

SECTION A-8-SEQUENCE OF CONSTRUCTION/MAINTENANCE OF TRAFFIC

INTRODUCTION

These guidelines serve as a tool to assist the designer in plan preparation. Sequence of construction, maintenance of traffic and constructability are related topics and significantly affect the quality of our plans. Broad issues of constructability and quality control are commented on, however they are not the focus of these guidelines. The purpose is to familiarize individuals with the technique and importance of preparing an adequate sequence of construction and maintenance of traffic plan. Constructability issues concerning sequence of construction and maintenance of traffic are covered. Reference material is located elsewhere in this section and in the Instructional and Informational Memoranda (IIM). References listed at the end of these guidelines provide additional resources and the list of items to consider may serve as a checklist.

As related issues, the sequence of construction and maintenance of traffic are included in one plan. The plan includes diagrams and appropriate notes to inform the contractor of when each operation is to be accomplished. The plan delineates traffic control procedures necessary prior to, during and following construction. The sequence is to be a guide with a step by step procedure from the beginning to the end of construction. It is important to provide the plan in a clear and easy to follow manner. Do not sacrifice plan clarity to reduce pages. The plan is necessary to insure that a project can be built as designed without undue difficulty and with minimum work orders. Developing a sequence of construction and maintenance of traffic plan is an essential part of the overall project design and may affect the design of the facility itself. Design of the proposed improvements should be coordinated with the maintenance of traffic plan. There may be acceptable design alternatives which would improve tie-ins to existing pavement and facilitate significantly smoother flowing sequence of construction and maintenance of traffic.

A plan is necessary for complex projects when construction warrants a step by step explanation of the construction process. Such projects may have high traffic volumes, peak hour traffic backups, major cuts and fills, major drainage structures, bridges, or utility relocations requiring traffic detours or shifts. Begin planning in the very early stage of design and continue to solicit assistance throughout the design process to finalize the plan. Request input at Field Inspection and other appropriate meetings as necessary.

Throughout the design process it is important to keep in view the big picture. Before beginning to prepare a sequence of construction plan, walk or drive the project to become familiar with the project and critical construction areas. Take notes, make sketches, video tape and take pictures to assist in communicating issues to consider. Develop a draft sequence of construction plan, thinking through each step as it relates to the other steps. These guidelines contain some helpful suggestions and references. Reviewing examples of well prepared sequence of construction plans is an excellent way to learn about the various issues. Brain storm alternative construction sequences to arrive at the most practical. It may be helpful to color code each phase of construction and make a written narrative of each phase.

Seek advice from individuals, sections or other divisions with particular expertise or experience necessary in preparing sequence of construction plans. Methods of obtaining advice include requesting individuals to review a sequence plan or setting up a meeting to discuss concerns and alternative solutions. There is a wealth of knowledgeable and experienced individuals within VDOT to consult when preparing sequence of construction and maintenance of traffic plans.

The road designer should consult and coordinate input from the Construction, Environmental, Maintenance, Materials, Right of Way, Structure and Bridge, Traffic Engineering, and Urban Divisions, the Project Engineer and Inspector throughout the process of developing a sequence of construction and maintenance of traffic plan. It may be appropriate to contact the District and Central Office representatives of referenced Divisions, particularly the District Traffic Engineer. Advantage should be taken of all opportunities to solicit public input concerning the planned sequence of construction and maintenance of traffic. The public commutes the subject area every day and is in a position to point out situations of concern. Evolution of a sequence of construction and maintenance of traffic plan is an ongoing process and modifications will be necessary prior to and during construction as issues surface or difficulties develop.

The road designer is responsible for preparation of the plan for inclusion in the plan assembly. Preparation will involve requesting, coordinating and organizing input from numerous other individuals. The designer is not expected to know all of the traffic control options and construction techniques and other related expertise necessary to prepare a comprehensive plan. The plan should be located in the front portion of the plan assembly, within the 1 series of sheets.

The Location and Design policy concerning sequence of construction and maintenance of traffic plans is as follows:

Preliminary Maintenance of Traffic/Sequence of Construction Plans are to be developed by the roadway designer in the earliest possible stage of plan development and reviewed by the Traffic Engineer prior to Field Inspection.

Maintenance of Traffic/Sequence of Construction Plans should safely and efficiently maintain traffic while providing capacity and operating speed comparable to the typical highway conditions where feasible.

The following note is to be shown on the Maintenance of Traffic/Sequence of Construction Plan:

"Unless otherwise approved or directed by the Engineer, the Contractor shall plan and prosecute the work in accordance with the following:"

The Traffic Engineering Division will determine locations where detailed plans for traffic control devices are required for inclusion in the final Maintenance of Traffic/Sequence of Construction Plan.

Following the Field Inspection, plans are revised to incorporate the District Administrator's Field Inspection recommendations, and prints of updated plans are provided to the Traffic Engineer (Central Office or District). The Traffic Engineer prepares necessary plans for traffic control devices and provides plans to the road designer for inclusion in the construction plan assembly.

