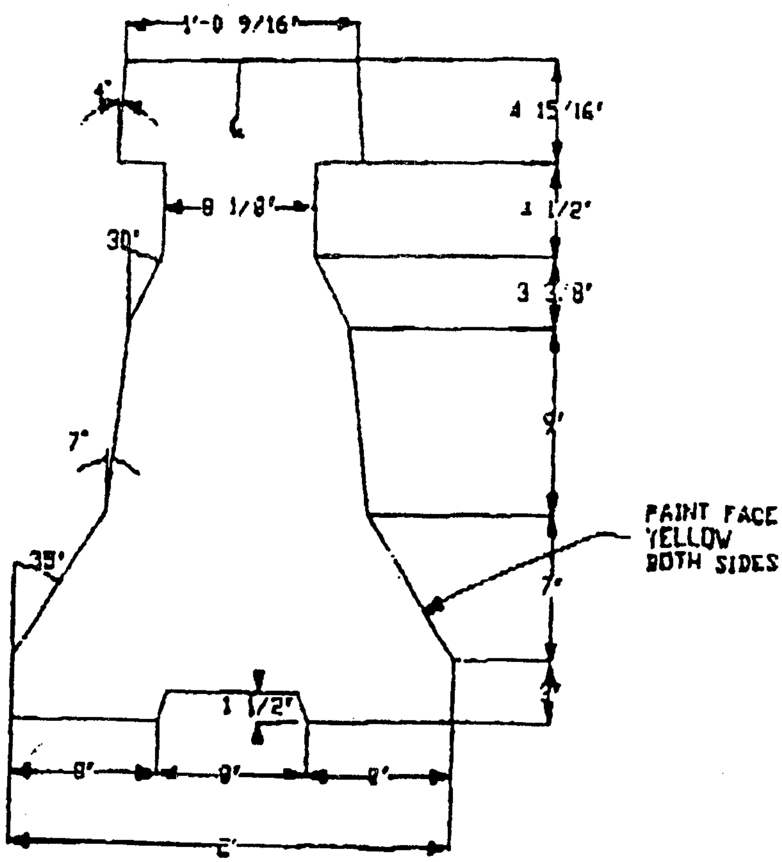
The Engineer will inspect the MCTB upon delivery to the project site. Any barrier sections having damage or defects in the concrete or the joint connections that will affect the performance of the system as determined by the Engineer, will be rejected and replaced with a suitable unit.

Any unit which is damaged or rendered unsuitable by the Contractor's operations or adjacent traffic, as determined by the Engineer, shall be removed from the site and replaced with a suitable unit by the contractor.

METHOD OF MEASUREMENT. This work will be measured by the number of linear feet of MCTB furnished, assembled, maintained and removed in accordance with the requirements of this specification and the directions of the Engineer.

240 BASIS OF PAYMENT. The unit price bid per linear foot shall include the cost of furnishing, assembling, maintaining, and removing MCTB units. The unit price bid shall also include the cost of removing and replacing barrier units damaged or made unsuitable by the contractor's operations or by adjacent traffic. The transfer and transport vehicle and lateral movement of the MCBT will be paid for under their respective items. The price bid for this item shall also include the one time relocation of the barrier from the northbound roadway to the southbound roadway or from the southbound roadway to the northbound roadway.

After assembly payment will be made for ninety (90%) percent of the quantity of MCTB furnished and assembled in accordance with the contract requirements. The remaining ten (10%) percent will be paid upon removal.



Memorandum

U.S. Department of Transportation
Federal Highway Administration

Subject: Quickchange Moveable Barrier System

Date: March 25, 1994

From: Executive Director

Reply to Attn of: HHS-11

To: Regional Administrators
Federal Lands Highway Program Administrator

This is to provide guidance, including a public interest finding, for the acceptance of the Quickchange Moveable Barrier System (QMB). Because the QMB is both a proprietary and a sole source product, this memorandum addresses several contract administration related issues about its use on Federal-aid projects.

The QMB is comprised of a series of interconnected sections of modified concrete safety barrier and a specially designed transport vehicle.

The QMB is specifically designed for rapid lateral transfer of the safety barrier. It is estimated the time required for initial barrier setup and final disassembly is one-half to two-thirds of that for the conventional portable concrete barrier. It is also estimated the setup time of the QMB is two to three times quicker than for channelizing drums, based on an equivalent crew size.

The QMB system has been acceptably crash tested according to safety performance criteria and has performed successfully in field use. Over the past 6 years, it has been evaluated in a number of States and found to be particularly applicable in two areas: (1) as a moveable barrier for reversible lane applications, and (2) as a work zone safety barrier. It is especially suitable for construction projects on high volume, congested urban freeways or expressways.

The first contract administration issue relates to the QMB being a patented product with no known acceptable equal. Since it cannot be bid in competition with other equivalent products, it can only be specified in a Federal-aid project if it is classified as an experimental feature or no equally suitable alternative exists.

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The benefits of a quick moveable barrier system like the QMB are well documented for use on construction improvements which require positive protection for travelers and workers, a frequent change of barrier location to accommodate traffic needs, and where alternative construction phasing and traffic handling schemes are not justified. Moveable barrier systems are also suitable for permanent incorporation into a project designed to accommodate unbalanced traffic flows on high volume facilities through the use of reversible traffic lanes.

