

# Design Guidance for Construction Work Zones on High-Speed Highways



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AASHTO Subcommittee on Construction Meeting

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# Panel, NCHRP 3-69

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# Overview

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- Construction work zone:

- .. area occupied for three or more days ...

- High-speed highways:

- ... 85th percentile free-flow speed of 50 mph or greater

- Coverage:

- ... information or guidance not available in another nationally referenced publication

# Final Deliverable, NCHRP 3-69

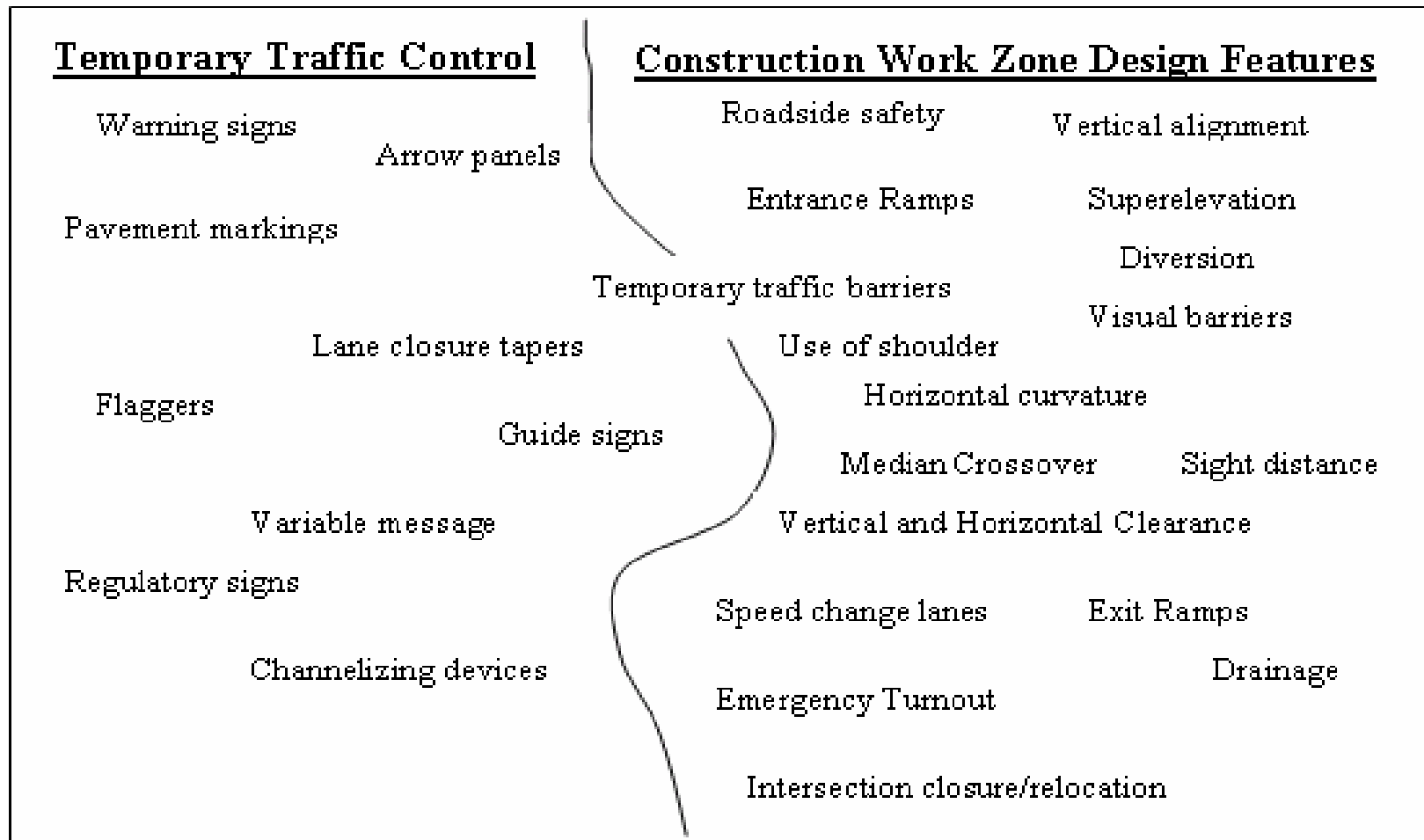
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- Research report (summary of methods)
- Hard copy appendix: *Design Guidance*
  - Dual units: Metric [US Customary]
  - *Green Book* format and conventions
- CD: *Work Zone Speed Prediction Model and User's Manual*

# Design Guidance

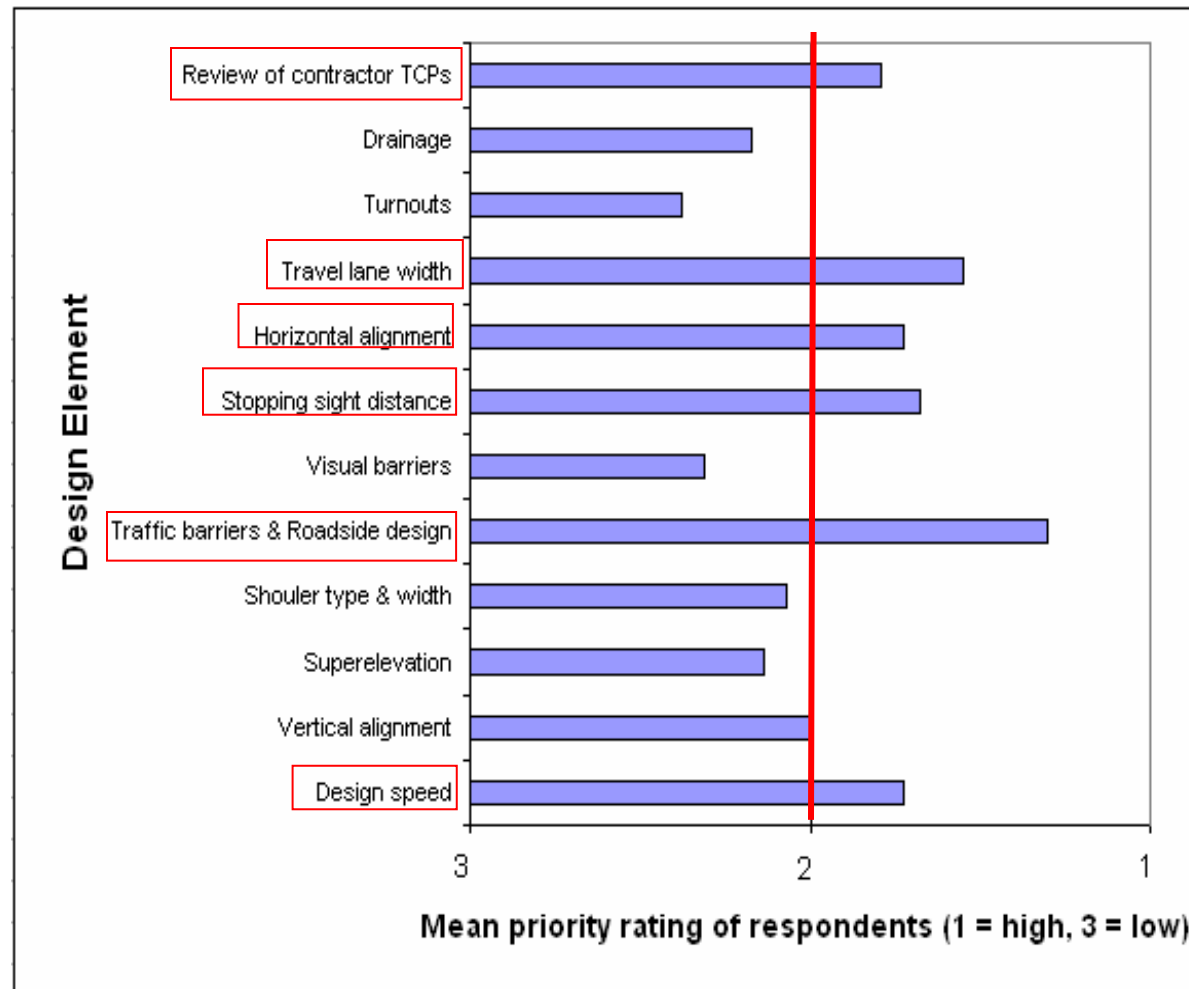
Publication	Summary of Coverage	Relationship to Other Publication
<i>AASHTO Green Book</i>	Geometric guidance for all types of roads, primarily permanent facilities.	This guidance supplements the limited guidance in the <i>Green Book</i> specifically related to work zones.
<i>MUTCD</i>	Traffic control devices, including temporary traffic control	This guidance should be used in conjunction with the <i>MUTCD</i> , which is applicable to work zones.
<i>AASHTO Roadside Design Guide</i> Chapter 9	Roadside safety, including work zone barriers, traffic control devices and other features	This guidance supplements <i>RDG</i> Chapter 9 regarding placement of temporary barriers in construction work zones.
Design Decision Guidance for Work Zones on High-Speed Highways	Geometric and physical features common to construction work zones on high-speed highways	