The Maintenance of Traffic/Sequence of Construction Plans are reviewed as follows:

1. Quality Review for Field Inspection
2. Field Inspection
 - a. Recommendations from the District Administrator at Field Inspection are submitted to the Location and Design Engineer and copied to the Traffic Engineer.

- b. After accepted Field Inspection recommendations have been incorporated into the plans, prints are provided to the District and State Traffic Engineer for review prior to Public Hearing/Right of Way Stage.
 - c. Detours, right of way, and easements must be completed in sufficient detail for the right of way requirements to be incorporated into Public Hearing/Right of Way plans.
3. Right of Way and Constructability Review
 4. Advertisement Quality Review
 5. Pre-advertisement meeting

SEQUENCE OF CONSTRUCTION

A sequence of construction plan is to include diagrams and appropriate notes to inform the contractor of when each operation may to be accomplished and advise of traffic control necessary during construction.

Except for the most simple projects, a sequence of construction is necessary. Delays and redesign during construction are often extremely costly, may also cause an unsafe situation and can unnecessarily cause additional disruption of traffic patterns. Our desire is to minimize the inconvenience to the public. To the extent possible, the plan should have flexibility. Recognize that the contractor may, with the Engineer's approval, modify the sequence of construction, but to approach a project without a plan is risky. The sequence may seem simple at first glance but thinking through the steps helps make us aware of possible difficulties. Each project presents unique challenges and developing a sequence of construction offers opportunities to address these concerns at an early stage.

The road designer is responsible for determining the need for barricades and detours during construction. The designer is also to review the plans carefully to determine if it will be necessary to shift traffic lanes away from the normal position during construction and determine required easements. If shifting lanes is necessary, a sequence of construction is to be prepared by the designer with input from the appropriate Assistant Construction Engineers and/or Assistant District Engineer. The sequence of construction plan is to be reviewed by District office representatives and individuals from applicable divisions and agencies at each stage of plan development. The Construction, Environmental, Maintenance, Materials, Right of Way, Structure and Bridge, Traffic Engineering, and Urban Divisions, Project Engineer and Inspector should be consulted concerning their respective areas of responsibility.

When a Sequence of Construction Plan is necessary, it will be included in the plans that are distributed for review at the Field Inspection and it will be of sufficient detail to present the basic concept for discussion and determination of environmental, traffic, safety, and right-of-way requirements. Reviewing examples of well prepared sequences of construction plans is an excellent way to learn about the various issues to be addressed. Examples should address different construction challenges. Discussion should take place at the Field Inspection concerning a narrative if a Sequence of Construction Plan is not necessary. All of the above items are to be discussed thoroughly at the Field Inspection and recommendations included in the Field Inspection Report. Form LD-105 is no longer required, however, it provides guidance to issues to address at Field Inspection.

A copy of the sequence of construction plan, with the accepted field inspection recommendations incorporated, is to be furnished to the Traffic Engineer prior to the Public Hearing/Right of Way stage. If detours, right of way or easements are required for the maintenance of traffic, the sequence of construction must be completed in sufficient detail for the right of way requirements to be incorporated into the Public Hearing/Right of Way plans.

When a sequence of construction plan or narrative is unnecessary for a particular project, the file will be documented accordingly with the listing of the names of those involved in the decision and the reasons for the decision. The field inspection prints must also indicate that a sequence of construction plan or narrative is not necessary and that only such items as flagging, warning lights, etc., will be required.

Items to address under Sequence of Construction:

Adjoining projects and sequence of construction must be coordinated. There may be occasions where a portion of one project would be more efficiently constructed at a designated stage of the construction sequence of another project. This may apply at intersections or other locations. Surplus material may be utilized from an adjoining project. Section 105 of the 1997 Road and Bridge Specifications specifies that there shall be cooperation among contractors on adjoining projects.

Bridge construction should be addressed in the sequence of construction. The coordination of the bridge construction with the roadway portion should be evaluated relative to connecting temporary bridge parapet with the traffic barrier service to insure the proper tie when performing the installations. Bridge construction often requires very large cranes and other large equipment and materials. It is desirable to avoid constructing a bridge in sections. Also avoid setting beams over traffic. Input should be furnished by the Structure and Bridge, Construction and Traffic Engineering Divisions to provide a plan taking these issues into account. Detours may be necessary during periods of bridge construction.

Construction activity: Sequences of construction should be designed to prevent worker activity left and right of traffic at the same time. This situation makes the driver feel restricted, slows traffic and endangers workers. Construction normally takes place on the outside portion of the project and moves in (on major widening or reconstruction projects). Weather and other factors impact the length of construction time. Weather may affect concrete pavement and other concrete construction.

