REDUCED CHANNELIZING DEVICE SPACING

A. INTRODUCTION

To determine the spacing of channelizing devices, state Departments of Transportation (DOTs) and the Manual of Uniform Traffic Devices (MUTCD) consider all or some of the following factors: (1) the speed limit, (2) channelizing device size, (3) taper type, (4) roadway geometric features, (5) device location within the different work zone component areas, (6) special traffic conditions, and (7) the risk of errant vehicle intrusions into the work space area.

Although prior research on work zone delineation for channelization supported the current MUTCD standard of speed limit spacing[1] and did not find any significant difference in motorists' understanding and behavior among the various devices[2] and spacings tested[3]; overall, the data suggested that devices placed more closely together have the potential to perform the same or better, but not worse, than devices placed farther apart[4]. Research also suggested that the extra expense of placing more devices was not significant because of their low rental and/or amortization cost, and the crew's proficiency on their setup and removal.

A state-of-the-practice on-line survey conducted by SHA in October 2004, revealed that among DOTs with their own channelizing device spacing policies, there is a tendency towards the use of reduced channelizing device spacing to increase driver alertness and as a consequence increase road worker's safety and to address special traffic conditions (NYSDOT, Caltrans and VDOT are three examples). Moreover, the MUTCD policy does not prevent or prohibit the use

[1] That is, the devices should be spaced at a maximum distance in feet equal to 1.0 times the speed limit in mph when used for taper channelization, and a distance in feet equal to 2.0 times the speed limit in mph when used for tangent channelization.

[2] e.g., Barricades, drums, vertical panels, cones, and tubes among others

[3] Devices spaced at 1.0, 1.5 and 2.0 times the posted speed limit in mph.

[4] For instance, it was reported that when devices were placed at one-half speed limit spacing, they produced speed reductions at night, apparently from the illusion that the motorist was going faster than he really was.

of more devices at closer spacing, but only regulates the maximum spacing of channelizing devices.

Lastly, section 7.2 of the Maryland State Highway Administration's Standards for Highways and Incidental Structures states the following with respect to channelizing device spacing:

7.2 Maximum spacing between channelizing devices

Taper Channelization: equal in feet to the posted speed limit.

Tangent Channelization: equal in feet to twice the posted speed limit.

SHA's current channelizing device spacing policy is in essence equal to the MUTCD speed limit spacing criteria, whose ease-of-use and practicability are undisputable. Furthermore, the speed limit device spacing criteria has not been refuted by previous research and despite being about half-a-century old, it is still widely used by state DOTs across the United States today. Nonetheless, this policy may be upgraded to incorporate factors such as the effect of device size, the need to address special roadway/traffic conditions, and the need to enhance road worker's safety against the risk of errant vehicles entering the work space area.

B. CONDITIONS CAUSING THE USE OF REDUCED CHANNELIZING DEVICE SPACING

The following is a list of conditions in which more channelizing devices at closer spacing may be used to provide additional information to the driver, in hope of a safer behavior and response while traveling through the work zone. The list is far from comprehensive, but should provide a good starting point.

a) Reduced channelizing device spacing should be used along the work zone activity area where the likelihood of errant vehicles entering the work space area is more probable.

b) Reduced channelizing device spacing should be considered where road workers have significant exposure to traffic.

c) Reduced channelizing device spacing should be used when there is conflict between existing pavement markings and these devices.

d) Reduced channelizing device spacing may be used along roadway curves with a sharp degree of curvature such that several devices are always visible to the driver.

e) In transition areas and situations where traffic patterns are significantly modified, channelizing devices may be placed at closer spacing to better delineate/emphasize the new pattern (e.g., a lane closure situation occurring on a four-lane undivided highway where the greater traffic volume is on the side where the work is being done and as a consequence, one of the opposing traffic's lanes is closed and made available to the side with heavier traffic. Closely spaced devices should be used to emphasize the new lane lines).

f) Reduced channelizing device spacing may be used at intersections to reduce the frequency of deliberate and/or inadvertent traffic encroachments.

g) Closer device spacing may be used with the purpose of reducing work zone average speeds during nighttime operations.

C. REDUCED CHANNELIZING DEVICE SPACING GUIDELINES

A proposed policy that supplements the MUTCD by addressing some of the issues described in prior sections and which decisively favors closer device spacing is summarized in Table 1.

