



**ABSTRACT**

In the United States an average of approximately 1,100 people die and 40,000 people are injured annually as a result of motor vehicle crashes in work zones. For addressing the safety in the work zones, a clear understanding of work zone traffic control devices and the dangers they pose to the drivers, pedestrians and workers should be obtained. This would be valuable for highway agencies in setting up proper traffic management plans based on the prevailing conditions.

The purpose of this paper is to educate transportation departments, consulting engineers, and others on the safety benefits of Longitudinal Channelizing Devices as an alternative to drums and temporary concrete barrier for work zone traffic channelization. The results show that the acceleration of vehicles in case of water-filled longitudinal channelizing devices is much lesser than concrete barriers, hence, the former proves to be a much safer and efficient tool for work zone areas.

## 1 INTRODUCTION

2 As most of the nation's highway infrastructure is aging, the current highway works  
3 have shifted from the construction of new highways to the maintenance and rehabilitation of  
4 existing roadways which in turn creates work zone areas. Majority of this reconstruction  
5 work occurs simultaneously along moving traffic which is also accommodated on the  
6 roadway under repair. Approximately 20 percent of the National Highway System (NHS) is  
7 under construction during the peak construction season. More than 3000 work zones are  
8 expected to be present on the NHS during the peak season. Hence, in this period proper  
9 traffic control is critical for safety in work zones. However, traffic control devices  
10 themselves may pose a safety hazard when impacted by errant vehicles. In New York State  
11 Department of Transportation (NYSDOT), 496 work zone crashes took place from 1994  
12 through 1996, out of which one-third of them involved collision with work zone traffic  
13 control devices and 37 percent of those involving serious injury (1).

14 Improvements in our highway infrastructure will benefit all road users by creating  
15 safer roadways, providing jobs, and alleviating congestion. Our nation needs to build better  
16 roads, bridges, and transit systems without sacrificing the safety of motorists, pedestrians,  
17 and workers.

18 Projects may require numerous traffic control devices and other safety features on or  
19 adjacent to travel lanes. The Manual on Uniform Traffic Control Devices (MUTCD),  
20 approved by the Federal Highway Administration (FHWA) as the National Standard,  
21 contains the basic principles of design and use of all accepted traffic control devices for all  
22 streets and highways which are thought to provide a safe work zone environment for  
23 construction workers and motorists (2). In this aspect, Longitudinal Channelizing Devices  
24 (LCDs) were first introduced in the 2003 edition of MUTCD, at the time referred to as  
25 longitudinal Channelizing Barricades (LCBs). According to the current version of the  
26 MUTCD, LCDs are described as lightweight, deformable devices that can be connected  
27 together to delineate or channelize vehicles or pedestrians.

28 Presently, Temporary Concrete Barrier have been specified almost exclusively into  
29 most construction jobs over the last few years. The consequences of using concrete barriers  
30 with regard to the dangers it causes to the motoring public have not been completely  
31 analyzed. According to Roadside Design Guide (3), published by the American Association  
32 of State Highway and Transportation Officials (AASHTO), "...a barrier should be installed  
33 only if it is clear that the result of a vehicle striking the barrier will be less severe than the  
34 crash resulting from hitting the unshielded object itself." In comparison, LCDs are much  
35 safer in use than temporary concrete barrier, which, when impacted by wayward motorists,  
36 create high gravitational (G) forces that can cause serious injury and death to the driver and  
37 occupants of the vehicle. Yet roadway engineers increasingly rely on dangerous and  
38 improper installations of concrete barrier simply to prevent pedestrians or traffic from  
39 entering a work zone or closing a road. An overwhelming number of temporary barrier  
40 installations have nothing to do with shielding an errant vehicle from a massive object.  
41 Whereas LCDs are designed to give way and allow the vehicle to pass through the device, in  
42 turn keeping the G Forces from impact low and tolerable to the human body.

43 Hence, this study was performed to evaluate and compare the safety and economic  
44 benefits of LCDs with respect to the concrete barriers. Through this analysis an elaborate  
45 understanding of water-filled LCDs was obtained and its safety levels were also studied.  
46

## 1 **WATER-FILLED LONGITUDINAL CHANNELIZING DEVICES**

2 The FHWA has accepted the use of several LCDs on the NHS from various  
3 manufacturers. While all of the accepted LCDs are considered crashworthy, as with all  
4 accepted traffic control devices, the test level for which each device is accepted varies. A  
5 review of the FHWA acceptance letter for the LCD being considered would let an engineer  
6 know what speed level the particular LCD has been tested to and the conditions under which  
7 the LCDs were tested (i.e., crash test level, evaluation criteria, with or without ballast, etc.)  
8 prior to adopting it for use in a particular situation.