Drainage: Temporary ditches or pipes may be necessary. Replacement of existing drainage may require a temporary diversion ditch or pipe. Jacking versus open cut for pipe causes less interruption to traffic but is normally a considerably more expensive method of pipe installation. Proposed pipes under roadways with high traffic volumes or difficult detours options are candidates for jacking. New construction and extensions of box culverts require considerable construction time. Urban projects should incorporate precast drainage items as much as practical, since improvements in urban areas are generally adjacent to and performed under traffic. Precast items would reduce worker exposure time to traffic and vice-versa since a precast item can be installed much quicker than a cast in place item. Openings for cross-drain pipes on interstates should be designed to prevent small children and animals from accessing the freeway.

Environmental concerns include avoiding wet lands and seeding disturbed slopes at the earliest appropriate stage of construction.

Excavation and earthwork: The Grading Summary and material hauls must match maintenance of traffic and sequence of construction plans. Consider borrow material versus surplus material at each stage of the sequence. Address locations where surplus material may be placed. Areas of graded slopes may be appropriate locations to waste surplus material. Consider areas of major cut or fill to anticipate slope tie in difficulties. In development of the Grading Diagram and Summary, it is essential that the project sequence of construction be taken into consideration to avoid specifying use of material which is not available in the appropriate phase of construction. On complex projects, it may be necessary for the designer to develop rough

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grading diagrams and summaries for each phase of work to accurately determine the grading effort required.

Example plans: Review example plans and seek advice from individuals with experience.

Funeral homes and Churches: Construction should be prohibited in the immediate vicinity of funeral homes and churches during services. This is common courtesy and enhances public relations. This consideration will normally be addressed during preconstruction meetings, but may warrant a plan note.

Intersection reconstruction may require a Sequence of Construction/Maintenance of Traffic Plan as these areas may be very involved.

Material hauls: The contractor should plan the transfer of materials and equipment in a manner that minimizes the impact on traffic movement, as much as practical.

Nighttime construction: In order to reduce the disruption of traffic flow and avoid stopping traffic, certain construction activities, such as the placement of bridge beams or overhead sign structures should be accomplished at night. However, additional safety precautions may be necessary when accomplishing this activity.

Note in the plans that the Contractor shall plan and execute the work in accordance with the Sequence of Construction Plan unless a change is approved or directed by the Engineer.

Note in the plans that it is not the intent of the sequence of construction plan to enumerate every detail which must be considered in the construction of each stage, but only to show the general handling of traffic.

Pavement or structure demolition sequence should be considered.

Railroad crossings or construction adjacent to rail lines should be considered. Input should be obtained from the Virginia Department of Rail and Public Transportation concerning special requirements. Avoid situations where traffic signals, road intersections, road grades and etc. could trap vehicles on the tracks.

Sound barrier walls: The sequence of constructing sound barriers should be closely reviewed, especially when located on the shoulder, since access for work vehicles may require a lane closure. Consideration should be given to sound barrier construction at an early stage of the project construction to help shield adjacent areas from noise.

Time of day, holidays or other day and time restrictions may be necessary stating when construction or traffic flow restraints are not allowed. Notes may be necessary stating specific dates/times. Local ordinances such as noise may restrict when work can be performed. Section 105 of the 1997 Road and Bridge Specifications specifies restricts Holiday work times unless permission is granted by the Engineer.

Utilities: On some projects utility relocations are complete prior to beginning the road construction. Existing utilities should be addressed in the sequence of construction as to when and by whom they will be relocated. A portion of the road construction may be necessary prior to installing or relocating utilities.

Walk or drive the project: Take pictures, notes, video and make sketches. This process will help in recalling and conveying to others the areas of concern.

MAINTENANCE OF TRAFFIC

A maintenance of traffic plan is necessary to insure that motorists, pedestrians and construction workers can safely travel or perform their jobs during roadway construction. A well-thought-out and carefully developed plan will contribute significantly to the safe and expeditious flow of traffic as well as the safety of the construction forces. The goal of any maintenance of traffic plan should be to safely route vehicle, bicycle, worker and pedestrian traffic, including persons with disabilities, through or around construction areas. Geometrics and traffic control devices should operate in a manner comparable to the existing operating situation while providing room for the contractor to work effectively. A maintenance of traffic plan informs the contractor in writing as to how we expect the traffic to be maintained throughout the project and how the summaries have been worked up. The plan may constitute a traffic maintenance sequence and include drawings and diagrams to convey instructions. Traffic flow arrows are recommended.

It is advantageous to prepare and evaluate the maintenance of traffic plan from the motorist's point of view. We have all been delayed in traffic due to road construction. Many times it is unavoidable.

Preparing an efficient maintenance of traffic plan is one way we can better serve the public. It has been said that the shortest distance between two points is always under construction. This may be the public's perception when they are inconvenienced. Imagine how a driver would view the plan in operation. Realize that there may be an element of surprise or uncertainty for the driver, who will likely be unfamiliar with the revised traffic pattern and hazards. The maintenance of traffic plan must be coordinated with the sequence of construction. Reviewing examples of well prepared maintenance of traffic plans is an excellent way to learn about the various issues to be addressed. The examples should address different construction challenges. Do not hesitate to seek advise from Divisions, sections or individuals with expertise or experience in preparing a maintenance of traffic plan, particularly the District Traffic Engineer.