# Design Guidance



# Design Guidance

## State DOT Priorities





# Design Guidance: Contents

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1. Terminology
2. Controls, Concepts and Principles
3. Conceptual Design and Planning
4. Roadway Design
5. Roadside Design and Barrier Placement
6. Ancillary Design Information

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# Conceptual Design and Planning

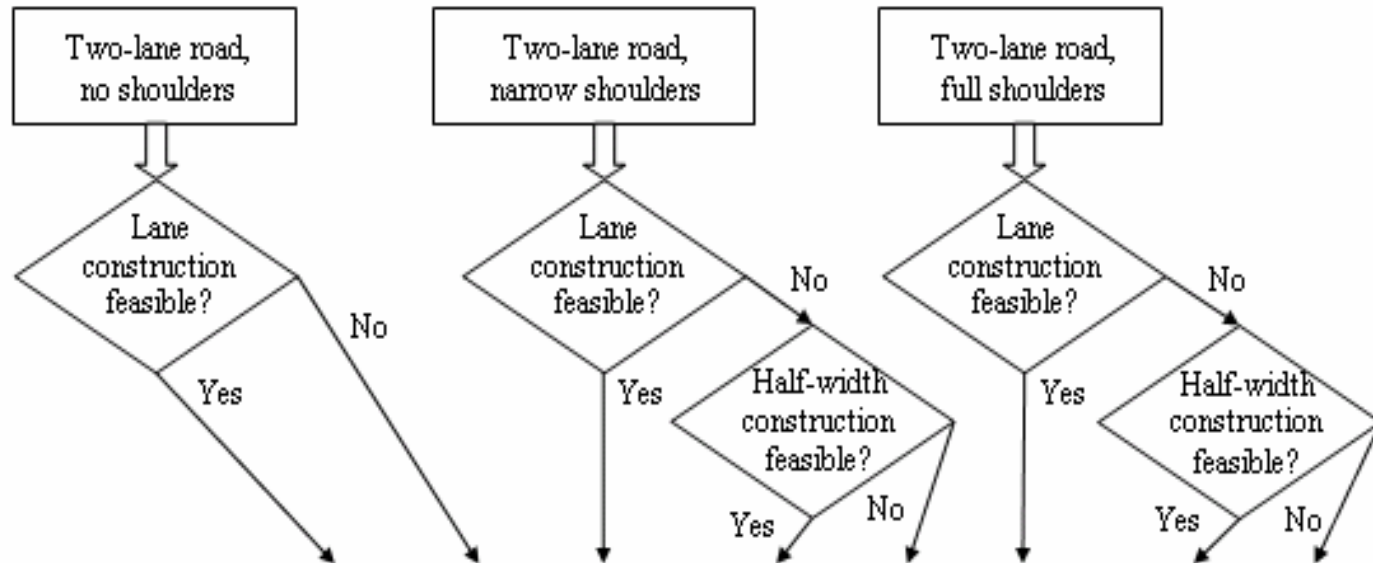
Type/Strategy	Summary	Advantages	Disadvantages
Alternating one-way operation	Mitigates for full or intermittent closure of lane(s). Used primarily with two-lane facilities.	Low agency cost and low non-transportation impacts; flexible, several variations available.	Requires stopping of traffic; reduces capacity.
Detour	Re-routes traffic onto other existing facilities.	Flexible; cost varies depending on improvements to detour route. In some cases, only TTC needed.	Usually reduces capacity; and service and infrastructure on existing roads may be degraded; may need agreement of another agency.
Diversion	Temporary roadway provided adjacent to construction.	Separates traffic from construction; reduced impact on traffic.	Cost may be substantial, especially if temporary grade separation of hydraulic structure involved; right of way often required.
Full road closure	Facility closed to traffic for specified (limited) duration.	Generally also involves expedited construction; separates traffic from construction.	Some form of mitigation needed (detour, diversion). Potentially significant traffic impacts.
Intermittent closure	Traffic stopped for a short period of time.	Flexible and low agency cost.	Useful only for activities that can be completed in short time. Requires stopping traffic.

# Conceptual Design and Planning

Type	Summary	Advantages	Disadvantages
Lane closure	One or more travel lanes closed.	Maintains service; fairly low agency cost.	Reduces capacity; may involve traffic close to active work.
Lane constriction	Traveled way width reduced.	Maximizes number of travel lanes.	Traveled way width is less than desirable.
Median crossover	Maintain bi-directional traffic on one roadway of a normally divided highway.	Separates traffic from construction; right of way not required.	Reduced capacity; not consistent with approach roadway; relatively costly; interchanges need special attention.
Use of shoulder(s)	Use shoulder as travel lane.	Fairly low cost, depending on shoulder preparation.	Displaces traditional refuge for disabled vehicles. Debilitates shoulder pavement structure. Cross slopes may be problematic.