9 “Although continuous line applications of LCDs may appear to form a solid wall,  
10 they do not meet the vehicle redirection requirements for temporary traffic barriers. Thus,  
11 while LCDs must be crashworthy, they do not provide positive protection for obstacles,  
12 pedestrians or workers. Since LCDs look very similar to water-filled barriers, the two devices  
13 are often confused with each other. To help reduce this confusion, Task Force 13, which  
14 serves the American Association of State Highway & Transportation Officials (AASHTO),  
15 Associated General Contractors of America (AGC) and the American Road & Transportation  
16 Builders Association (ARTBA) Joint Subcommittee on New Highway Materials and  
17 Technologies, has addressed this matter through the development of warning label guidelines  
18 that will provide users with sufficient information to discern between LCDs and barriers. It is  
19 anticipated that these guidelines will educate users about the performance of the different  
20 devices in order to avoid the unintentional use of LCDs at sites where actual barriers are  
21 intended. Task Force 13 and the American Traffic Safety Services Association (ATSSA)  
22 have approved the guidelines, and the FHWA has endorsed them. Task Force 13 is currently  
23 developing a website to disseminate the guidelines. The FHWA plans to include a link to the  
24 guidelines on its Crashworthy Work Zone Traffic Control Devices website (4).”

25 Unfortunately, LCDs have only been used to delineate pedestrian travel paths in work  
26 zones. As such, LCDs have ensured that the temporary pedestrian travel path meets the  
27 MUTCD accessibility requirements for persons with disabilities. Although LCDs are  
28 exceptional at meeting this requirement, there are other uses where LCDs are accepted by the  
29 FHWA, but are rarely considered. For instance, LCDs can be used in place of concrete  
30 barriers to close roadways to vehicular traffic. Closing roads using concrete barrier exposes  
31 motorists to extremely hazardous high angle impacts. Using LCDs to close roadways instead  
32 of concrete barrier mitigates this hazard. LCDs can be used to denote the edge of the  
33 pavement or separate the active travel lanes from the work area, where positive protection is  
34 not required. Again, using LCDs in this manner greatly reduces the risk to motorists and their  
35 passengers of an impact with concrete barrier.

36 In contrast to traditional channelizing devices (e.g., cones, drums, etc.) that have  
37 some open space between devices, LCDs can be connected together to form a solid line.  
38 Thus LCDs can prevent drivers and pedestrians from going between devices and entering the  
39 work area (whether inadvertent or deliberate). A solid line of LCDs also provides continuous  
40 delineation of the travel path, which may be beneficial at major decision points in work  
41 zones, such as lane closures, exit ramps, business access points (i.e., driveways) and  
42 temporary diversions (i.e., crossovers).

43 Of course, LCDs also could be used in a more traditional fashion. For example, in  
44 lane closures, single LCDs acting as Type 2 barricades (i.e., oriented 90° toward oncoming  
45 traffic) could be used in lieu of drums to form the merging taper. While the LCDs would not  
46 be used in a continuous line (i.e., there would be some open space between devices), due to

1 their larger size the LCDs may still appear to form a solid wall to drivers approaching the  
2 lane closure in the closed lane. LCDs also are considered to be highly visible and have good  
3 target value, thus LCDs might increase the sight distance to the lane closure. In addition, the  
4 larger size of the LCDs may allow for increased spacing of the devices (i.e., more than one  
5 times the speed limit in mph); thus fewer devices would be needed (4).”