When any of the work zone conditions listed in Table 1 are present, the spacing between channelizing devices shall be equal to 20 feet for low-speed facilities, and 40 feet for high-speed facilities. In all other cases, taper and tangent channelization should conform to MUTCD guidelines contained in section 6F.58 (Channelizing Devices).

Table 1. Channelizing device spacing for particular work zone conditions

Work Zone Location/Condition	Spacing in Feet	
	Low-speed (45 mph or less)	High-speed (Greater than 45 mph)
Transitions and Curves[1]	20'	40'
Work Zone Activity Area[2]		
Intersections		
Conflict Areas[3]		
Hazardous conditions[4]		
Nighttime Operations		

[1] Use on curves with a degree of curvature greater than 6 degrees.

[2] Where work is taking place.

[3] Areas with no pavement markings or where there is a conflict between existing pavement markings and channelizing devices.

[4] e.g., equipment very near the traffic stream, unusual conditions hidden from the motorists, trucks entering and leaving the traffic stream, etc.

Disclaimer

The information provided in this section of the Maryland State Highway Administration's Work Zone Safety Tool Box is only to provide guidance. The Work Zone Safety Tool Box supplements current practices and standards provided in the current edition of the following documents:

1) The Manual on Uniform Traffic Control Devices (MUTCD)
2) The Maryland Supplement to the Manual on Uniform Traffic Control Devices
3) Maryland State Highway Administration Standard Sign Book
4) Maryland State Highway Administration Book of Standards for Highway and Incidental Structures
5) Maryland Department of Transportation State Highway Administration Standard Specifications for Construction and Materials

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E. LITERATURE REVIEW SUMMARY

E.1. MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES FOR STREETS AND HIGHWAYS, 2003 EDITION, REVISION 1

Section 6F.58 (Channelizing Devices) states the following:

Guidance

- The spacing of channelizing devices should not exceed a distance in feet equal to 1.0 times the speed limit in mph when used for taper channelization, and a distance in feet equal to 2.0 times the speed limit in mph when used for tangent channelization.

Section 6C.08 (Tapers) states the following:

Guidance

- When used, a downstream taper should have a length of approximately 100 ft per lane with devices placed at a spacing of approximately 20 ft.

Support:

- The one-lane, two-way taper is used in advance of an activity area that occupies part of a two-way roadway in such a way that a portion of the road is used alternately by traffic in each direction.

Guidance:

- … A short taper having a maximum length of 100 ft with channelizing devices at approximately 20 ft spacings should be used to guide traffic into the one-way section.

The MUTCD policy on channelizing device spacing is summarized in Table 2.

Table 2. MUTCD - Maximum Spacing of Channelization Devices

Speed Limit	Taper Channelization		Tangent Channelization
	Merging Taper, Shifting Taper, and Shoulder Taper	One-Lane, Two-Way, and Downstream Taper	
[mph]	[ft]	[ft]	[ft]
20	20	20	40
25	25	20	50
30	30	20	60
35	35	20	70
40	40	20	80
45	45	20	90
50	50	20	100
55	55	20	110
60	60	20	120
65	65	20	130
70	70	20	140
75	75	20	150

E.2. NCHRP REPORT 236 - EVALUATION OF TRAFFIC CONTROLS FOR HIGHWAY WORK ZONES

Laboratory and field tests to assess the effectiveness of selected channelizing devices in eliciting desired driver responses were conducted on the early 1980's by the Transportation Research Board (refer to NCHRP Report 236, Evaluation of Traffic Controls for Highway Work Zones). Traffic cones, barricades, drums, vertical panels, and steady-burn lights were deployed in both a closed highway and in three active work zones at varying spaces. Motorists' reactions were measured by observed speed changes, points of lane change, path consistency and detection distances. Some of the study's pertinent findings were:

1. The optimum spacing is somewhat dependent on the device type. What may be suitable for large drums may not be appropriate for small cones.
2. The results of both the control and field evaluation studies tended to support the MUTCD standard of speed limit spacing, that is, devices in a taper should be placed approximately as many feet apart as the posted speed limit.