# Conceptual Design and Planning

## Screening two-lane road strategies

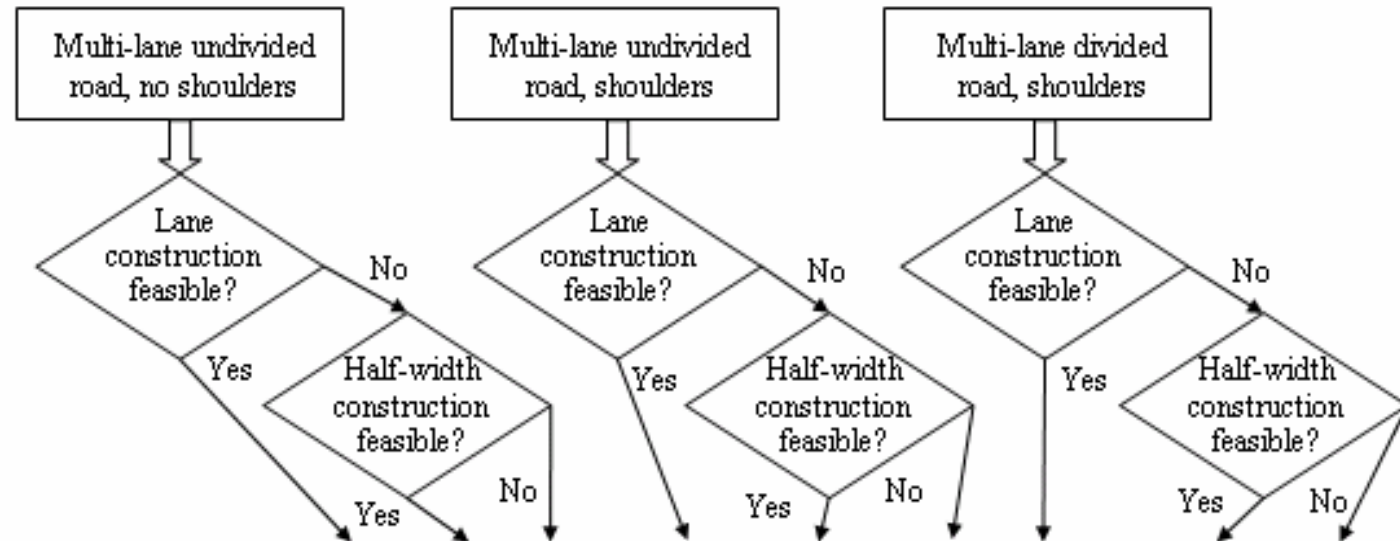


Alternating, one way operation (mitigation)	2s		3s	3s	2s			3s
Detour (mitigation)	3s, 5s	2s	4s, 6s	4s, 6s	3s, 5s			4s, 6s
Diversion (mitigation)	4s, 6s	3s	5s, 7s	5s, 7s	4s, 6s			5s, 7s
Full road closure	5, 6	2, 3	6, 7	6, 7	5, 6			6, 7
Intermittent closure	1	1	1	1	1	1	1	1
Lane closure	2, 3, 4		2, 3, 4, 5	2, 3, 4, 5	2, 3, 4	2	2	2, 3, 4, 5
Lane constriction			2	2				2
Use of shoulder(s) (mitigation)			2s	2s		2s	2s	2s
Options with unmitigated reduction in lanes	2		3	3	2			3

Notes: Numerals indicate general ranking and feasibility. Several strategies often used in combination. Designation "s" indicates possible use in support of other strategy(ies).

# Conceptual Design and Planning

## Screening multi-lane road strategies



Alternating, one way operation (mitigation)			4s			4s			
Detour (mitigation)	4s	3s, 5s	3s, 6s	4s	4s, 6s	3s, 6s	5s	3s, 5s	4s, 6s
Diversion (mitigation)	5s	4s, 6s	5s, 7s		5s, 7s	5s, 7s		4s, 6s	5s, 7s
Full road closure		5, 6	6, 7		6, 7	6, 7		5, 6	6, 7
Intermittent closure	1	1	1	1	1	1	1	1	1
Lane constriction			2	2		2	4		3
Lane closure(s)	2, 3, 4, 5	2, 3, 4	2, 3, 4, 5	2, 3, 4	2, 3, 4, 5	2, 3, 4, 5	2, 3, 4, 5		2, 3, 4, 5
Crossover	3s	2	2		2, 3	2		2, 3, 4	
Reversible lane (mitigation)	3s				3s				
Use of shoulder(s) (mitigation)				2s	3s	2s	3s, 4s		2s, 3s
Options with unmitigated reduction in lanes	2, 3	2	2, 4	3	2, 3	2, 4	2	2	2, 3

Notes: Numerals indicate general ranking and feasibility. Several strategies often used in combination. Designation "s" indicates possible use in support of other strategy(ies).

# Contracting Strategies and Issues

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- A+Bx
- Design-Build
- Incentive-Disincentive
- Lane rental
- Night construction
- Review of contractor WZ designs

# Contracting Strategies and Issues

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## Perceived Consequences of Night Work

<b>Advantages</b>	<b>Disadvantages</b>
<p data-bbox="205 898 884 1032">Lower traffic volumes and lower traffic impacts</p> <p data-bbox="205 1127 968 1261">Lower impacts to commercial activity</p>	<p data-bbox="1064 821 1560 881">Higher agency cost</p> <p data-bbox="1064 898 1545 958">Higher safety risks</p> <p data-bbox="1064 976 1860 1101">Disrupts normal social patterns of work force</p> <p data-bbox="1064 1127 1213 1187">Noise</p> <p data-bbox="1064 1205 1675 1346">Possible compromise in construction quality</p>



# Contracting Strategies and Issues

## Framework for Reviewing Contractor Work Zone Designs

Evaluation categories and factors		Agency (base) design	Contractor proposed design
Road user factors	Safety (queue formation, exposure to roadside hazards, speed reductions)		
	Mobility (capacity, delay, interruption of commercial and industrial flow)		
	Access (abutters, intersections, interchanges)		
	Non-motorized traffic		
	Special groups (oversize vehicles, modal connections)		
Agency factors	Worker safety		
	Emergency services implications		
	Community impacts (local events, noise)		
	Contract administration and inspection		
	Coordination with other project schedules		
	Quality of completed construction (traffic interference, time of day and seasonal effects)		
	Cost		
Other factors (for project)			

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# Superelevation-Horizontal Curvature

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- ❑ Many DOTs indicated not having an established procedure for SE in WZs
- ❑ 8 DOTs use different SE approach for WZs than permanent roads; 7 use Method 2 distribution
- ❑ **Recommended guidance:** Method 2 or 5

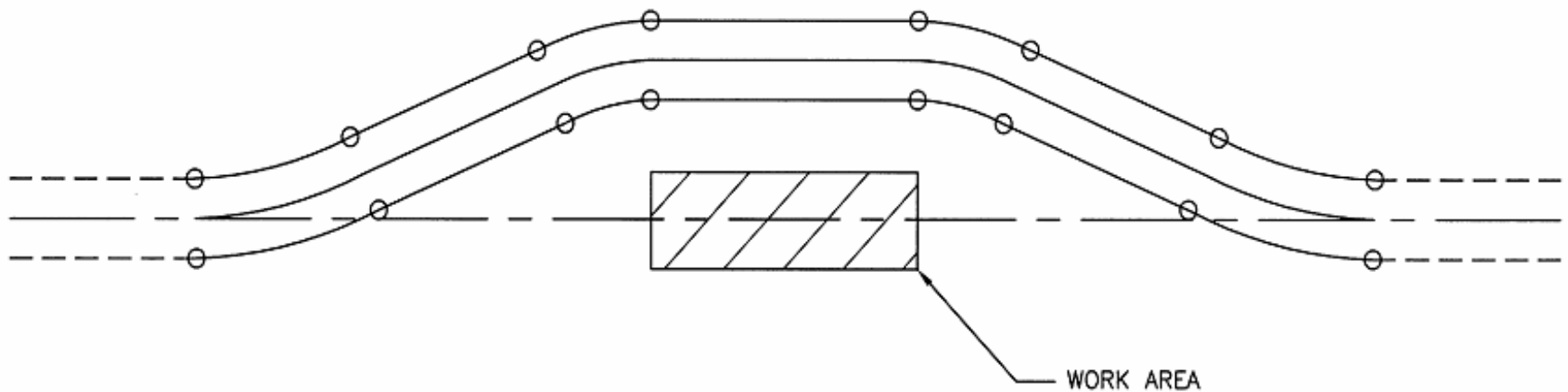
# Sight Distance

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- Half of states responding to survey (16 of 32) do not apply stopping sight distance criteria to WZ design
- **Recommended guidance:** Provide at least 300 ft of SD with 3.5 ft eye height and 2.0 object height