Based on our review of the available products and the extraordinary operational and safety benefits of the QMB, we have found it is in the public interest to advise the States that a suitable alternative product is not available. Therefore, States' requests to use the QMB on appropriate projects, including any premium or royalities, will be approved for Federal participation.

The second contract administration issue is equipment purchase participation. If the QMB system is purchased for permanent installation as part of a project, our normal project reimbursement procedures are in effect. However, if a State desires to purchase the QMB through a Federal project for potential use on future projects, our equipment reimbursement policy should be followed. The major points of this policy are as follows:

- As reiterated in Mr. Willett's May 5, 1993, memorandum to the Regional Administrators (copy attached), the policy prohibits the direct purchase of equipment with Federal funds. While this memorandum addressed "construction engineering equipment," the policy also holds true for other equipment temporarily used on a construction project by either the State or the contractor.

- The allowable cost of equipment chargeable to a specific project should be based on that proportion of useful life that the equipment is used on that project. This policy is consistent with the cost principles contained in OMB Circular A-87.

Moveable barrier systems like the QMB definitely have a place in highway operations and construction projects. When proposed by a State for appropriate projects, we fully support the use of such a system. The QMB is eligible for Federal participation, regardless of experimental status, in accordance with the above guidance.

E. Dean Carlson

E. Dean Carlson

Attachment

Leap Frogging Special Provision

156.03 Supplement

Maximum lane closure allowed is 2.0 miles. When construction operations (i.e., paving) requires more than 2.0 mile lane closure, establish an additional lane closure at the end of the existing lane closure and remove existing lane closure as soon as roadway is ready and use second closure.

NIGHT TIME WORK

The City of Seattle has granted a variance to their noise ordinance for night work within the project limits. Night time work under this contract shall be restricted to the traffic control set-up unless otherwise approved by the Engineer in writing. In no case shall the Engineer approve other work between the hours of 10 P.M. to 7 AM. weekdays and 10 P.M. to 9 A.M. weekends without the consent of the City of Seattle. This variance allows the Contractor to exceed the local noise ordinance levels under the conditions outlined in this section and is approved for 14 night periods.

Except in the case of emergency, whenever the Contractor works between the night time hours of 10 P. M. to 7 A.M. Monday through Friday or 10 P.M. to 9 A.M. on Saturday through Sunday and exceeds the local ordinance noise levels. the Contractor shall have in his possession. a variance which covers such work. The Contractor shall in addition to other restrictions of this section or other ordinances, perform the following measures to minimize construction noise:

All use of impact tools such as jackhammers and impulse tools such as pavement grinders shall be restricted to the hours of 7 A.M. to midnight Monday through Friday and 9 A.M. to midnight on Saturday and Sunday.

All trucks performing export haul shall have rubber bed liners between the hours of 10 P.M. and 7 A.M. Monday through Friday and between 10 P.M. and 9 A.M. on Saturday and Sunday.

All backup warning devices shall be the least intrusive ambient sensitive type or the contractor may use a backup observer in lieu of backup warning devices as allowed by WAC Chapter 296-155-610 (2) (e).

Lighting used for night time work shall. where ever possible. be directed away from oncoming traffic and residences or shielded.

Any material or debris that spilled on the pavement shall be removed by hand or by sweeping. The contractor shall employ no scraping type equipment or activity to clean pavement surfaces.

Failure of the Contractor to perform all obligations under this section will result in the suspension of all night work.

The contractor shall be responsible to obtain any variances to perform work outside the project limits or within the project limits in addition to the variance already obtained by the State. A copy of the variance obtained by the State. A copy of the variance obtained by the State is available at the project construction office.

Other noise mitigation measures may be required. and it is understood that the Contractor is responsible for devising methods that comply with all ordinances. Compliance with the above noise mitigation measures shall not be considered a warranty that the equipment or the activity will comply with all local regulations.

Sample Special Provision
Project No. ______

A+B METHOD

A. GENERAL

The process for bidding will take into account not only the contract amount bid but also the bidder's stated delivery time in which the project (or specified phase of the project) [1] will be substantially complete. This method shall only be used to determine the successful bidder. It shall not be used to determine the award amount nor final payment to the contractor when the project is completed.

B. DEFINITION OF TERMS

For this project the following definitions apply:

(a) Calendar Day - Any day or portion of a day on the calendar including Saturdays, Sundays, and legal holidays, beginning and ending at midnight.

(b) Contract Amount - The summation of the products of the quantities shown in the bid schedule multiplied by the unit bid prices.

(c) Daily road user cost - The amount which represents the average daily cost of interference and inconvenience to the road user. The daily road user cost is $ [2] .

(d) Substantially complete - When all project work (or the work for a specified phase of the project) requiring lane or shoulder closures or obstructions is completed, and traffic is following the lane arrangement as shown on the plans for the finished roadway (or the specified phase of work). All pavement construction, resurfacing, traffic control devices, and pavement markings shall be in their final position (or as called for in the plans for the specified phase of work) at this time.