3. Although no statistically significant, on a 55-mph facility, devices placed at 110 ft tended not to perform as well as when they were place at one-half speed limit spacing.
4. It was also observed that when devices were placed at one-half speed limit spacing, they produced a speed reduction at night, apparently from the illusion that the motorist was going faster than he really was.
5. All devices elicited a shift in lateral placement towards the left edge of the lane away from the devices.
6. During the day speed reduction is controlled by device size.
7. During the night speed reduction is controlled by the amount of visible reflective surface.
8. Device size has a greater impact on behavior than device shape.
9. Barricades, drums, vertical panels, cones, and tubes, when designed properly, all perform adequately both day and night.
10. The approach-end taper treatment of a channelizing system must be detectable at a distance sufficiently long so that the motorist can adjust his speed and path in a safe and efficient manner.

Based on these and other findings, it was recommended that:

A. All devices be placed at speed limit spacing for most conditions and, in all cases, along the taper or transition section.
B. If there is no construction work or hazards in the closed lane for a substantial length, the spacing can be increased to no more than twice the speed limit.
C. Shorter spacing may prove to be useful where speed reduction is desired.
D. Variable spacing for curve sections may be desirable depending on the direction and degree of curvature.

E.3. WORK ZONE TRAFFIC CONTROL DELINEATION FOR CHANNELIZATION (REPORT FHWA-RD-90-089).

In the early 1990's the Federal Highway Administration sponsored a project whose main objective was to determine the most optimum spacing configuration for eight different channelizing devices. The devices were spaced at the standard distance of 1.0 times the posted speed limit in mph, as well as at 1.5 times and 2.0 times the standard distance. Over 240 subjects representing a cross section of the driving population were tested. Field testing was undertaken at six active work zones, under both day and night conditions.

1. It was hypothesized that fewer larger devices, such as drums, could be used in place of small devices, such as cones, to do the same job. The research failed, however, to find a significant difference in motorists' understanding and behavior among the devices and the spacings between the devices that were tested.
2. The findings of this research did not suggest the need for major changes to the basic spacing criteria for channelizing devices in the vicinity of the taper at work zones.
3. The type and spacing of devices may not be the most critical factor relative to guidelines for work zone delineation.
4. A channelizing device spacing criteria that is dependent on the sight line existing at the approach to the work zone may be more appropriate than the posted speed limit criterion. That is, at locations with clear sight lines wider device spacing may be allowed. Where sight distances are limited, the use of larger devices or more devices on the taper may be more suitable.
5. The cost analysis indicated very small differences associated with the different spacing options. Each of the devices is amortized or rented for pennies a day and most crews are very proficient at the setup and removal of these devices.
6. From a contractor's view, it is best to use as few devices as possible without jeopardizing safety.

7. The effectiveness of the various devices may be affected by the extent and type of work activity, the use of other traffic control devices, the nature of traffic, the horizontal and vertical alignment of the roadway, and cross-sectional features.
8. There were no indications that the size of a device affected a driver's reaction to a closed lane situation.
9. There appears to be no scientific basis for the spacing criteria used with work zone channelizing devices.

F. DOT'S ON-LINE SURVEY

An on-line survey was conducted to review the state of the practice on the topic of channelizing device spacing. The survey revealed the following:

- The vast majority of states (72 percent) use the MUTCD provisions for channelizing device spacing in work zones (see Table 2 and Figure 1).
- From those states surveyed, California, Maryland, Minnesota Missouri, New York, and Virginia have slight to moderately different provisions than those contained in the MUTCD.
- California recommends a device spacing approximately equal to 0.5 times the speed limit in mph for intermediate and short-term projects (for both taper and tangent sections) where there are no pavement markings or where there is a conflict between existing pavement markings and channelizing devices. On state highways a flat spacing of 10 ft is recommended for taper and tangent sections.
- Maryland guidelines are very similar to the MUTCD, though, the verb shall is used instead of the verb should.
- In addition to the spacing criteria used by the MUTCD (i.e., posted speed limit, type of taper and roadway geometry) Minnesota has a channelizing device spacing policy defined by type of application, duration of use, and the type of device deployed. The resulting spacings are similar to the MUTCD values; however, when more formidable devices are used (such as a

Type III barricade) spacings equal to 20.0 times the posted speed limit are recommended for tangent sections.