Maintaining a safe flow of traffic during construction must be carefully planned and executed. Although it is often better to provide detours, frequently it will be necessary to maintain the flow of traffic through the construction area. Construction areas are protected by barriers, appropriate speed limits, channelizing devices, signs, signals, lighting, impact attenuators, truck mounted crash cushions and flagging to provide safe traffic control during construction. Construction area devices may include variable message signs or divided highways. Sometimes it will also be necessary to encroach on the through-traffic lanes or shift lanes entirely in order that the construction can be undertaken. When this is necessary, designs for traffic maintenance should produce as minimal an effect as possible on normal traffic flow. The plan depends on the nature and scope of the improvement, volumes of traffic, highway or street pattern, and capacities of available highways or streets. The plan should have some built-in flexibility to accommodate unforeseen changes in work schedule, delays, or traffic patterns.

Adequate advance warning and sufficient follow-up information are needed for the motorist. Standards for the use and application of signs and other traffic control devices when highway construction occurs are set forth in Part VI of the Federal Highway Administration's Manual on Uniform Traffic Control Devices, MUTCD. Designs for the use and application of signs and other traffic control devices are developed by the Traffic Engineering Division of VDOT. Traffic control devices instructions published by the Traffic Engineering Division are included in The Virginia Supplement to the Manual on Uniform Traffic Control Devices. Part VI of the Virginia Supplement was modified and reproduced as a separate publication, Virginia Work Area Protection Manual. Location and Design is responsible for the design of the facilities (except bridges) to accommodate the traffic.

The stopping of public traffic by a flagger or any other means should be avoided where possible and should be approved by the District Administrator. Designs that provide for constant movement around an obstruction in the roadway, even if it is slow, are more acceptable and are

less irritating to drivers than requiring them to stop. Construction operations frequently create the need for adjustments in traffic patterns including the shifting of lanes.

Splitting traffic in the same direction on both sides of construction is not acceptable. The minimum taper length for lane transitions in construction areas can be computed by a formula found in the MUTCD. Various configurations are illustrated in the MUTCD and should be used in developing maintenance of traffic plans. Designed shifts in traffic flows are to conform to the geometrics shown in the standards for detours (Standard GS-10) and/or as indicated in the "Safety Guidelines for Construction Zones" (See IIM LD- (D) 93).

Depending on various project conditions, the Traffic Engineering Division may recommend one of the following methods of maintaining traffic for a project.

A. Under the following circumstances a simple sequence would normally be used:

1. If the Average Daily Traffic volume (ADT) is 1000 or less.
2. If there are no pipes that are 1200 mm (48") or greater in diameter.
3. If there are no double lines of 600 mm (24") pipe or greater.
4. If there are no major drainage structures.
5. If no major off-site detours are required.
6. If there are no major utility relocations required.

A simple sequence may read:

"Traffic is to be maintained throughout the project on the present road or on the grade where the present road is to be raised or lowered. Short periods of one-way, flag controlled traffic may be allowed at the option of the Engineer."

B. Under the following conditions a simple sequence requiring time restrictions should be considered, but keep in mind that these are only meant to be used as general guidelines. Time restrictions may not be necessary in all of the following situations:

1. If the ADT is 1000 or more and could present a problem with peak-hour traffic backup;
2. If there are pipes larger than 1200 mm (48") in diameter;
3. If there are double lines of 600 mm (24") pipe or larger.
4. If there are major drainage structures.

A simple sequence with "time" restrictions may read:

"Traffic is to be maintained throughout the project on the present road or on the grade where the present road is to be raised or lowered with a minimum lane width of _____. Two-way traffic is to be maintained between the hours of ____:____ a.m. to ____:____ p.m. weekdays, and at all times on Saturdays, Sundays and Holidays, unless otherwise directed by the Engineer."

C. A more in depth sequence or an off-site detour may be required in situations where neither of the simple sequences listed above are appropriate. This may require a step by step description of the sequence.

When construction operations are scheduled to take place adjacent to passing traffic, a clear zone should be called for in the plans between the work and the passing traffic. Under most conditions, positive barriers or time restrictions are justified.

ITEMS TO BE ADDRESSED UNDER MAINTENANCE OF TRAFFIC INCLUDE:

Access to adjacent residential and commercial properties should be maintained at all times. Maintenance of traffic and sequence of construction notes should reflect this policy and emphasize the requirement at fire stations, emergency rooms and other emergency facilities. Section 104 of the 1997 Road and Bridge Specifications specifies that entrances shall be maintained.

Asphalt medians: Temporary medians should be considered where construction creates situations with new traffic patterns for motorists. This channelizing will provide improved safety by forming a positive separation of opposing traffic.