C. PREPARATION OF PROPOSAL

The bidder shall establish the number of calendar days to be used to substantially complete the project (or specified phase of the project).

The total number of calendar days established by the bidder to substantially complete the project (or specified phase of the project) shall not exceed [3] days. Bids showing time for completion in excess of this amount will be considered non-responsive.

The product of the number of calendar days proposed by the bidder multiplied by the daily road user cost of $ [2] per calendar day shall be added to the contract amount bid. The sum will be the amount used for consideration of bids for award.

D. CONSIDERATION OF BIDS

Each bid submitted shall consist of two parts:

(A) The contract amount.

(B) Total number of calendar days proposed by the bidder to substantially complete the project (or specified phase of the project).

The successful bid will then be determined by the Department as the lowest combination of (A) and (B) according to the following formula:

(A) + [(B) x (daily road user cost)] = Bid amount for award consideration

The preceding formula shall be used only to determine the successful bidder and shall not be used to determine the contract award amount nor final payment to the contractor when the project is completed. Only the unit prices shall be used to determine final payment to the contractor, except as may be adjusted under Sections E and F of this contract provision.

E. EARLY OPENING OF PROJECT (OR SPECIFIED PHASE OF PROJECT) TO UNRESTRICTED HIGHWAY TRAFFIC

The Contractor will be paid $ [2] for each calendar day the project (or specified phase of the project) is substantially complete before the number of calendar days stated by the contractor in the bid. The total number of calendar days for incentive payment may not exceed [4] days.

F. FAILURE TO SUBSTANTIALLY COMPLETE THE PROJECT (OR SPECIFIED PHASE OF THE PROJECT) IN THE TIME BID

Failure to substantially complete the project (or specified phase of the project) within the established number of calendar days stated by the contractor in the bid will result in the daily road user cost of $ [2] being assessed for every calendar day in excess of the stated number, up to the time in which the project (or specified phase of the project) is substantially complete.

This assessment will be deducted from any monies due or to become due the contractor.

The engineer will be the sole authority in determining as to when the project (or specified phase of the project) is substantially complete.

G. FAILURE TO COMPLETE ALL WORK ON TIME

Following substantial completion, for each calendar day that any work shall remain uncompleted after the contract time prescribed for the completion of all work, $ [5] will be deducted from any money due the contractor, not as a penalty, but as liquidated damages.

Notes:

[1] The time element (i.e. B part) of the A+B method can be applied to the project as a whole or to specific critical phase or phases of a project (i.e. bridge(s)).

[2] Amount of the average daily oad user costs as justified and documented by the contracting agency. This amount is applied as an incentive for every day the contractor finishes before the number of days stated by the contractor in the bid or as a disincentive for every day the contractor finishes after the number of days stated by the contractor in the bid. The incentive amount which is indicated in the contract must be the same as the disincentive amount.

[3] The maximum number of calendar days allowed by the contracting agency for substantial completion of the project (or specified phase of the project).

[4] A maximum number of calendar days should be included so that the contracting agency has greater control of their expenditures. However, the maximum number of days should be set at a level which encourages the contractor to complete the project (or specified phase of the project) as early as possible.

[5] The liquidated damages rate should be based on construction engineering inspection costs and in cases where there is a public need, may also include road user costs. Since construction engineering inspection costs and road user costs are also included in setting incentive/disincentive (I/D) amounts, in the administration of contracts which include both I/D clauses and liquidated damages, the contracting agency must be sure that the contractor is not charged twice (both as a disincentive and as a liquidated damage) for the same cost being incurred, be it construction engineering inspection or road user costs.

FHWA/HNG-22/S.J.GAJ
November 15, 1991

Sample Special Provision
Project No. ____

LANE RENTAL FOR CONSTRUCTION - DAILY BASIS

A. GENERAL

Monetary assessments will be made against the contractor for each calendar day there are restrictions or a reduction in the number of available travel lanes or shoulder width.

B. DEFINITION OF TERMS

For this contract the following definitions apply:

(a) Calendar Day - Any day or portion of a day on the calendar including Saturdays, Sundays and legal holidays, beginning and ending at midnight.

(b) Rental Charge - The amount, as shown in the proposal, which represents the average daily cost of interference and inconvenience to the road user for each lane and/or shoulder closure or obstruction.

(c) Obstruction - When the contractor's operations have resulted in the useable lane width of the travelway or shoulder to be less than that specified in the plan documents.

C. LANE RENTAL

This contract includes a lane rental procedure under which the contractor is assessed a rental charge for each lane and/or shoulder closure or obstruction from the time of Notice to Proceed until such time that the project is complete.

One lane of the roadway shall remain open for each direction of traffic at all times. The rental charge to be assessed for each lane or shoulder closure or obstruction per direction of traffic per calendar day is as follows:

Closure and/or obstruction	Daily[1] Rental Charge
one lane	$ 20,000
one shoulder	$ 5,000
one lane and shoulder	$ 25,500
two lanes	$ 45,000
two lanes and shoulder	$ 50,000

The applicable lane rental charges will be deducted from any monies due the contractor for work performed. The deduction will be made based on the applicable rate for any and all closures or obstructions whether work is being performed or not. This deduction will be done on each progress payment.