- In addition to the MUTCD criteria, Missouri has a policy that considers the specific location of the channelizing devices in the work zone area (e.g., transition area, activity area). Greater channelizing device spacings are recommended for the work zone transition area than the activity area. In general, channelizing device spacings are comparable to MUTCD values.
- The state of New York as part of an initiative to reduce work zone crashes caused by errant vehicles intruding into the work activity area, established a blanket policy mandating a fixed channelizing device spacing of 40 ft for stationary work zones where road workers are exposed to traffic.
- Virginia has a policy based on the location of the channelizing devices and posted speed limits. Posted speed limits are classified into two categories -- 35 mph or less, and greater than 35 mph. The resulting device spacings are about half of those recommended by the MUTCD.

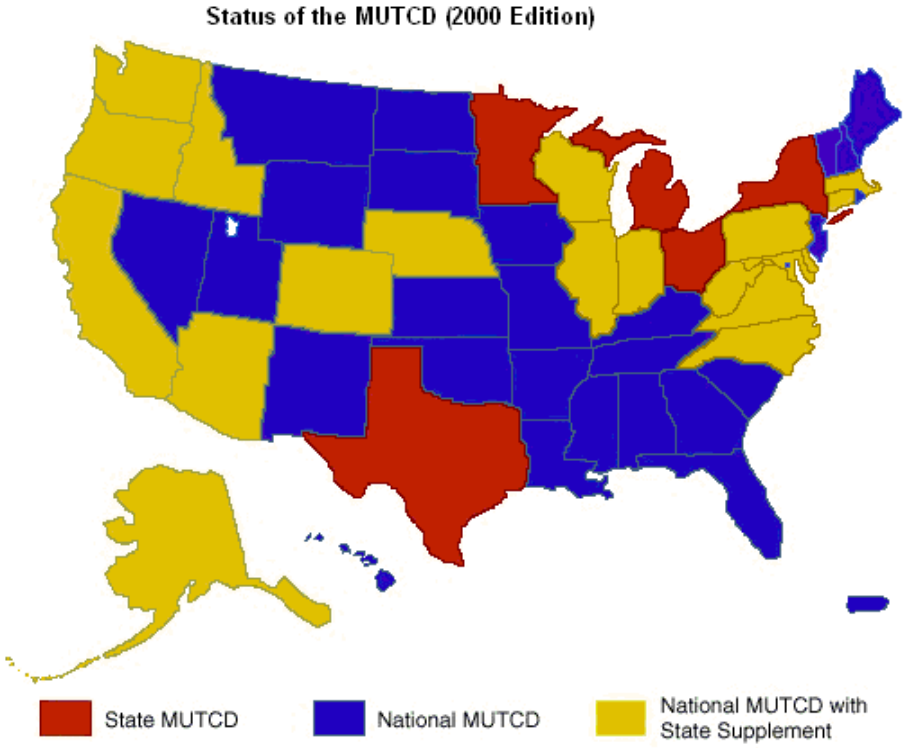

Figure 1. Who Uses the MUTCD and How?*

Table 2. Who Uses the MUTCD and How?*

No.	Status	State	Comments	MUTCD
1	National MUTCD	Alabama	-	Yes
2		Arkansas	-	Yes
3		Florida	-	Yes
4		Georgia	-	Yes
5		Hawaii	-	Yes
6		Iowa	-	Yes
7		Kansas	-	Yes
8		Kentucky	-	Yes
9		Louisiana	-	Yes
10		Maine	-	Yes
11		Mississippi	-	Yes
12		Missouri	- See Missouri's Guidelines for Temporary Traffic Control Zones	Differ
13		Montana	-	Yes
14		Nevada	-	Yes
15		New Hampshire	-	Yes
16		New Jersey	-	Yes
17		New Mexico	-	Yes
18		North Dakota	-	Yes
19		Oklahoma	-	Yes
20		Rhode Island	-	Yes
21		South Carolina	-	Yes
22		South Dakota	-	Yes
23		Tennessee	-	Yes
24		Utah	-	Yes
25		Vermont	-	Yes
26		Wyoming	-	Yes
27	**State MUTCD**	Michigan	Similar to MUTCD provisions.	Yes
28		Minnesota	Provisions based on type of channelization device.	Differ
29		New York	Reduced channelizing device spacing	Differ
30		Ohio	No changes to MUTCD provisions.	Yes
31		Texas	No changes to MUTCD provisions.	Yes
32	**National MUTCD with State Supplement**	Alaska	Supplement was not found on-line	N/A
33		Arizona	No changes to MUTCD provisions.	Yes
34		California	Special provisions.	Differ
35		Colorado	No changes to MUTCD provisions.	Yes
36		Connecticut	Supplement was not found on-line	N/A
37		Delaware	Supplement was not found on-line	N/A
38		Idaho	No changes to MUTCD provisions.	Yes
39		Illinois	No changes to MUTCD provisions.	Yes
40		Indiana	No changes to MUTCD provisions.	Yes
41		Maryland	Similar to MUTCD provisions.	Differ
42		Massachusetts	Supplement was not found on-line	N/A
43		Nebraska	No changes to MUTCD provisions.	Yes
44		North Carolina	No changes to MUTCD provisions.	Yes
45		Oregon	Supplement was not found on-line	N/A
46		Pennsylvania	Supplement was not found on-line	N/A
47		Virginia	Shorter device spacing than MUTCD provisions.	Differ
48		Washington	No changes to MUTCD provisions.	Yes
49		West Virginia	Supplement was not found on-line	N/A
50		Wisconsin	Supplement was not found on-line	N/A