# Roadway Design: Diversion

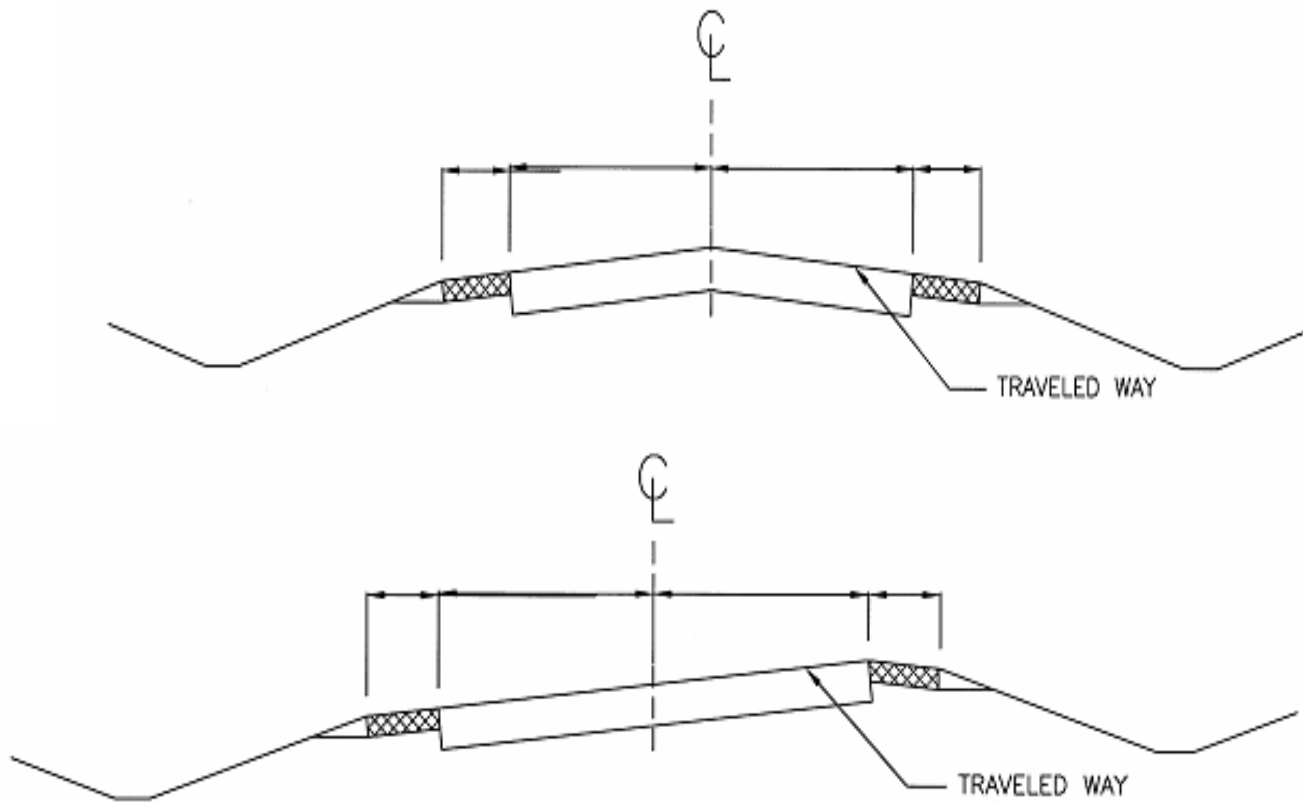
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Example plan view

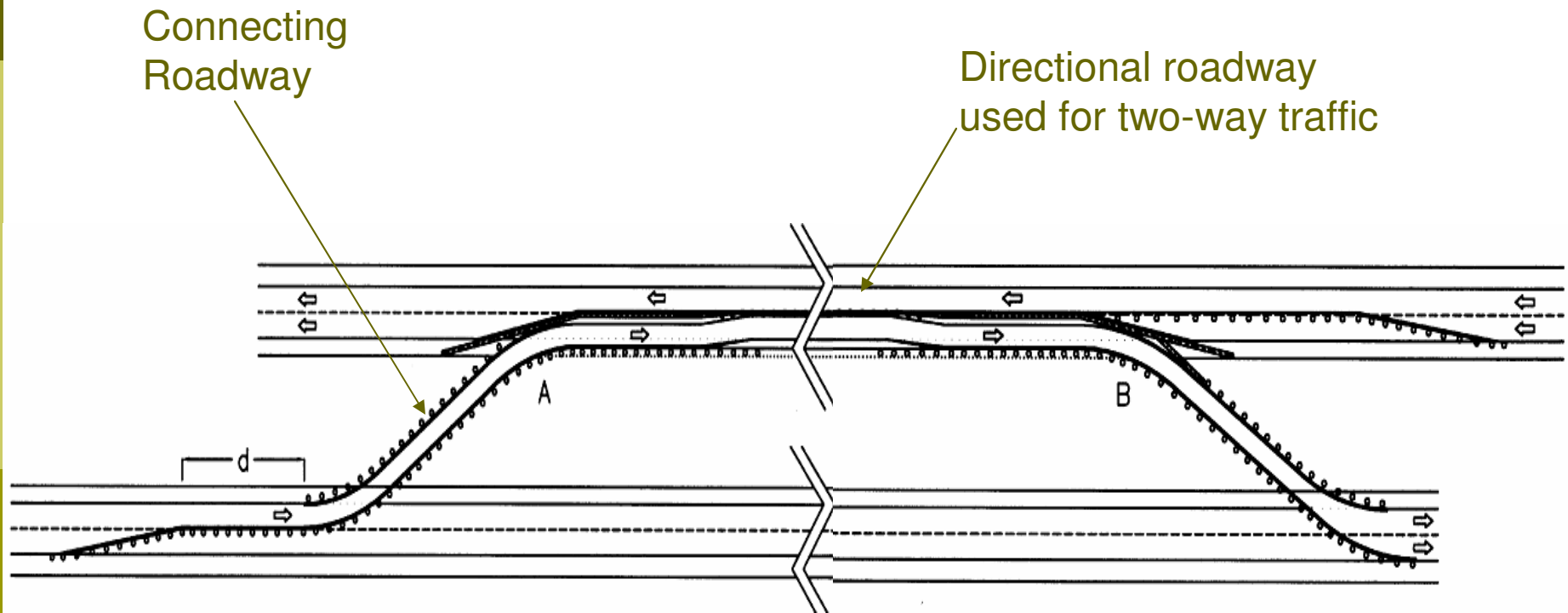
# Roadway Design: Diversion

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Example normal crown and superelevated sections