D. FAILURE TO COMPLETE WORK ON TIME

All contract work shall be completed by [2]. For each calendar day that any contract work remains uncompleted after the contract time prescribed for the completion of all work, $ [3] will be deducted from any money due the Contractor, not as a penalty, but as liquidated damages.

On those days when the contractor is to be charged the liquidated damages fee, but the contractor has closed or obstructed a lane and/or shoulder, the contractor will be charged the greater amount, either the appropriate lane rent or the liquidated damages fee indicated.

This assessment will be deducted from any monies due or to become due the contractor.

Notes:

[1] This sample specification has been written in a manner such that rent is to be charged for every calendar day which a lane and/or shoulder is closed or obstructed, with any portion of a calendar day treated as a whole calendar day. The rental rates included in this example are included only for example purposes. Rental rates need to be determined for each project based on actual user costs for that project. As an option, portions of a calendar day could be handled as fractional periods (i.e. 6 hrs. or 12 hrs.) and the daily rental charge applied proportionally.

[2] A maximum number of calendar days should be specified to encourage the contractor to complete the project as early as possible.

[3] The liquidated damages rate should be based on construction engineering inspection costs and in cases where there is a public need may also include road user costs. Since construction engineering inspection costs and road user costs may be included in setting lane rental rates, in the administration of contracts

which include both lane rental and liquidated damages, the contracting agency must be sure that the contractor is not charged twice (both as rent of a lane or shoulder and also as a liquidated damage) for the same cost being incurred, be it construction engineering inspection or road user costs.

Sample Special Provision
Project No. ____

LANE RENTAL FOR CONSTRUCTION - HOURLY BASIS

A. GENERAL

Monetary assessments will be made against the contractor for each hour there are restrictions or a reduction in the number of available travel lanes or shoulder width.

B. DEFINITION OF TERMS

For this contract the following definitions apply:

(a) Calendar Day - Any day on the calendar including Saturdays, Sundays and legal holidays, beginning and ending at midnight.

(b) Hour - Any continuous 60-minute period or portion of a continuous 60-minute period beginning at that point when a lane and/or shoulder is closed or obstructed by the contractor's operation.

(c) Rental Charge - The amount, as shown in the proposal, that represents the average hourly cost of interference and inconvenience to the road user for each lane and/or shoulder closure or obstruction.

(d) Obstruction - When the contractor's operations have resulted in the useable lane width of the travelway or shoulder to be less than that specified in the plan documents.

C. LANE RENTAL

This contract includes a lane rental procedure under which the contractor is assessed a rental charge for each lane and/or shoulder closure or obstruction from the time of Notice to Proceed until such time that the project is complete.

One lane of the roadway shall remain open for each direction of traffic at all times. The rental charge to be assessed for each lane and/or shoulder closure or obstruction per direction of traffic per hour [1] is as follows:

Closure and or obstruction	Hourly[2] Rental Charge	Hourly[2] Rental Charge
	6:30 - 9:00 AM 3:00 - 6:00 PM	All other hours of the day
one lane	$ 2,000	$ 500
one shoulder	$ 500	$ 125
one lane and shoulder	$ 2,500	$ 625
two lanes	$ 4,500	$ 1,250
two lanes and shoulder	$ 5,000	$ 1,375

The applicable lane rental charges will be deducted from any monies due the contractor for work performed. The deduction will be made based on the applicable rate for any and all closures whether work is being performed or not. This deduction will be done on each progress payment.

D. FAILURE TO COMPLETE WORK ON TIME

All contract work shall be completed by [3]. For each calendar day that any contract work remains uncompleted after the contract time prescribed for the completion of all work, $ [4] will be deducted from any money due the contractor, not as a penalty, but as liquidated damages.

On those days when the contractor is to be charged the liquidated damages fee, but the contractor has closed or obstructed a lane and/or shoulder, the contractor will be charged the greater amount, either the appropriate lane rent or the liquidated damages fee indicated.

This assessment will be deducted from any monies due or to become due the contractor.

Notes:

[1] In some unusual situations, where opening the roadway to traffic is extremely critical, having rental rates for portions of an hour, such as 15-minute increments may be considered.

[2] This sample specification has been written in a manner such that rent is to be charged for every hour a lane and/or shoulder is closed or obstructed, with any portion of an hour treated as a whole hour. The rental rates included in this example are included only for example purposes. Rental rates need to be determined for each project based on actual user costs for that project.

[3] A maximum number of calendar days should be specified to encourage the contractor to complete the project as early as possible.

[4] The liquidated damages rate should be based on construction engineering inspection costs and in cases where there is a public need

may also include road user costs. Since construction engineering inspection costs and road user costs are also included in setting lane rental rates, in the administration of contracts which include both lane rental and liquidated damages, the contracting agency must be sure that the contractor is not charged twice (both as rent of a lane or shoulder and also as a liquidated damage) for the same cost being incurred, be it construction engineering inspection or road user costs.

636.06 Installation of Signal and Lighting Systems. Add the following:

In addition, the following additional requirements apply:

(a) **Signal installation.** Commercial power is available for the signal system at this site. Provide an electrical generator as a backup power source capable of operating the traffic signals and the lighting system in the event of failure or a power failure. Equip the backup generator with fuel tanks of sufficient size for continuous operation of at least 5 days.