Barrier, attenuator service and truck mounted attenuator guidelines and standards are contained in the Construction Zone Safety IIM LD- (D) 93. Engineering Services will be contacted to design the Impact Attenuators. The location of drums, barriers, or barricades, as means of channelizing traffic, should be detailed in the maintenance of traffic plans when special conditions exist. Channelizing devices are addressed in the Virginia Work Area Protection Manual (Page 50). Concrete barrier placement is important. There will be instances when construction access in runs of traffic barrier service will be necessary for the contractor to access with materials and equipment. These locations should be reviewed to determine if attenuators or a transition is needed, or time restrictions and use of surface treatment to prevent debris on public travelway. Runs of traffic barrier should be properly transitioned on either end, in the clear zone, as indicated in the Virginia Work Area Protection Manual, for the operating speed during construction. Otherwise, temporary impact attenuators will be required. Applicability of Quickset Barrier System; use of Quick Change barriers may facilitate changing the number of lanes during rush hour. There may be times when it is practical to implement the Quick-change Traffic Barrier System to maintain roadway capacity in the AM and PM peak hours, yet provide additional work space for specific work activities during off-peak times. The NEAT attenuator system is an end treatment for temporary work zones which has FHWA approval for use on these barrier systems.

Bridges; Temporary bridges may be cost effective for reconstruction of existing bridges.

Bridge rails, existing: In many instances, existing bridges do not have the accepted approach guardrail runs and terminal treatments. Due to the unusual and distracting work techniques used in bridge construction that may be in the immediate vicinity of traffic during the erection of the proposed structure, maintaining traffic on the existing structure may require guardrail, at least on the right side of approaching traffic to eliminate run off the road or fixed object impacts by an errant motorist.

Clear zone: Clear zone requirements should be maintained and the contractor should be instructed to maintain the clear zone free of stored materials and parked equipment as much as practical.

Construction equipment: Idle construction equipment must not impact sight distances at intersections and especially in school zones or entrances. When the construction site is in the vicinity of an airport, consideration should be given to include a note on the plans that the contractor shall be responsible to insure construction equipment does not violate Federal or airport clearance regulations.

Coordinate work: There may be times that several contractors are working in the same vicinity. During these times advanced work zone signing should be coordinated to insure driver expectancy is not compromised by the placement of unnecessary or conflicting signing.

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Detours may be necessary to provide the smoothest and safest traffic flow around work zones. If a temporary detour is shown in the traffic control plan, it should be graphically indicated in the plan assembly, with the proper directional advanced signing for the contractors guidance prior to initiating work activities. Address issues of alignment, grade, length, width, pavement strength, truck restrictions, detour capacity for rerouting traffic, detour quantities (including grading, drainage, pavement, etc.) and a detour removal detail (with pay items). Temporary detour grades are necessary where such grades are not obvious such as paralleling existing pavement. When shoulders are used as a detour, the pavement width and strength should be reviewed to accommodate the appropriate vehicle loads. Detour operating speed should approximate existing highway operating speed (every attempt should be made to not reduce the speed by more than 16 km/h (10 mph)). Attention should be given to maintaining emergency (fire, etc.) vehicle, bus and mail routes. It may be appropriate to request District input, research or communication with the fire department, school authorities and other authorities concerning the maintenance of traffic patterns. Include traffic items provided by the District Traffic Engineer.

Edgeline markings: A 0.3 m (one foot) offset should be provided between the face of traffic barriers and the edgeline marking. This provides some lateral distance for distracted or crowded drivers to maneuver if needed.

Emergency access: During construction of roadway improvements and especially one lane maintenance projects and bridge projects, construction and flagger crews should be alert to the access needs of fire, rescue and police vehicles in the vicinity. Safety of the workers and public on the project and elsewhere is of primary importance.

Glare screens: Consideration should be given to using glare screens where practical, and when sight distances will not impact merging motorists. Glare screens reduce motorists distractions to worker activity behind the traffic barrier service and may result in a better quality product since workers would not be distracted by traffic. Also, reducing distractions will enhance safety, improve traffic flow and decrease rubber-necking.

Grades are important to consider when establishing maintenance of traffic. Vertical and horizontal alignment must be considered. Design alternatives for the vertical and horizontal alignment of the proposed improvements should consider the maintenance of traffic plan. There may be acceptable design alternatives which would improve tie ins to existing pavement and facilitate a significantly smoother flowing sequence of construction and maintenance of traffic. Detours, material haul roads, temporary access locations and road connections must be vertically and horizontally evaluated. Also, insure that required construction fill will not encroach on existing travel way and maintained traffic while constructing deep cuts and high fills. When sheet piling is necessary, it requires subsurface investigation.

Grading diagram coordination is important with the maintenance of traffic plan. Plan the traffic plan to facilitate implementation of the grading diagram.

Guardrail laps should be switched when traffic flow is reversed for a significant length of time.