* Information as of August 2003

F.1. California Supplement

- Section 6F.58 (Channelizing Devices) states the following: The spacing of channelizing devices should not exceed the maximum distances shown in Table 6F-102.

Table 6F-102. Maximum Spacing of Channelizing Devices

Speed (mph)	Maximum Channelizer Spacing		
	Taper* (ft)	Tangent (ft)	Conflict** (ft)
20	21	42	10
25	26	53	13
30	32	63	15
35	37	74	18
40	42	84	20
45	48	95	23
50	53	106	25
55	58	116	28
60	63	127	30
65	69	137	33
70	74	148	35

- (*) Maximum channelizing device spacing for all speeds on one-lane/two-way tapers is 20 ft.
- (*) Maximum channelizing device spacing for all speeds on downstream tapers is 20 ft.
- (**) Use on intermediate and short-term projects for taper and tangent sections where there are no pavement markings or where there is a conflict between existing pavement markings and channelizing device.
- On state highways a spacing of 10 ft is recommended for taper and tangent sections.

F.2. Maryland Supplement

- The spacing of taper channelizing devices shall be equal in feet to the posted speed limit.
- The spacing of tangent channelizing devices shall be equal in feet to twice the posted speed limit.

F.3. Minnesota Manual on Uniform Traffic Control Devices

Section 6C.8 (Tapers) states:

- Channelizing devices should be placed at 12 ft spacings when used in a one-lane, two-way taper.

Section 6F.55 (Channelizing Devices) states:

- The maximum spacing of channelizing devices is shown in Table 6F-2.
- The spacing of channelizing devices should not exceed a distance in feet equal to 1.0 times the posted speed limit in mph when used for taper channelization. The spacing of channelizing devices should be between 2.0 to 4.0 times the posted speed limit in mph when used for tangent channelization.

Channelizing Device	Application				Duration			Spacing				complete information found in this MN MUTCD Section
	Channelize	Mark Hazard	Close Roadway	Restrict Traffic	Short Term	Intermediate Term	Long Term	Maximum Transition Spacing meters	Maximum Transition Spacing feet	Maximum Tangent Spacing meters	Maximum Tangent Spacing feet	
Cone		2						0.3 S	S	0.6 S	2S	6F.56
Tubular Marker								0.3 S	S	0.6 S	2S	6F.57
Surface Mounted Delineator								0.3 S	S	0.6 S	2S	6F.57.1
Weighted Channelizer								0.3 S	S	0.6 S	2S	6F.57.2
Drum								0.3 S	S	1.2 S	4S	6F.59
Vertical Panel								0.3 S	S	1.2 S	4S	6F.58
Type I Barricade								0.3 S	S	1.2 S	4S	6F.60
Type II Barricade								0.3 S	S	1.2 S	4S	
Type III Barricade								N/A	N/A	6.0 S	20S	
Direction Indicator Barricade								0.3 S	S	N/A	N/A	6F.61
Portable Barrier								N/A	N/A	N/A	N/A	6F.62
Raised Island								N/A	N/A	N/A	N/A	6F.63
Opposing Traffic Divider								0.3 S	S	0.6 S	2S	6F.64

NOTES:
1. Cones shall not be used in unattended work zones.
2. Emergency use only

N/A - Not Applicable
S - Posted speed limit (in mph) prior to work starting

Table 6F-2 Recommended Application and Maximum Spacing of Channelizing Devices

- The spacing of channelizing devices shown in the temporary traffic control layouts are based on the distances contained in Table 6F-3.