The 2 power supplies shall be so interconnected that if the main power source fails, the emergency power will automatically be activated and the signals and lighting system will be operational in less than 30 seconds. When power is restored, the emergency power system shall automatically return to standby mode.

Install the signal timing device in a lockable control box in a convenient location. Set the signal system so that both signal heads will normally indicate a stop condition so that any vehicle entering the construction site, will be required to come to a full stop before proceeding through the detour. The timing device and preprogrammed cycle will start only when a vehicle is detected by one of the sensor loops. Set the timing device to have an all-red interval of sufficient duration to clear traffic, traveling at a reasonable speed, from the single lane detour structure. The CO will determine the light duration time. Provide the CO with 3 keys to the control box.

Provide a complete, temporary lighting system for the signal system and Traffic Control Plan. Provide 40-foot light poles, with either conventional highway luminaries or sign lighting luminaries.

(b) **Lighting installation for White River Trailhead and Crystal Mountain intersection.** Coordinate removal of existing lights and installation of new lights such that service is not interrupted. Install overhead lights according to the plans and the Washington State Electrical code.

APPENDIX C

ROAD USER COST CALCULATIONS

General.

The bidder is hereby notified that the Idaho Transportation Department is using a special bidding procedure for this project.

The process of bidding will take into account not only the price offerings of the bidder but also the speed with which the contractor can provide a usable facility to the traveling pubic.

The contractor is advised that in order to open the I-184 eastbound ramp structures to unrestricted traffic flow in or before the number of calendar days proposed in his bid it may be necessary to provide multiple crews, work overtime, and/or weekends and holidays.

Preparation Of Proposal.

In addition to the requirements of Subsection 102.04 of the Standard Specifications, the bidder shall establish the number of calendar days necessary to widen the Franklin ramp, rehabilitate the two (2) I-184 eastbound ramp structures, and reopen those structures to unrestricted highway traffic in its ultimate location in accordance with the plans and specifications. The number of calendar days shall be indicated in the bid proposal.

The product of this number of calendar days proposed by the bidder multiplied by the daily road user cost of *$13,000* per calendar day shall be added to the total bid amount determined from bid items. The sum of these two amounts will be the amount used for the comparison of bids.

The total number of calendar days established by the bidder to open the I-184 eastbound ramp structures to unrestricted highway traffic in its ultimate location shall not exceed *32* calendar days or May 27, 1993. Bids showing time in excess of these amounts will be considered non-responsive.

Proposal Guaranty.

As a supplement to Subsection 102.06 of the Standard Specifications, it will not be necessary for the proposal guaranty to include an amount to cover the product of calendar days times the daily road user cost.

ACCELERATING PROJECT COMPLETION (INCENTIVE/DISINCENTIVE CLAUSE)

Consideration Of Bids.

Each bid submitted shall consist of two parts:

(A) The dollar amount for all work performed under the contract.

(B) The total number of calendar days required to widen the Franklin ramp, rehabilitate two (2) I-184 eastbound ramp structures, and open those structures to unrestricted highway traffic in its ultimate location.

The lowest and best bid price will then be determined by the department as the lowest combination of (A) and (B) according to the following formula:

(A) + [(B) x Road User Cost] = Bid amount for award consideration

where *$13,000* per calendar day is the stipulated adjustment for road user costs. The preceding formula shall only be used to determine the lowest and best bidder and shall not be used to determine final payments to the contractor when the project is completed. Only the unit bid prices shall be used to determine final payment to the contractor.

Extension Of Contract Time.

Contract time for opening the I-184 eastbound ramp structures to unrestricted highway traffic in its ultimate location will be on a calendar day basis proposed by the successful bidder.

The Resident Engineer shall be the sole judge as to what and whether a time extension shall be considered justifiable according to Subsection 108.06 of the Standard Specifications. Each extension granted shall be documented in writing by the Resident Engineer with reason for extension.

Early Completion Of Work Necessary To Open I-184 Eastbound Ramp Structures To Unrestricted Highway Traffic.

The contractor will be paid an incentive payment of $13,000 for each calendar day the I-184 eastbound ramp structures are open to unrestricted traffic in its ultimate location before the established completion date determined from the calendar days proposed by the successful bidder, not to exceed an amount equal to ten (10) percent of the awarded contract amount.

The incentive payment will be paid by change order.

Failure To Open I-184 Eastbound Ramp Structures To Unrestricted Highway Traffic On Time.

The contractor will be assessed a disincentive charge equal to but not greater than the Road User Cost of *$13,000* for each calendar day beyond the calendar days bid by the contractor until the I-184 eastbound ramp structures are open to unrestricted highway traffic in its ultimate location. There shall be no limit on the total amount assessed.

The disincentive charge will be processed by change order.

The I-184 eastbound ramp structures will be open to unrestricted highway traffic in its ultimate location when all work requiring lane closures is complete and traffic is following the lane arrangements as shown on the plans for the finished roadway. This will include all bridge rehabilitation construction, resurfacing, and all other traffic control devices in their final position.