Highway advisory radio: Interstate improvements may warrant the need for highway advisory radio broadcast, to provide advanced warning to motorists that delays should be expected unless the suggested alternate route is used.

Impact attenuators: These are required at the introductory locations of traffic barrier service, unless the traffic barrier can be transitioned as indicated in the Virginia Work Area Protection Manual. Engineering Services will be contacted to design the Impact Attenuators.

Lane closures: When lane closures are proposed in the traffic control and sequence of construction plan, the use of electronic arrowboards and variable message signs should be addressed. This subject is normally addressed at Field Inspection by the Traffic Engineer.

Lanes, number of: While it may not always be possible to provide the same number of lanes that were available prior to initiating construction activities, the same number of lanes should be provided during peak hours. Lane restrictions may not be appropriate during certain periods and this should be noted on the plan.

Lane shifting: Lane shifting should be designed to accommodate the operating speed for the particular work zone. When these areas are on 4 lane divided facilities and the operating speed is considerably high, the proper superelevation is imperative. Also, the adequate horizontal and vertical alignment must be available to maintain driver expectancy and should not be designed for more than a 16 km/h (10 mph) speed reduction than that of the remainder of the work zone.

Lane widths: Adequate lane widths should be available. Geometric Design Standards in the front of Appendix A of the Road Design Manual specify lane widths. Lane widths should be a minimum of 3.3 m (11') and in minor work zones 3.0 m (10'). When determining lane widths, the percent of truck traffic should be considered.

Navigable streams: Advanced up and down stream signing should be provided for sportsmen, canoeist and fishermen when overhead construction activities are required for bridge placement over navigable streams.

Pavement design should incorporate existing pavement when practical. Pavement design should consider temporary markings, so proper courses may be specified at appropriate construction stages. Milling may excessively weaken existing road pavement strength, such as at bridge approaches and the Materials Division should be consulted for appropriate instructions.

Pavement markings for temporary use may be covered with the final pavement course. Details should be provided for any special pavement marking requirements. Pavement marking eradication information is in IIM LD- (D) 93. Temporary pavement markers should be considered to provide more positive guidance at nighttime and during inclement weather.

Pavement surface within the construction and detour areas should be maintained in a condition that will permit the safe movement of traffic at a reasonable speed.

Peak traffic hour work: The maintenance of traffic plan should direct the contractor not to perform work which would impede the flow of traffic during peak hours of traffic congestion, holidays, etc.

Pedestrian traffic must be maintained. The maintenance of traffic plan should accommodate pedestrian traffic as well as automobile traffic, particularly in urban areas.

Phases: Engineering studies indicate work zone lengths should not exceed 0.8 km (0.5 mile) in length. Research in work zones indicates an increase in accident rates when motorists are subjected to extended travel times adjacent to work zone activities. Consideration should be given to constructing the facility in phases containing 0.8 km (0.5 mile) work zone lengths, where practical. There may be situations with minimal driver distractions and inconvenience where a work zone should be as much as two miles in length.

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Railway crossings must be considered. Avoid designs where traffic signals, road intersections, road grades and etc. could trap vehicles on the tracks. This was also mentioned under sequence of construction.

Right of way or temporary construction easements may be required for construction or temporary detours: Sheet piling may be more economical in some situations.

Safety issues are always of paramount importance. They encompass more items when maintaining traffic through a construction site because safety of the workers is an additional element. The worker is often protected only by the barriers or other features of the maintenance of traffic plan.

Shoulders: In relatively long work zone areas, the construction of an adequate shoulder is desirable, to provide lateral placement of stalled or disabled vehicles beyond the travel lanes.

Sight distance: Adequate vertical and horizontal sight distance must be maintained for safety reasons.

Signalization, temporary and permanent: Existing and proposed pole locations must be taken into account. Signal timing: When construction activities, such as resurfacing, require the closure of an existing lane, it may be necessary to lengthen the green time for that leg. This would help retain the capacity of the intersection. The State Traffic Engineer is responsible for preparation of the sign, signal and lighting plans. Temporary traffic signalization may be required at some locations for construction purposes. They will require detailed plans, just as permanent signals.

Signs with variable messages: Due to terrain or inclement weather, the use of passive signing may not be enough to maintain the desired element of safety. It may be appropriate to install variable message signs to attract the driver's attention when approaching a changing traffic pattern.

State police: There may be certain roadway improvements where the worker is adjacent to motorists and there is a danger of automobile encroachment into the work area. These projects may require the participation of state police for the enforcement of posted speed limits within the work zone. See State Police Participation in IIM LD- (D) 93. Interstate roadway improvements may warrant an increase in the number of existing safety patrols to reduce delays and provide assistance to stranded motorists within the travel lanes.

Stubs should be designed where appropriate to facilitate improved maintenance of traffic for future road extension. Pavement stubs and "tie-in" construction should be addressed in the maintenance of traffic plan.

Tapers are needed for lane drops or at locations where traffic must be shifted laterally. Appropriate values for taper lengths can be found in Part VI of the MUTCD.