Posted Speed Prior to Work Starting (mph)	Merging Taper, Shifting Taper, Shoulder Taper, and Downstream Taper		Two-Way Traffic Taper		Tangent	
	meters	feet	meters	feet	meters	feet
0 - 30	10	25	3	12	15 - 30	50 - 100
35 - 40	10	25	3	12	15 - 30	50 - 100
45 - 50	15	50	3	12	30 - 60	100 - 200
55	15	50	3	12	30 - 60	100 - 200
60 - 65	15	50	3	12	30 - 75	100 - 250
70 - 75	15	50	3	12	30 - 90	100 - 300

Table 6F-3 Recommended Spacing of Channelizing Devices

F.4. Michigan Manual on Uniform Traffic Control Devices

- One-Lane, Two-Way Taper: A short taper having a maximum length of 100 ft with channelizing devices at approximately 16 ft spacing should be used to guide traffic into the one-way section.

F.5. Missouri Guidelines for Temporary Traffic Control Zones

- Recommended channelizing device spacing for shoulder and lane tapers in the transition area are shown in the following table.

Speed Limit (mph)	Taper Length[1] (ft.)		Channelizer Spacing[4] (ft.)
	Shoulder[2]	Lane[3]	
0-35	70	245	35[5]
40-45	150	540	40[5]
50-55	185	660	50[6]
60-70	235	840	60[6]

[1] Taper lengths may be adjusted to accommodate crossroads, curves, intersections, ramps, or other geometric features.
[2] Based on 10 ft. shoulder width.
[3] Based on 12 ft. lane width.
[4] Channelizer spacing may be reduced to discourage traffic encroachment.
[5] Spacing reduced to ½ at intersections.
[6] Spacing may be reduced to ½ at intersections.

- Recommended channelizing device spacing in the activity area are shown in the following table.

Speed Limit (mph)	Buffer Length (ft.)	Channelizer Spacing[1] (ft.)
0-35	120	50[2]
40-45	220	100[2]
50-55	335	100[3]
60-70	550	100[3]

[1] Channelizer spacing may be reduced to discourage traffic encroachment.
[2] Spacing reduced to ½ at intersections.
[3] Spacing may be reduced to ½ at intersections.

F.6. New York Work Zone Intrusion Countermeasures

Engineering Directive ED 99-002 states the following:

- While channelizing devices cannot physically prevent work space intrusions, longitudinal devices are highly effective in providing positive guidance, and discouraging intentional intrusion.
- Although the MUTCD provides guidance on the use of channelizing devices, little specific information is available on the effects of device size and spacing.

- Based on favorable experience at night work zones, and on urban projects in several Regions, close channelizing device spacing used in combination with larger devices appeared to reduce the number of deliberate work space intrusions and inadvertent intrusions as well.
- A maximum channelizing device spacing of 40 ft should be provided at stationary work zones where road workers are exposed to traffic.
- This spacing should be maintained a reasonable distance upstream of workers, and may be used throughout the work zone.
- Where tapers are located 500 ft from the work activity area (1,000 ft for high speed facilities) the 40 ft spacing should be used in the taper as well.
- Drums or vertical panels are preferred for long-duration work zones, and at any locations where the risk of intrusion is high.

F.7. Virginia Work Area Protection Manual

- The spacing of channelizing devices should be as shown in Table 6F-1.

Table 6F-1. Spacing of Channelizing Devices:

Spacing of Channelizing Devices		
Work Zone Locations	**Posted Speed Limit**	**Spacing in Feet**
In Transitions and Curves	35 mph or less	20'
Parallel to the Travelway	35 mph or less	40'
Spot Construction Access *	35 mph or less	80'
In Transitions and Curves	Greater than 35 mph	40'
Parallel to the Travelway	Greater than 35 mph	80'
Spot Construction Access *	Greater than 35 mph	120'
* For easier access by construction vehicles into the work area, spacings may be increased to this distance, but shall not exceed one access per quarter mile.		

- The spacing of channelizing devices in tangent sections of the work zone is normally twice the distance for devices used in the taper and around curves of 6 degrees and greater.