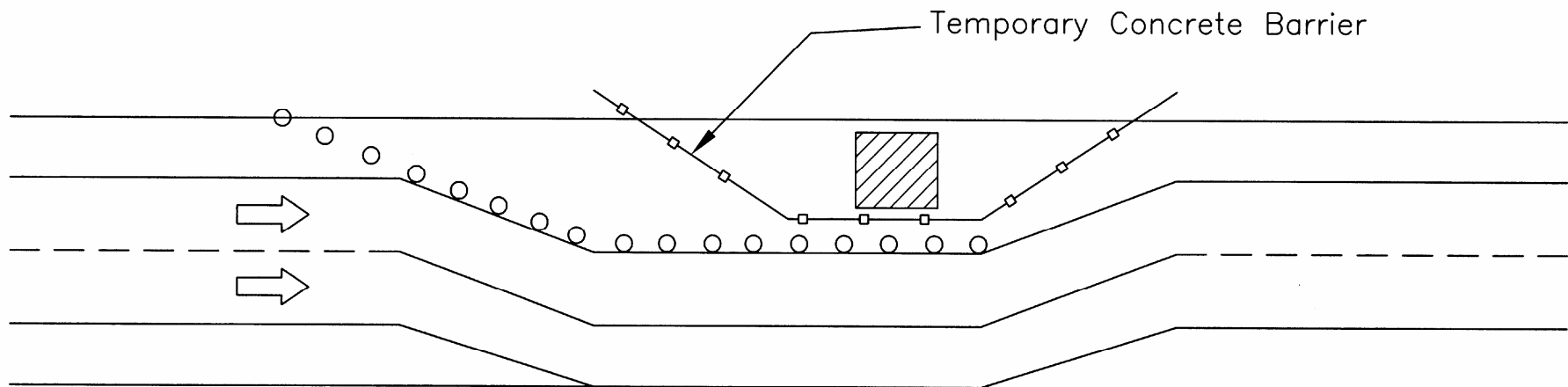
# Roadway Design: Median Crossover



Example plan view

# Roadway Design: Use of Shoulder

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Example plan view

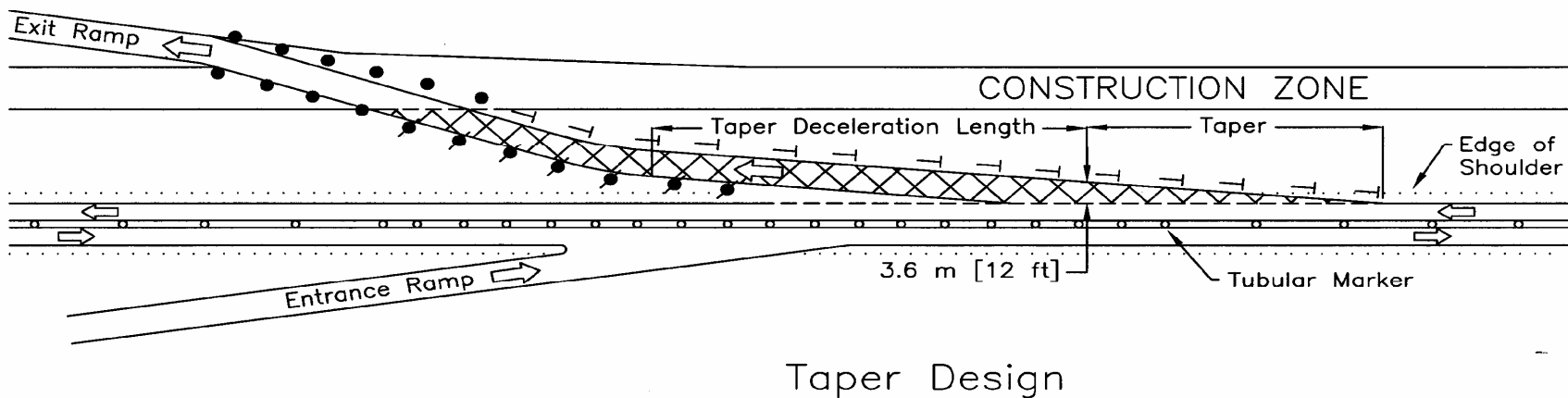
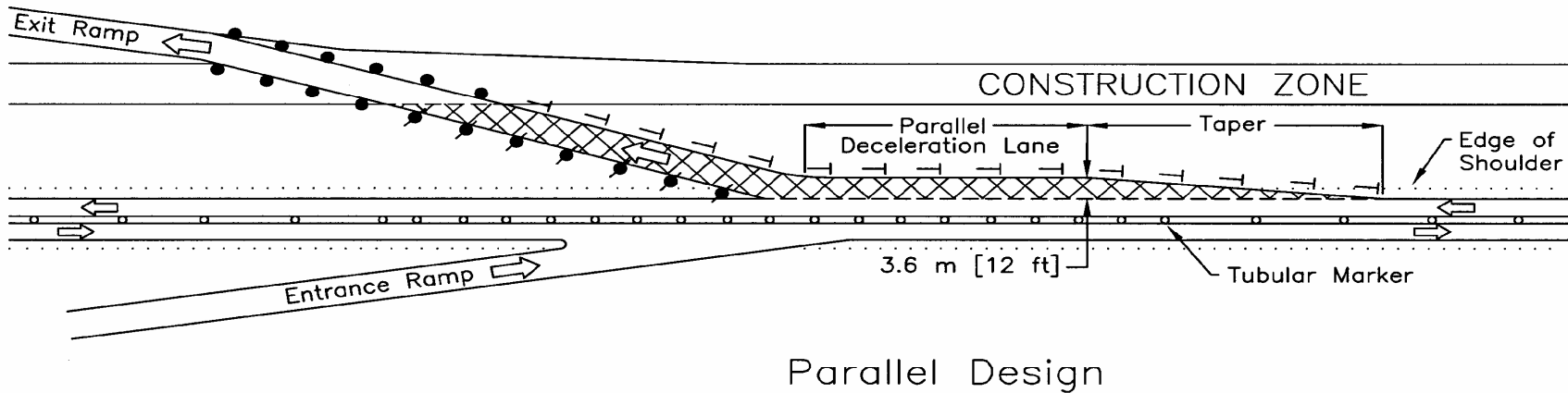


# Roadway Design: Interchange Ramps

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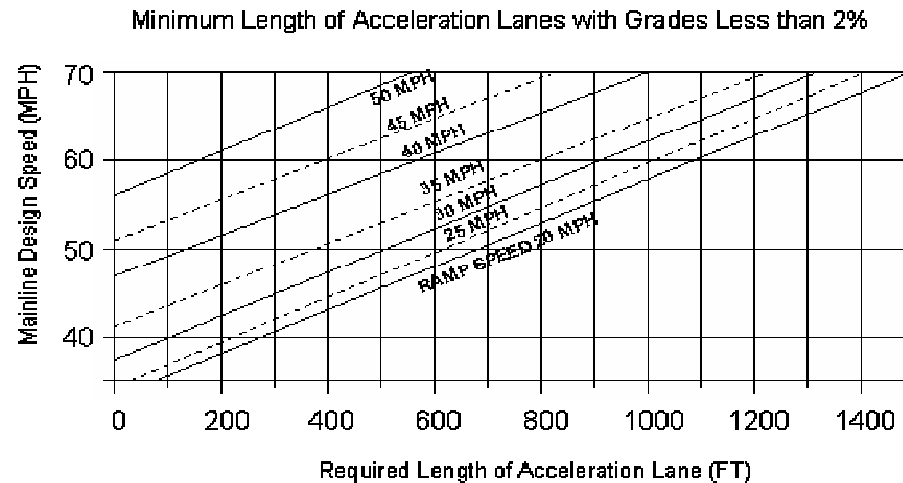
- Combination of TTC and geometry
  
- Entrance and exit ramps
  - Temporary ramps (with crossovers)
  - Minimum acceleration/deceleration lane lengths