Traffic volume capacity: Attempt to maintain the traffic volume capacity of existing roads.

Turn lanes should be maintain (left and right).

Utility adjustment must be accommodated.

Wrecker service: Some work zones, mainly on limited access facilities, may require the implementation of 24 hour wrecker availability for the towing of disabled vehicles.

NOTES WHICH MAY BE APPROPRIATE ON MAINTENANCE OF TRAFFIC AND
SEQUENCE OF CONSTRUCTION PLANS INCLUDE:

(These notes should be developed in coordination with the District Traffic Engineer)

Unless otherwise approved or directed by the Engineer, the contractor shall plan and prosecute the work in accordance with the following sequence of construction and maintenance of traffic plan and this shall be coordinated with the bridge plans.

It is not the intent of the sequence of construction plan to enumerate every detail which must be considered in the construction of each stage, but only to show the general handling of traffic.

All areas excavated below existing pavement surface and within the clear zone, at the conclusion of each workday, shall be back filled to form an approximate 6:1 wedge, against the existing pavement surface for the safety and protection of vehicular traffic. All cost for placing, maintaining and removing the 6:1 wedge shall be included in the price bid for other items in the contract and no additional compensation will be allowed.

Traffic barrier service shall be installed and removed so as not to present any blunt end or hazard to the motoring public. The placement and removal of the traffic barrier service and barricades are to be coordinated by the Project Safety Officer.

LIMITATION OF OPERATION notes may include:

The following restrictions will apply, except in cases where the Engineer determines they are not in the best interest of the Department and/or the traveling public.

Traffic shall not be detained on route_____for longer than five minutes at any time, unless directed by the Engineer.

Closing of traffic lanes or shoulders is only permitted between 10:00 P.M. and 6:00 A.M. Monday through Friday.

No lane restrictions will be permitted from 12:00 Noon Friday until 9:00 A.M. Monday and during the following period: 6:00 A.M. Dec. 23, 1996 through 7:00 P.M. Jan. 3, 1997;

Note concerning southbound traffic may read: All travel lanes shall be open between the hours of 4:00 P.M. and 6:00 P.M. Monday through Friday. One travel lane may be closed all other times with the exception of dates listed below.

CONSTRUCTABILITY

Constructability relates to whether the project can be constructed as designed with the information shown in the plans. Many of the necessary items to consider when determining the constructability of a project are included in the Road Design Manual's Quality Control Checklist.

There is a huge advantage in having a construction expert review the concept of a project before even preliminary plans begin. A construction expert can review the proposed project and what it is intended to achieve, the proposed location of a project, the duration for design and construction and various design alternatives. This review should involve a dialogue with the design leaders of the project.

The construction expert will look at the proposed project through the eyes of the constructor and will consider the advantages and disadvantages of the potential design alternatives. There should be a review of the site and of the surrounding areas.

Geology, topography, accessibility, utilities, existing infrastructure, businesses, residences, etc., should be examined from the contractor's perspective. Potential strategies likely to be adopted by the contractors to deal with all these site issues should be discussed with the design team to see how the design might be developed to dovetail with strategies that are beneficial to the contractors and the local population in the prosecution of the project.

The review may go several miles beyond the environs of the project to examine access for large equipment.

There are issues that can impact design decisions and should be examine early. It provides the opportunity for the designer to begin design with certain key issues in mind which can frequently be accommodated in the design without adverse cost impact to the design. It is not that constructability issues drive the design but that design accommodates constructability in its evaluation. This is much better than trying to inject constructability into the design later.

The construction expert should have a broad knowledge of construction in several fields, not just highways and bridges, together with an understanding of, and empathy with, both the designer and the constructor. Constructability is more than simply making life easier for the contractor. It is the incorporation of construction expertise into the design process so that it will meet all of the design requirements, including aesthetics, at the lowest reasonable cost of construction.

A construction expert will have this broad expertise, together with the ability to work cooperatively and sympathetically with the design team and to respect the integrity of their design. In this way, the constructability review process becomes a team operation where the constructability resource and the design team work together cooperatively to integrate constructability into the design process.

ITEMS TO BE ADDRESSED UNDER CONSTRUCTABILITY INCLUDE:

Access to adjacent residential and commercial properties should be maintained at all times.

Contractor operations: Adequately evaluate and explain appropriate construction task and operations. This may include the order of construction activities.

Drainage issues: Drainage network errors have had the largest dollar impact and account for 25% of total errors on plans; last minute design changes to the roadway plans, which often require adjustments to the drainage plans, caused many of these errors. Check inverts of culverts and systems to insure positive drainage and outfall. Utility conflicts can significantly affect the sequence of construction. Address the need for temporary drainage for construct, detours, slope drains, etc. (IIM LD- (D) 11).

Easements and right of way must be sufficient to construct Project. Few issues can cause more construct delay than the lack of necessary easements or right of way.