The Resident Engineer shall be the sole authority in determining when the I-184 eastbound ramp structures are complete to safely open the highway to unrestricted traffic in its ultimate location.

Failure To Complete All Work On Time.

Following opening the highway to unrestricted traffic, all remaining contract work will be completed within five (5) working days. For each working day that any work remains incomplete after the specified five (5) working days, $700 will be deducted from monies due the contractor, not as a penalty, but as liquidated damages as shown in Subsection 108.07 of the Standard Specifications.

ROAD USER COST CALCULATION

[1] KEY NO. 5400   [2] PROJECT NAME WYE IC BRIDGE REPAIR   [3] ROUTE I-184

[4] CONSTRUCTION YEAR ADT 12,400 (One direction only)   [5] % TRUCKS (MU) 10

[6] NORMAL MILES 1.0   [7] DETOUR MILES 3.5

MILES PER MINUTE

[8] POSTED SPEED (MPH) 55 ÷ 60 = 0.92 miles/minute

[9] CONSTRUCTION SPEED (MPH) 20 ÷ 60 = 0.33 miles/minute

[9A] 30 ÷ 60 = 0.50 miles/minute

[9B] 35 ÷ 60 = 0.58 miles/minute

TRAVEL TIME DELAY

[10] (NORMAL MILES) 1.0 ÷ 0.92 (mi/min) = 1.09 travel time in min

[11] (CONSTRUCTION MILES) 0.5 ÷ 0.33 (mi/min) = 1.52 travel time in min

[11A] 2.5 ÷ 0.50 (mi/min) = 5.00 travel time in min

[11B] 0.5 ÷ 0.58 (mi/min) = 0.86 travel time in min

[12] TIME DELAY = 6.29 TRAVEL TIME IN MIN

TRAVEL TIME COSTS

[13] AUTO ADT (0.90)(12,400)x 0.15 [1] travel time costs/min = $ 1,679.40

[14] TRUCK (MU)(0.10)(12,400)x 0.30 [2] travel time costs/min = $ 373.20

[15] TOTAL TRAVEL TIME COSTS/MIN = $ 2,052.60

ROAD USER COSTS

[16] (Time Delay) 6.29 x (Total Travel Time Costs/Min) $2,052.60 = $ 12,910.85

USE = $13,000

During construction will traffic be delayed in both directions: Yes n/a No___
ADT represents I-184 eastbound ramp traffic only
If no, divide user costs in half

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[1] 1990 Consumer Price Index (automobile $9.00/60 = $0.15)
[2] 1990 Consumer Price Index (multi-unit truck $18.00/60 = $0.30)

KEY FOR ROAD USER COST CALCULATION

1: KEY NUMBER OF THE PROJECT

2: PROGRAMMED NAME OF PROJECT

3: ROUTE NUMBER

4: AVERAGE DAILY TRAFFIC FOR CONSTRUCTION YEAR

5: PERCENT OF TRUCKS (MULTI-UNITS) IN AVERAGE DAILY TRAFFIC

6: LENGTH OF ROADWAY CLOSED TO TRAFFIC IN MILES

7: LENGTH OF DETOUR IN MILES

8: LEGAL POSTED SPEED LIMIT ON ROADWAY DIVIDED BY MINUTES IN AN HOUR EQUALS MILES PER MINUTE.

9: AVERAGE RUNNING SPEED ON THE DETOUR DIVIDED BY 60 MINUTES IN AN HOUR EQUALS MILES PER MINUTE. INDIVIDUAL ROAD SEGMENTS MAY NEED TO BE ANALYZED WHEN THE SPEED CHANGES.

10: NORMAL MILES(6) DIVIDED BY MILES PER MINUTE (8) EQUALS TRAVEL TIME IN MINUTES.

11: DETOUR MILES (7) DIVIDED BY (9, 9A, AND/OR 9B) MILES PER MINUTE EQUALS TRAVEL TIME IN MINUTES. INDIVIDUAL ROAD SEGMENTS MAY NEED TO BE ANALYZED IF INDIVIDUAL ROAD SEGMENTS ARE USED.

12: TIME DELAY IS SUM OF THE DETOUR TRAVEL TIME (10) MINUS THE NORMAL TRAVEL (11, 11A, AND/OR 11B).

13: AUTOMOBILE AVERAGE DAILY TRAFFIC[1] TIMES TRAVEL TIME COSTS PER MIN FOR AUTOMOBILES (1990 CPI SHOWS $9.00 PER HOUR THEN DIVIDE BY 60) EQUALS TRAVEL TIME COSTS.

14: TRUCK (MULTI-UNIT) AVERAGE DAILY TRAFFIC[2] TIMES TRAVEL TIME COSTS PER MIN FOR MULTI-UNIT TRUCKS (1990 CPI SHOWS $18.00 PER HOUR THEN DIVIDE BY 60) EQUALS TRAVEL TIME COSTS.

15: TOTAL TRAVEL TIME COSTS PER MIN IS THE SUM OF 13 AND 14.