6 The current mind set of the safety community is geared toward using “positive  
7 protection” to protect maintenance workers in roadway work zones. As a result, concrete  
8 barrier has become the temporary traffic control device most commonly used in highway  
9 work zones. In fact, a recent survey of practices confirmed that temporary concrete barrier is  
10 the option most frequently used by state transportation agencies (5). When deciding on the  
11 correct and safe choice for temporary traffic control in a work zone, an evaluation of devices  
12 should place a particular emphasis on balancing the protection of construction and  
13 maintenance workers with the safety of road users traveling through work zones. According  
14 to the Bureau of Labor Statistics, there were 101 fatal occupational injuries at road  
15 construction sites in 2008 alone. In 2007, 831 workers and motorists were killed in highway  
16 work zones and more than 40,000 were injured. Eighty-five percent of those killed in work  
17 zones are drivers or their passengers (6). According to an exhaustive report on 2008 traffic  
18 fatalities released by the Illinois Department of Transportation (7), there were 31 fatal  
19 crashes in work zones in which 31 people were killed. Only two of the persons killed were  
20 road construction workers, more than 93% of fatal injuries were to drivers and their  
21 passengers. Four out of five of the people who die in work zone crashes are motorists, not  
22 highway workers according to the Virginia Department of Transportation (8).

23 As stated in Part 6 of the MUTCD, “the primary function of temporary traffic control  
24 is to provide for the safe and efficient movement of vehicles, bicyclists, and pedestrians  
25 through or around temporary traffic control zones while reasonably protecting workers and  
26 equipment”. Traffic engineers expect these devices to improve safety for the motorists and  
27 reasonably protect workers when they are installed and maintained properly. However, the  
28 widespread use of concrete barriers, much of it for channelization and not positive protection,  
29 has been because the emphasis on safety has been on positive protection for workers, while  
30 85% of fatalities are drivers and their passengers. These motorists and their passengers can  
31 be subject to average forces of 9.55 g’s and as high as 17.62 g’s shown in Table 1 (9) when  
32 impacting at 25 degree angles when traveling in standard size pickups.

33 The same vehicle when impacting water-filled longitudinal channelizing devices at 25  
34 degrees measured average ride-down accelerations of 5.05 g’s with the highest measurement  
35 at 7.4 g’s, shown in Table 2 (9). Keep in mind these angles are low and motorists can expect  
36 much higher forces when striking barriers that have been located perpendicular to traffic flow  
37 to close lanes. It is clear, when the crash test data is reviewed, that plastic water-filled LCDs  
38 create more positive outcomes in the event of an accident than the use of traditional concrete  
39 barrier due to the high G’s that motorists are subjected to when impacting concrete barrier.

40 The Roadside Design Guide urges temporary concrete barrier be placed only parallel  
41 to traffic (9). Most catastrophic crashes involving vehicles moving through the work zone  
42 and temporary concrete barrier occur when the barrier is struck at a high angle. Deploying  
43 temporary concrete barrier in work zones to close roads or to act as channelizing/delineating  
44 devices exposes vehicles and occupants to the possibility of engaging a massive object that  
45 can cause substantial injury and death. In this case, water-filled LCDs, which are designed to

1 channel traffic without the risk associated with impacting a temporary concrete barrier,  
 2 should be used.  
 3

4 **TABLE 1 NCHRP-350 Crash Tests Carried Out on Concrete Barriers**

Acceptance Code	Test Level	Material	Deflection (feet)	Acceleration (g's)
B-149	3	concrete	6.23	8.60
B-122	3	concrete	0.94	10.98
B-102	3	concrete	7.50	10.10
B-98	3	concrete	5.05	7.70
B-94	3	concrete	4.17	8.90
B-93	3	concrete	5.48	7.20
B-90	3	concrete	2.46	12.20
B-86A	4	concrete	2.71	6.80
B-86	3	concrete	2.50	18.20
B-86	3	concrete	2.67	
B-84	3	concrete	5.25	10.40
B-79	3	concrete	8.38	9.50
B-70	3	concrete	3.61	11.70
B-69B (concrete)	3	concrete	2.00	12.30
B-67	3	concrete	6.33	
B-63	3	concrete	4.42	5.40
B-62	3	concrete	1.38	4.50
B-61	3	concrete	0.85	17.62
B-54	3	concrete	6.00	12.40
B-52A	3	concrete	4.27	
B-52	3	concrete	4.27	5.70
B-42		concrete	0.66	10.06
B-41	3	concrete	3.74	10.50
<b>Average G's</b>				<b>8.73</b>

5  
 6 **TABLE 2 Crash Tests Carried Out on Water-Filled Longitudinal Channelizing Devices**

Acceptance Code	Test Level	Material	Acceleration (g's)
WZ-214	3	Plastic	3
WZ-255	3	Plastic	5.6
WZ-191	2	Plastic	7.4
WZ-279	2	Plastic	4.19
<b>Average G's</b>			<b>5.05</b>

7  
 8 If 85 percent of work zone crash fatalities are drivers and their passengers, and water-  
 9 filled LCDs provide a higher degree of safety for the motorists passing through work zones,  
 10 it would seem logical that water filled devices would be the traffic control device of choice.