Environmental issues: These are issues that can cause more construction delay or unexpected cost. Environmental Division representatives will provide guidance on these issues such as permits required for construction in live streams or concerning wetlands.

Equipment necessary such as piers, cranes, etc.: Adequate equipment clearance such as a crane swing radius is a constructability issue, for safety and functional reasons. Large equipment deserves special consideration as to how it will be transported to the job site and to provide adequate maneuvering clearance during construction. The Construction Division is a source for advice.

Excavation near existing structures: One issue may be a question of providing adequate horizontal distance to maintain the integrity of existing structures. A subsurface investigation may be appropriate for some locations. The Construction Division is a source for advice.

Materials supply: Consider where and how materials may be supplied to the project. Consider what form of transportation may be utilized to transport material to the job site.

Picture how each aspect of the project will be constructed from the beginning as it would look in the field rather than from plan view.

Plan information: Provide comprehensive plan information for construction of the project.

Plan views, profiles and cross sections must agree.

Precast versus cast-in-place structures should be addressed when appropriate.

Quantity summaries must be complete.

Right of way and easements must be adequate to construct project, store material and operate equipment. Signing, lighting, signalization and other issues present possible needs for additional easements or right of way.

Utility conflicts and relocations can significantly affect project construction schedules.

REFERENCES:

Guidance concerning sequence of construction, maintenance of traffic and their impact on constructability are found in the following references:

Road Design Manual:

- 1E- 9 Quality Control and Checklist
- 2D-14 Pavement Termination
- 2D-29 Traffic Barriers - Guardrail and Concrete Barriers
- 2D-70 Safety Items and Sequence of Construction
- 2G-10 Temporary Detours

Instructional and Informational Memoranda:

- LD- (D) 11 Erosion and Sediment Control, Sheet 5: construction entrances
- LD- (D) 93 Construction Zone Safety
- LD- (D) 104 Guardrail Criteria
- LD- (D) 120 Materials for Maintenance of Traffic During Construction
- LD- (D) 138 Earthwork Quantities, Sheet 3 (first paragraph)
- LD- (D) 144 Stage Construction Projects, Separate Road and Bridge Contracts and Incidentals Thereto
- LD- (D) 173 Construction Access, Temporary Construction Causeway Design
- LD- (D) 213 Pavement Markings, Construction Signs, Type III Barricades, Insertable Sheets to be included in applicable plan assemblies

Road and Bridge Standards:

Standard GS-10, Minimum Design Criteria for Temporary Detours

Road and Bridge Specifications:

Section 104, Scope of Work and Section 107, Legal Relations and Responsibility to the Public

The Federal Highway Administration's Manual on Uniform Traffic Control Devices, MUTCD

The Virginia Supplement to the Manual on Uniform Traffic Control Devices

The Virginia Work Area Protection Manual, January 1996, replaces Part VI of the Virginia Supplement to the Manual on Uniform Traffic Control Devices

SEQUENCE OF CONSTRUCTION AND MAINTENANCE OF TRAFFIC ITEMS TO CONSIDER

A. SEQUENCE OF CONSTRUCTION
(Items to Consider)

Adjoining projects
 Bridge construction
 Construction activity
 Drainage
 Environmental concerns
 Excavation and earthwork
 Example plans
 Funeral homes and Churches
 Intersection reconstruction
 Material hauls
 Nighttime construction
 Note in the plans
 Pavement demolition
 Railroad crossings
 Sound barrier walls
 Time of day, holidays or other time restrictions
 Utilities
 Walk the project; take notes, make sketches and take pictures and videos.

Pavement surface

MAINTENANCE OF TRAFFIC
(Items to Consider)

-continued-
 Peak traffic hour work
 Pedestrian traffic
 Phases
 Railroad crossings
 Right of way and easements
 Safety issues
 Shoulders
 Sight distance
 Signalization
 Signs with variable messages
 State police
 Stubs
 Tapers
 Temporary grade separation
 Traffic volume capacity
 Turn lanes
 Utility adjustment
 Wrecker service

B. MAINTENANCE OF TRAFFIC
(Items to Consider)

Access to adjacent properties
 Asphalt medians, temporary
 Barrier and attenuator service
 Bridge rails, existing
 Clear zone
 Construction equipment
 Coordinate work
 Detours
 Edgeline markings
 Emergency access
 Glare screens
 Grades
 Grading diagram
 Guardrail laps
 Highway advisory radio
 Impact attenuators
 Lane closures
 Lanes, number
 Lane shifting
 Lane widths
 Navigable streams
 Pavement design
 Pavement markings

C. CONSTRUCTABILITY
(Items to Consider)

Contractor operations
 Drainage
 Easements and right of way
 Environmental
 Equipment
 Excavation
 Materials
 Picture each aspect
 Plan
 Plan/profiles/cross sections agree
 Precast versus cast-in-place
 Quantity summaries
 Signing, lighting, signalization
 Utility conflicts