16: **ROAD USER COST** EQUALS (12) THE TIME DELAY TIMES (15) THE TOTAL TRAVEL TIME COSTS PER MIN

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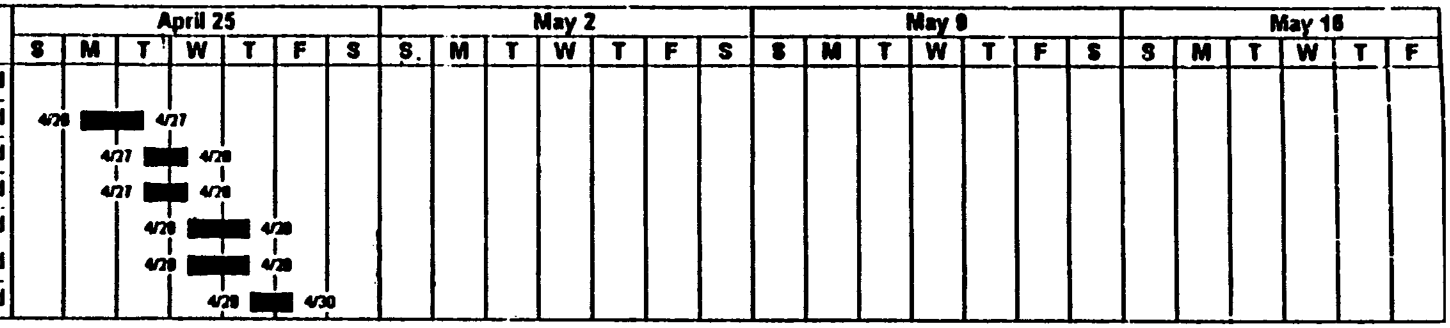
[1] ADT x % automobiles in ADT = automobile average daily traffic

[2] ADT x % multi-unit trucks in ADT = truck (multi-unit) average daily traffic

CONTRACT TIME DETERMINATION

PROJECT: WYE I.C. BRIDGE REHAB., KEY NO: 5400.MPP DATE: 3/5/93

ID	Work Activies	Dur
1	WYE I.C. BRIDGE REH.	6d
2	MOBILITATION	2d
3	REMOVAL BIT. SURFACE	1d
4	REMOVAL CURB	1d
5	PLACE CURB	2d
6	JCT. BOX ADJUSTMENT	2d
7	PL. MIX PAVEMENT	1d