1 Water-filled LCDs can be used even in cold weather conditions by mixing water with any of  
2 the sodium chlorides, calcium chloride, or more environmentally friendly additives like  
3 potassium acetate or BX36. But these devices are rarely if ever used. In road construction  
4 work zones, resistance to change to use of water-filled LCDs (as with many devices new to  
5 the transportation infrastructure environment) slows industry-wide adoption of water ballast  
6 devices. There is an enduring familiarity with concrete and a tendency to rely on concrete  
7 barrier for every use, even when it is not the safest or most appropriate device for the job.  
8 Because there is no requirement or incentive for change, engineers simply continue to specify  
9 temporary concrete barrier for all traffic control jobs, in spite of the innovation of safer and  
10 more effective mechanisms. Findings show that deployment of new devices face roadblocks  
11 because (a) transportation projects are complex, multifaceted, and inter jurisdictional with  
12 many players having different interests; (b) multiple layers of decision making sometimes  
13 lack logic; (c) public-sector procurement is driven by competitive, multiple low-bid  
14 processes that often infringe on intellectual property rights; (d) public agencies resist change;  
15 and (e) risk-averse executives hesitate to implement new innovations (10). This research  
16 underlines the need for improved communication among researchers, developers, operators,  
17 and decision makers.

18 In addition to the institutional factors contributing to the lack of innovation listed  
19 above, there is no funding for innovative practices. If better safety costs more money, it must  
20 be funded. FHWA's rule on Temporary Traffic Control (a.k.a. Subpart K) states:

21 "Payment for work zone traffic control features and operations shall not be incidental  
22 to the contract, or included in payment for other items of work not related to traffic control  
23 and safety; as a minimum, separate pay items shall be provided for major categories of traffic  
24 control devices, safety features, and work zone safety activities, including but not limited to  
25 positive protection devices, and uniformed law enforcement activities when funded through  
26 the project."

27 To comply with this rule states create itemized lists of work zone devices.  
28 Unfortunately, innovative devices are rarely if ever listed. For example, the Longitudinal  
29 Channelizing Device, a traffic control device listed in the MUTCD for several years, is not  
30 listed in any of the itemized lists published by any State DOTs.

31 It is important to recognize that utilizing the full array of work zone traffic control  
32 devices available, and deploying suitable traffic control devices for each specific job, can  
33 prevent many accidental injuries and deaths in work zones. The continued reliance on  
34 temporary concrete barrier for every work zone application is extremely hazardous to the  
35 motoring public.

36 In addition, temporary concrete barriers also cause unnecessary work zone congestion  
37 while they are unloaded and set into position by cranes requiring the closure of a traffic lane  
38 for the installation. Manually unloading lightweight plastic LCDs, positioning them by hand,  
39 and adding a very small volume of ballast is much more affordable and does not require an  
40 additional lane for a flat bed and crane.

41 The four primary functions of barriers are to keep traffic from entering work areas,  
42 such as excavations or material storage sites; to provide rigid or positive separation for  
43 workers and pedestrians; to separate two-way traffic; and, to provide rigid or positive  
44 separation for construction such as false work for bridges and other exposed objects.

45 As noted earlier, temporary barriers are not traffic control devices in themselves;  
46 however, when placed in a position identical to a line of channelizing devices and marked

1 and/or equipped with appropriate channelization features to provide guidance and warning  
2 both day and night, they serve as traffic control devices.

3 Longitudinal channelizes have been designed with several features that provide great  
4 advantages and benefits over contemporary traffic control devices. They fill the void in work  
5 zone traffic control devices that lies between concrete barrier, drums and barricades. The  
6 obvious advantages when compared to concrete are greater ease of handling, greater ease of  
7 installation, lower costs of installation, and fast setup time. At a minimum a four-person  
8 team must be utilized to run a crane, operate a tractor-trailer, and guide the heavy concrete  
9 barricade into place. When this cost is added to the purchase price of concrete barricade,  
10 tremendous savings are realized by utilizing lightweight plastic channelizing units. Not only  
11 is there price value, but also the lightweight plastic barrier will not damage expensive asphalt  
12 or concrete surfaces. In addition, the interconnecting plastic channelizing units do not  
13 require an expensive end treatment (a crash cushion that must be installed on the terminal  
14 end of a concrete barrier) as does concrete barrier.