# Roadway Design: Interchange Ramps

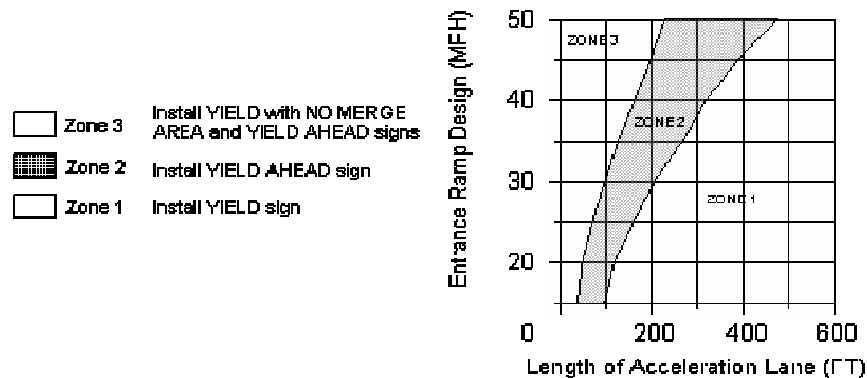


# Roadway Design: Interchange Ramps

## Maryland SHA process



Warrants for YIELD signs on Entrance Ramps to Expressways and Freeways



### Summary of process

1. The minimum acceleration lane length is determined using *Green Book* criteria. The top figure is the base value that may need adjustment for grade.
2. If an acceleration lane length equal or greater than the minimum criteria value is provided, no YIELD sign is warranted.
3. If an acceleration lane length less than the minimum criteria value is provided, the bottom figure is applied to determine appropriate signing.

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# Roadside Design and Barrier Placement

## Principles of Roadside Design

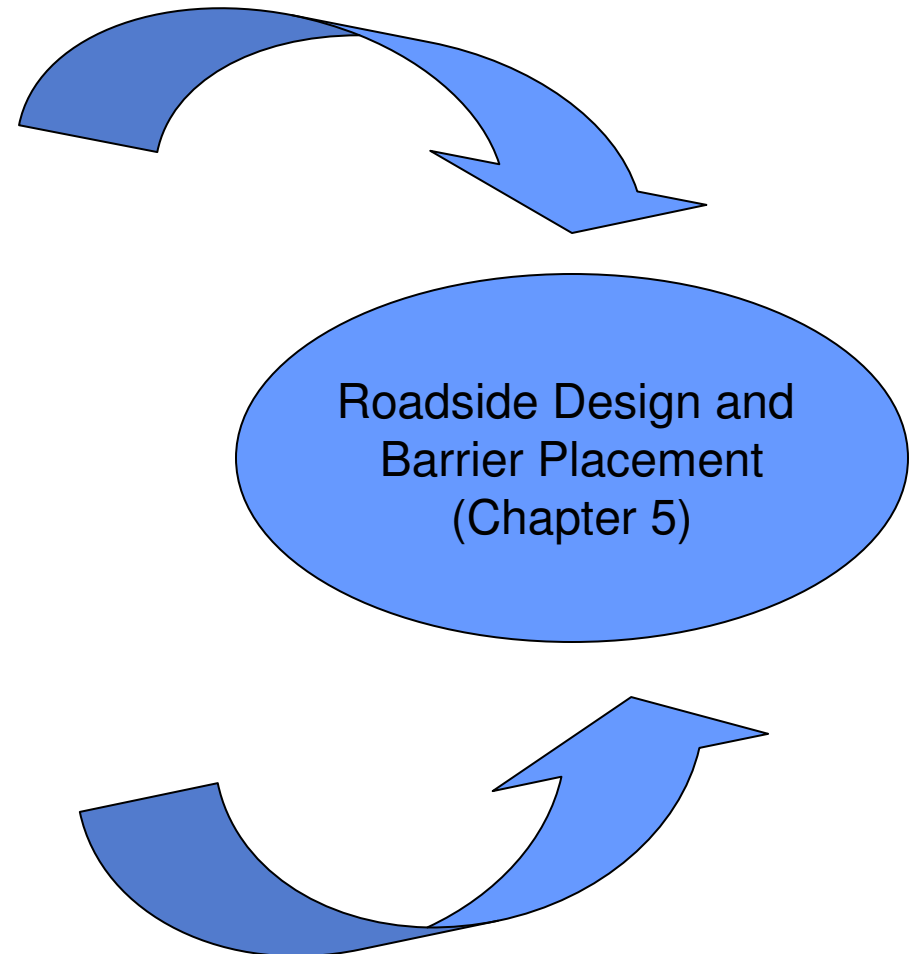
- forgiving roadside/clear zone
- identification and treatment of hazards
- benefit-cost analysis
- other considerations
  - o length of need
  - o flare rates
  - o end treatments
  - o crash cushions

## Existing Guidance (DOTs, *RDG*)

- adjusted clear zone
- types of construction hazards requiring analysis
- gaps

## Roadside Safety Analysis Program

- adaptation to work zones
- benefit-cost analysis
- common scenarios



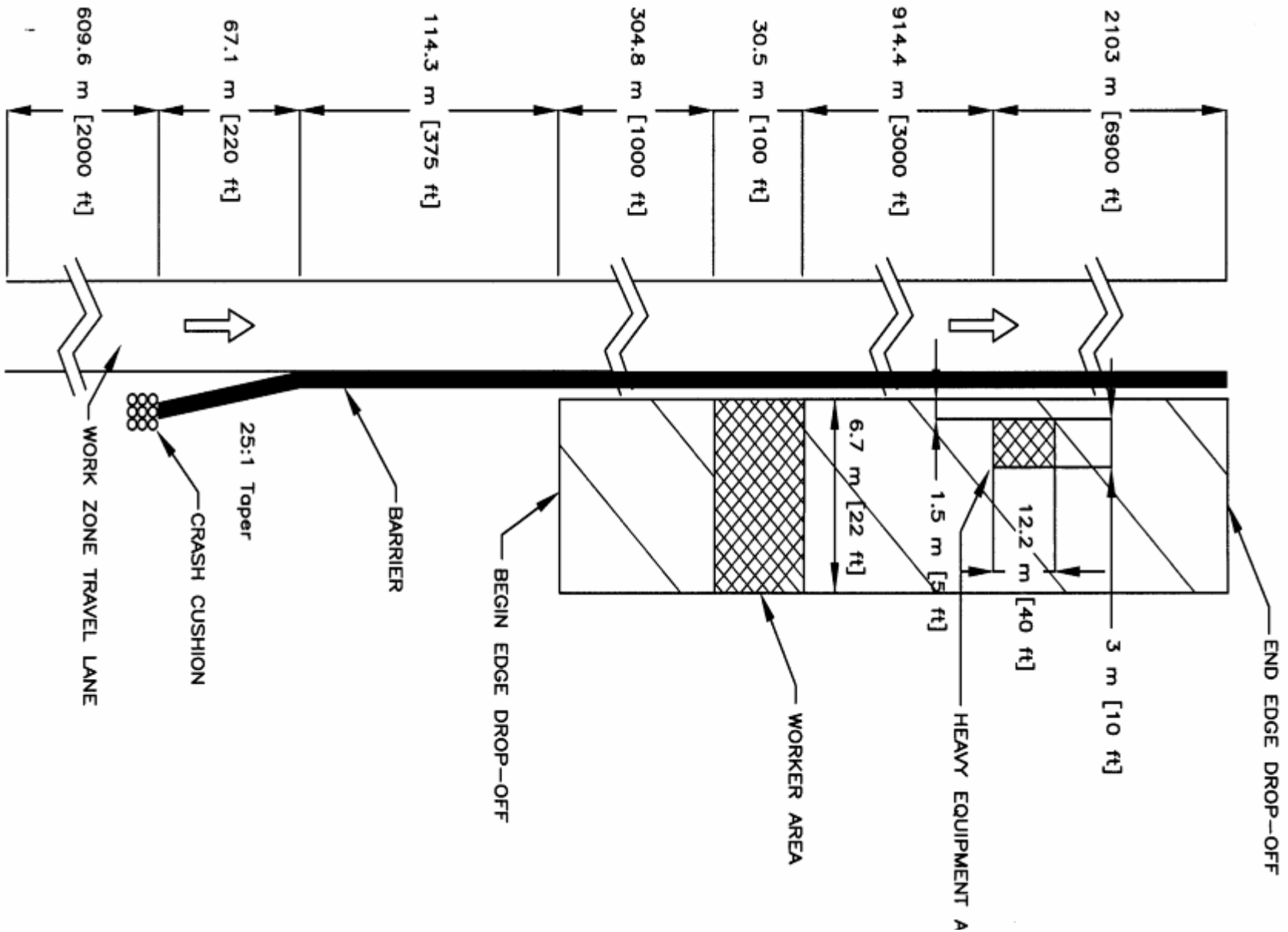
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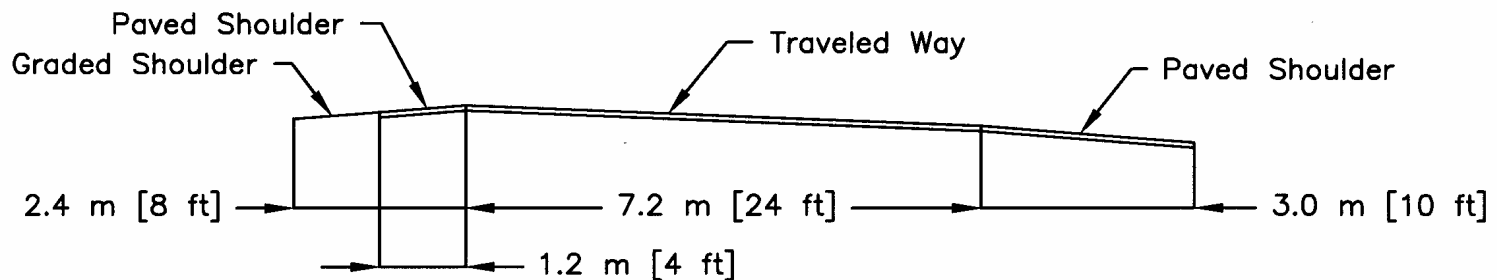
## Guidance for Generic Scenarios:

1. Right Lane and Shoulder Closure for Part-Width Construction on a Four-Lane Divided Highway
2. Shoulder Closure on a Four-Lane Divided Highway with Minor Encroachment
3. Median Work on a Four-Lane Divided Highway with Minor Encroachment
4. Bridge Reconstruction with Temporary Diversion/Runaround on a Two-Lane, Two-Way Highway
5. Separation of Two-Lane, Two-Way Traffic on a Normally Divided Facility (Results based on Ross & Sicking)
6. Protection of a Normally Downstream Barrier End for Two-Lane, Two-Way Traffic on a Normally Divided Facility

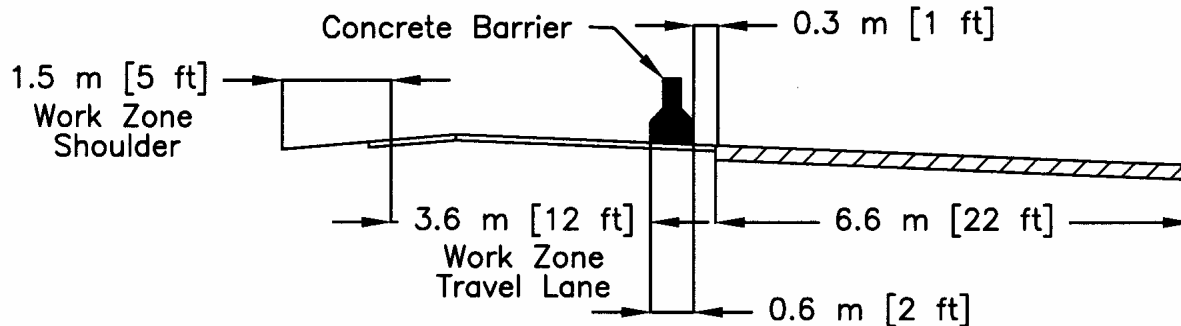
## Scenario 1: Shoulder Closure on a Four Lane Divided Highway with Minor Encroachment



# Generic Scenario 1: Shoulder Closure on a Four-Lane Divided Highway with Minor Encroachment



Typical Cross Section (Before Construction)