Estimated By: Blaine Schwendiman

Checked By: ______________

Critical

Noncritical

Milestone ◇

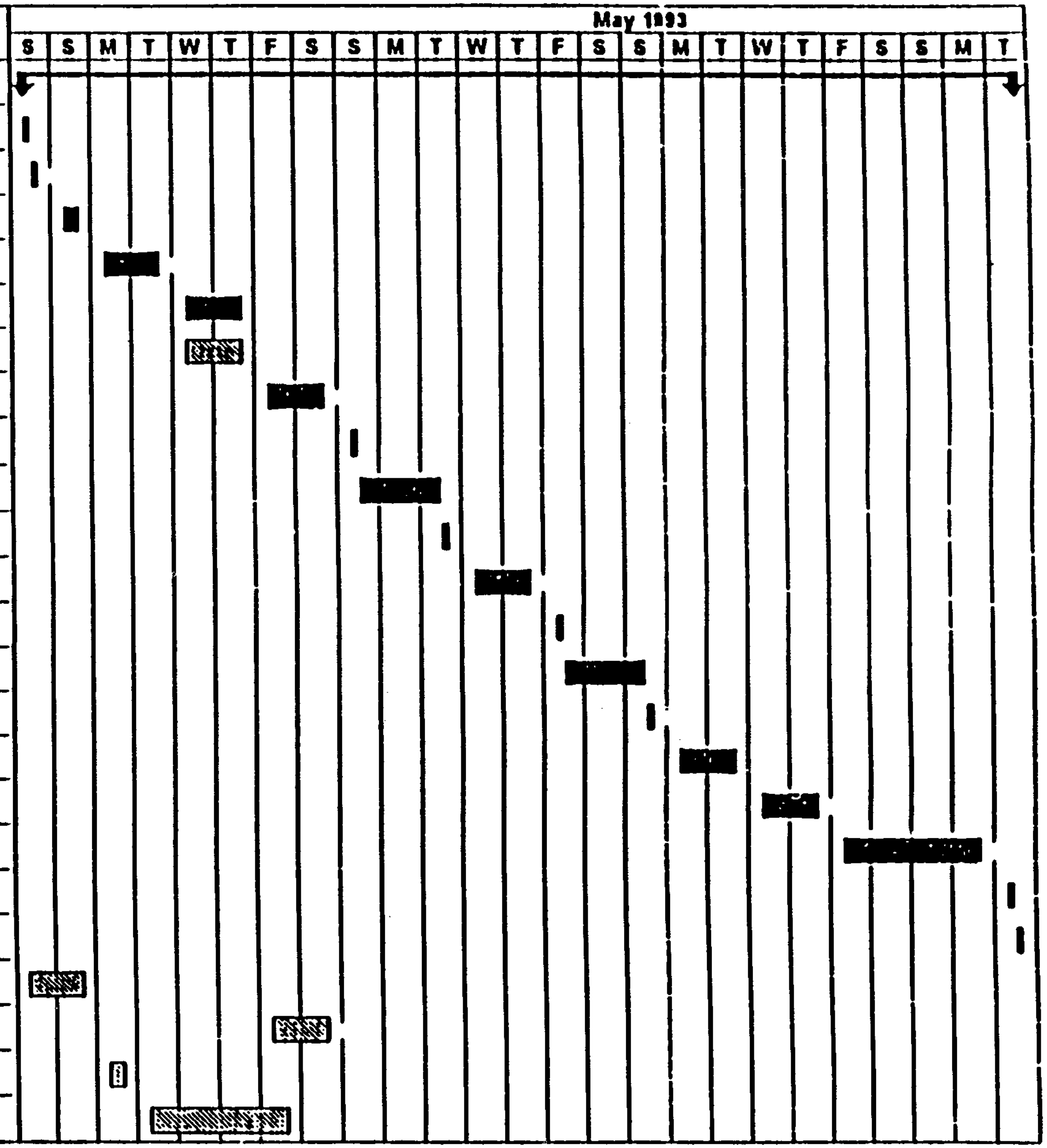
Shutdown

Estimated Working Days =6 days

CONTRACT TIME DETERMINATION

PROJECT: IM-184-1(18)0, KEY 5400, DATE: 2/19/93 8:00am

ID	Work Activies	Quant.	Dur	Pred	Start	Finish
1	REHAB PROJECT	1	25d		5/1/93	5/25/93
2	ASPHALT REMOVAL	1	0.5d		5/1/93	5/1/93
3	CHECK REBAR COVER	1	0.5d	2	5/1/93	5/1/93
4	CLASS A REMOVAL	1	1d	3	5/2/93	5/2/93
5	CLASS B REMOVAL	1	2d	4	5/3/93	5/4/93
6	MARK STRIPS (NEG MOM)	1	2d	5	5/5/93	5/6/93
7	CLASS C REM, POS MOM	1	2d	5	5/5/93	5/6/93
8	CLASS C REM @ STRIP #1	1	2d	6	5/7/93	5/8/93
9	PATCH STRIP #1	1	0.5d	8	5/9/93	5/9/93
10	CLASS C REM @ STRIP #2	1	2d	9	5/9/93	5/11/93
11	PATCH STRIP #2	1	0.5d	10	5/11/93	5/11/93
12	CLASS C REM @ STRIP #3	1	2d	11	5/12/93	5/13/93
13	PATCH STRIP #3	1	0.5d	12	5/14/93	5/14/93
14	CLASS C REM @ STRIP #4	1	2d	13	5/14/93	5/16/93
15	PATCH STRIP #4	1	0.5d	14	5/16/93	5/16/93
16	PREP FOR CONC OLAY	1	2d	15	5/17/93	5/18/93
17	PLACE CONC OVERLAY	1	2d	16	5/19/93	5/20/93
18	CURE CONC OVERLAY	1	4d	17	5/21/93	5/24/93
19	REMOVE COVER	1	0.5d	18	5/25/93	5/25/93
20	PLACE JT SEAL	1	0.5d	19	5/25/93	5/25/93
21	FABRIC EXP JT MAT	1	2d		5/1/93	5/2/93
22	INSTALL EXP JT MATL	1	2d	6	5/7/93	5/8/93
23	SUBMIT PATCHMIX FOR APPR	1	1d	4	5/3/93	5/3/93
24	TEST PATCHMIX	1	4d	23	5/4/93	5/7/93



Estimated By: Bob Newell
Checked By: ______________

Critical ▬ Milestone ◇ Summary
Noncritical ▬ Shutdown ▬

Estimated Working Days = 25 days

Equations:

Fraction of Last Hour with Congestion (FQ) = $Q_{t-1} \div (C - V_t)$

$Q_t = Q_{t-1} + (V_t - C_t)$

$D_t = Q_t \div C$

$DA_t = (D_{t-1} + D_t) \div 2$, except last congested hour

Average Delay Per Vehicle Entering for the Last Congested Hour = $\frac{1}{2} \times D_{t-1} \times FQ$

Total Delay = $\sum (V \times DA)$

Example:

Hour Beginning "t"	Hourly Volume "V"	Capacity "C"	Queue at End of Hour "Q"	Delay of Last Veh. Entering "D"	Avg. Delay Per Veh. Entering "DA"
2 PM	1600	1800	0	0	0
3 PM	1700	1800	0	0	0
4 PM	1850	1800	50	1.7 min.	0.85 min.
5 PM	1900	1800	150	5.0 min.	3.35 min.
6 PM	1900	1800	250	8.3 min.	6.65 min.
7 PM	1600	1800	50	1.7 min.	5.00 min.
8 PM	1400	1800	0	0	0.11 min.
9 PM	1200	1800	0	0	

Congestion Duration = 4 hours and 7.5 minutes

D_m = 8.3 minutes

Q_m = 250 vehicles

Total delay = 0.85 x 1850 + 3.35 x 1900 + 6.65 x 1900 + 5.00 x 1600 + 0.11 x 1400 = 28,727 min. = 478.8 hours

Source: Ref. 1

FIGURE C-1 EXAMPLE COMPUTATION FOR DELAY DUE INSUFFICENT CAPACITY