15 Hence, temporary concrete barriers have many disadvantages, and alternative traffic  
16 control devices that do not pose a hazard to the motoring public and are more cost effective  
17 should be evaluated for best practice. Where guidance emphasis will suffice, a Longitudinal  
18 Channelizing Device is ideal. Longitudinal Channelizing Devices are lightweight, plastic,  
19 water-fill able devices that form bright, visually-compelling, continuous walls in the manner  
20 of concrete but without the lethal potential to impacting vehicles. The FHWA recognizes the  
21 need for LCDs and the MUTCD has been updated to reflect the useful and effective  
22 deployment of LCDS as an alternative traffic control device. See Section 6F.66 MUTCD.

23 Insubstantial traffic control devices such as folding Type I or Type II barricades,  
24 delineator posts, reflective panels and cones can be used in these applications as well, but are  
25 regularly ignored by aggressive drivers as the size of these devices is not formidable and the  
26 spacing between devices permits intrusion by vehicles. If drivers do not respect traffic  
27 devices, they may accidentally or even intentionally enter a work zone, causing injury to their  
28 passengers and/or workers. LCDs create a large and commanding traffic control device,  
29 compelling drivers to exercise more care in avoiding impact. Without this boundary, drivers  
30 may not realize until too late that insubstantial delineator posts were actually marking the  
31 edge of a very hazardous drop-off. The posts can also be confusing to drivers who often have  
32 difficulty determining their intended travel path through the widely spaced array of markers.  
33 This risk is increased when visibility is inhibited by weather conditions of heavy rain, fog, or  
34 other precipitation. Lastly, delineator posts, panels and other lightweight safety devices are  
35 often knocked over by passing vehicles, weather and the air backwash of heavy vehicles. An  
36 unbroken, interconnected array of LCDs provides a clear, unambiguous travel path,  
37 particularly where there may be directional path changes within a work-zone. In addition,  
38 LCDs connected together can also reduce the potential for missing devices as ballasted LCDs  
39 are more resistant to becoming misaligned by passing vehicles and weather.  
40

## 41 CONCLUSION

42 For decades, road transportation departments, consulting engineers, and others who  
43 specify safety equipment in roadway construction projects have had few choices in traffic  
44 control devices. In order to reduce the number of work zone fatalities, these transportation  
45 professionals are urged to examine and consider new products offering vehicle occupants a  
46 safer environment. If 85 percent of work zone crash fatalities are drivers and their



1 passengers, and water-filled longitudinal channelizing devices provide a higher degree of  
2 safety for the motorists passing through work zones, it would seem logical that water filled  
3 devices would be the traffic control device of choice. Preventing accidents and protecting  
4 workers, pedestrians, and motorists is a national concern. The way to ensure elimination of  
5 these tragedies is to encourage and require the use of the safest product for each specific job  
6 instead of relying on the most familiar traffic control devices or those devices already on  
7 hand for the project. Also, as the results show that the acceleration of vehicles in case of  
8 water-filled longitudinal channelizing devices is much lesser than concrete barriers the  
9 former proves to be a much safer and efficient tool.

10 Historically, engineers have specified temporary concrete barriers as a “one solution  
11 fits all” solution, and a culture has developed leaving temporary concrete barrier as the  
12 default option for channelizing delineation. Only when road transportation departments and  
13 practitioners begin to look beyond the familiar traffic control products will work zone safety  
14 be improved. The individuals most often overlooked when making traffic control decisions  
15 are the occupants of vehicles traveling through work zones. They are frequently exposed to  
16 the dangerous practice of utilizing temporary concrete barrier as a delineator or to close a  
17 road, elevating exposure to high angle impacts or required to drive through a confusing array  
18 of delineators, risking head-on collision. Those vehicle drivers and occupants could be your  
19 family or mine, so we must ask ourselves if we are really considering all of the available  
20 traffic control devices and how the proper deployment of these devices can create safe work  
21 zones, preventing injuries and perhaps saving lives. Surely, it is worth consideration.  
22

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