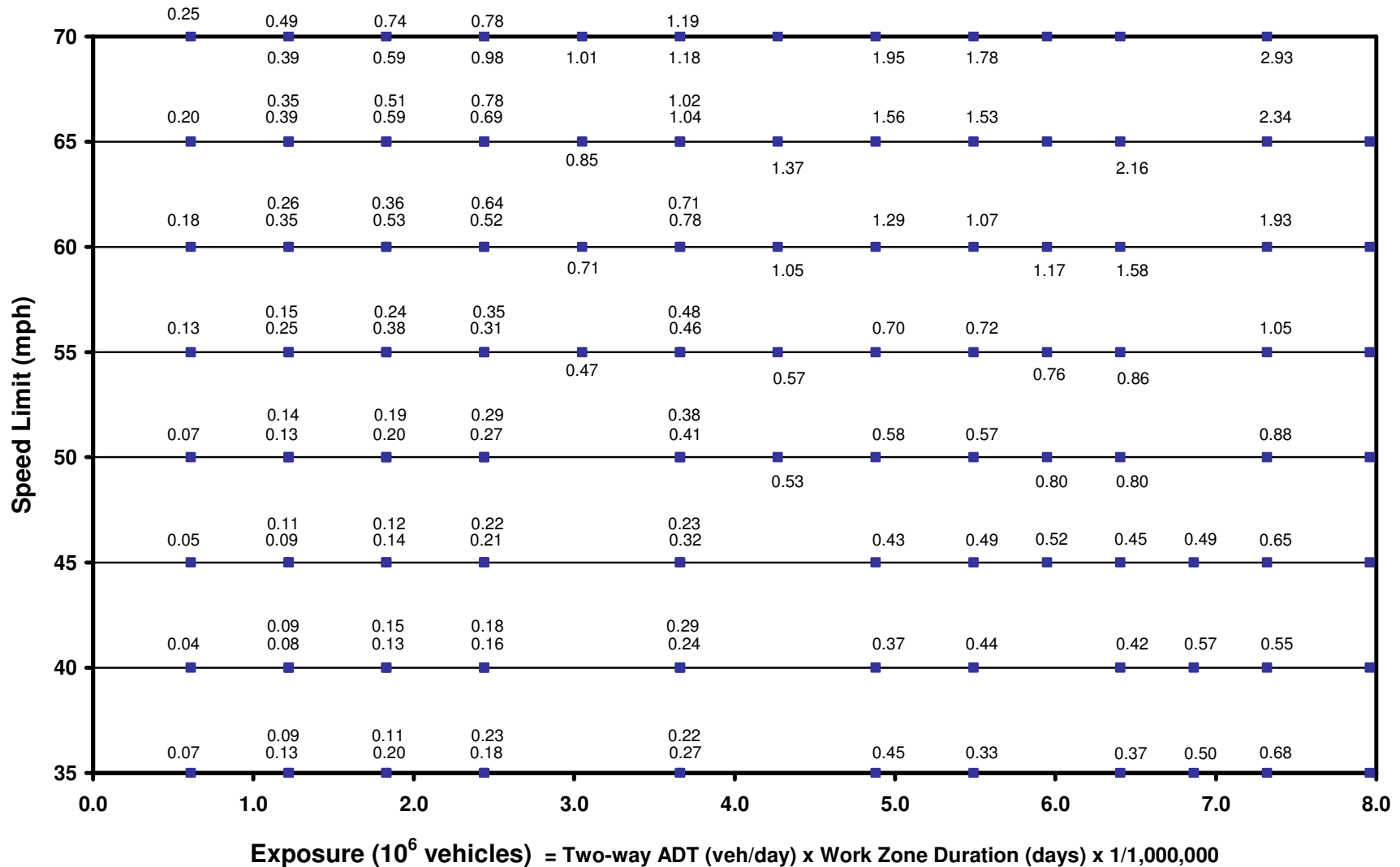


Typical Cross Section (During Construction)



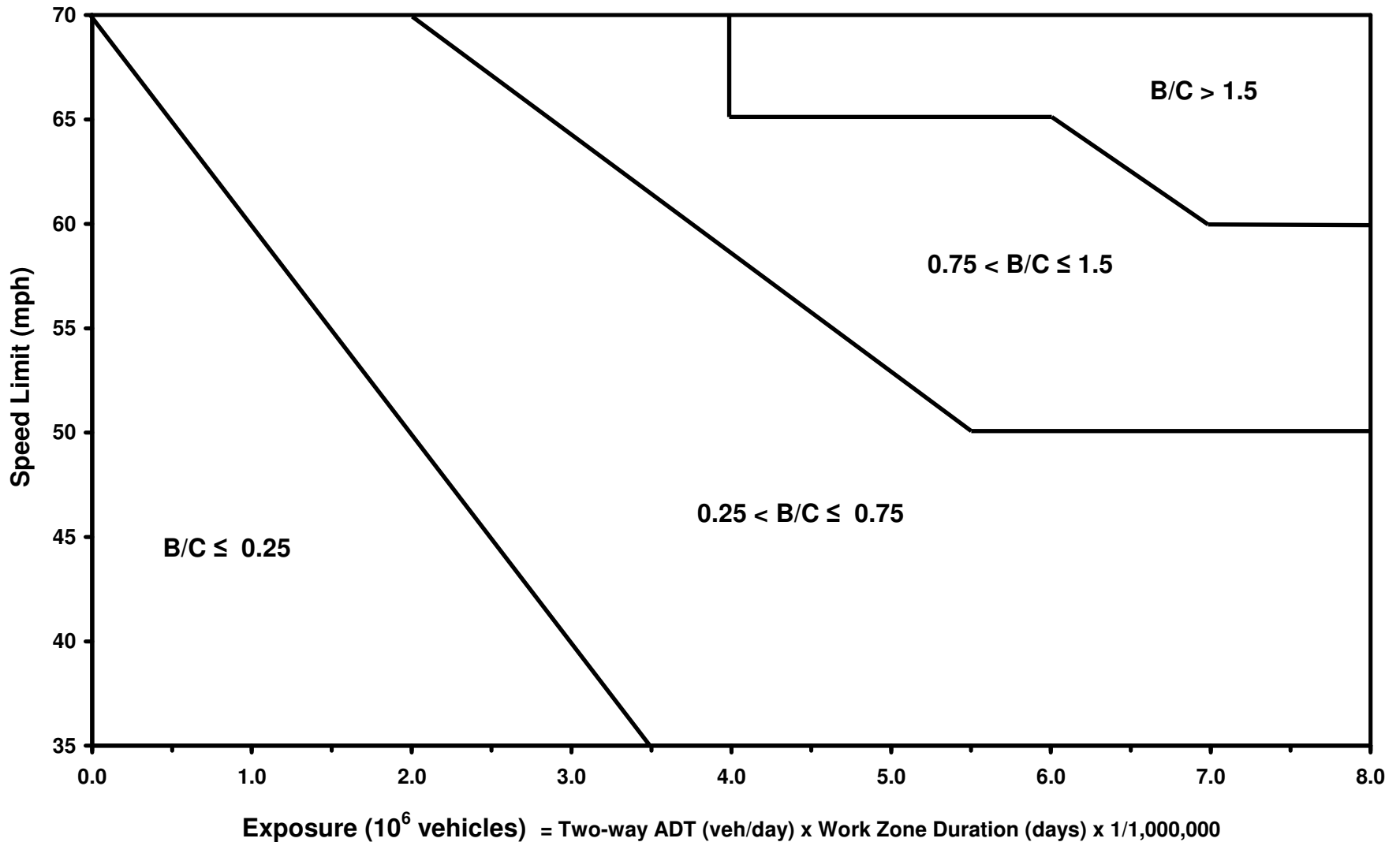
# Generic Scenario 1: Shoulder Closure on a Four-Lane Divided Highway with Minor Encroachment

## Results of Benefit Cost Analysis



# Generic Scenario 1: Shoulder Closure on a Four-Lane Divided Highway with Minor Encroachment

## Results of Benefit Cost Analysis



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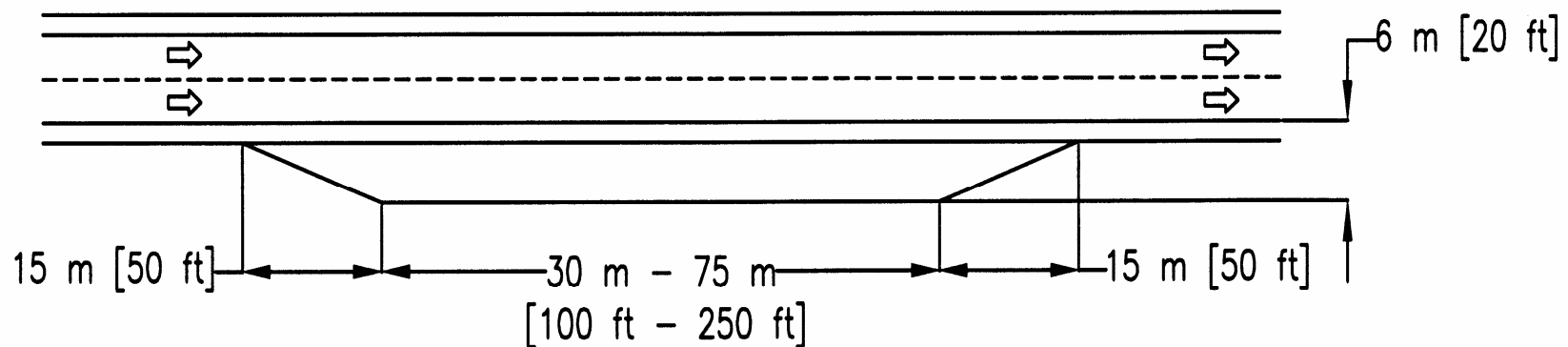
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- Drainage
- Temporary bridges
- Enforcement pulloff areas
- Emergency turnouts
- Screens \*
- Portable Changeable Message Signs \*
- Arrow Panels \*
- Lighting \*
- Rumble strips

\* Primarily references MUTCD

# Ancillary Design Information

## Example: Emergency Turnout



# The End

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□ Questions

□ Comments

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