Improving Work Zone Safety:
Why you should consider water ballast traffic control devices

A WHITE PAPER PREPARED BY THE WATER BARRIER MANUFACTURERS ASSOCIATION

The purpose of this paper is to educate transportation departments, consulting engineers, and others on the availability of new, cost effective, and safe alternatives to temporary concrete barrier for work zone traffic control.

Improvements in transportation infrastructure will benefit all Americans by creating safer roadways, providing jobs, alleviating congestion, and saving time and energy otherwise spent commuting. Throughout these infrastructure improvements, more attention must be given to safety and the prevention of work zone accidents, which take the lives of construction workers, motorists, and pedestrians. Our nation needs to build better roads, bridges, and transit systems *without sacrificing the safety* of motorists, pedestrians, and workers.

The *Manual on Uniform Traffic Control Devices* (MUTCD), approved by the Federal Highway Administrator as the National Standard, contains the basic principles of design and the use of all accepted traffic control devices for all streets and highways. Part 6 of the MUTCD contains the standards, guidance, options, and support information related to work zones. In work zones, temporary traffic control is primarily used to enhance traffic safety and mobility.

A thorough evaluation of these temporary traffic control devices should place a particular emphasis on balancing the protection of construction and maintenance workers with the safety of road users traveling through work zones. According to the Bureau of Labor Statistics, there were 101 fatal occupational injuries at road construction sites in 2008 alone. In 2007, 831 workers and motorists were killed in highway work zones and more than 40,000 were injured. Eighty-five percent of those killed in work zones are drivers or their passengers.[1] According to an exhaustive report on 2008 traffic fatalities released by the Illinois Department of Transportation[2], there were 31 fatal crashes in work zones in which 31 people were killed. Only two of the persons killed were road construction workers, more than 93% of fatal injuries where to drivers and their passengers. Four out of five of the people who die in work zone crashes are motorists, not highway workers according to the Virginia Department of Transportation.[3]

The current mindset set of the safety community is geared toward using “positive protection” to protect maintenance workers in roadway work zones. As a result, concrete barrier has become the temporary traffic control device most commonly used in highway work zones to provide positive protection. In fact, a recent survey of practices confirmed that temporary concrete barrier is the option most frequently used by state transportation agencies.[4] This has happened even when the data from work zone accident fatalities overwhelmingly indicate that maintenance workers are in the minority of those killed in work zone.

[1] **FHWA-HRT-09-011,** http://www.tfhrc.gov/focus/mar09/03.htm

[2] http://www.dot.il.gov/travelstats/2008cfweb.pdf

[3] http://virginiadot.org/programs/WorkZoneSafetynewsroom.asp

[4] Work Zone Positive Protection Tool Box, ATSSA, p.5.

As stated in Part 6 of the MUTCD, “the primary function of temporary traffic control is to provide for the safe and efficient movement of vehicles, bicyclists, and pedestrians through or around temporary traffic control zones while reasonably protecting workers and equipment”. Traffic engineers expect these devices to improve safety for the motorists and reasonably protect workers when they are installed and maintained properly. However, the widespread use of concrete barrier has been because the emphasis on safety has been on positive protection for workers, while 85% of fatalities are drivers and their passengers. These motorists and their passengers can be subject to average forces of 9.55 g’s and as high as 23.5 g’s (See table 1)[5] when impacting at 25 degree angles when traveling in standard size pickups. The same vehicle when impacting water-filled barrier systems at 25 degrees measured average ride-down accelerations of 4.42 g’s with the highest measurement at 12.10 g’s, (See table 2)[6]. Keep in mind these angles are low and motorists can expect much higher forces when striking barriers that have been located perpendicular to traffic flow to close lanes. It is clear, when the crash test data is reviewed, that plastic water ballast devices create more positive outcomes in the event of an accident than the use of traditional concrete barrier due to the high G’s that motorists are subjected to when impacting concrete barrier.

Table 1 [4] summarizes most of the full-scale NCHRP-350 crash tests carried out on concrete barriers.

[5] Results of NCHRP-350 Test 3-11 from FHWA
[6] Ibid

TABLE 1

Acceptance Code	Test Level	Material	Deflection (meters)	Deflection (feet)	Acceleration (g's)
B-149	3	concrete	1.90	6.23	8.60
B-134A	3	steel	0.70	2.30	23.50
B-134	3	steel	2.10	6.89	5.30
B-131	4	steel	1.50	4.92	13.30
B-122	3	concrete	0.29	0.94	10.98
B-117		steel	0.31	1.03	12.36
B-102	3	concrete	2.29	7.50	10.10
B-98	3	concrete	1.54	5.05	7.70
B-94	3	concrete	1.27	4.17	8.90
B-93	3	concrete	1.67	5.48	7.20
B-90	3	concrete	0.75	2.46	12.20
B-86	3	concrete	0.76	2.50	18.20
B-86	3	concrete	0.81	2.67	
B-84	3	concrete	1.60	5.25	10.40
B-79	3	concrete	2.56	8.38	9.50
B-70	3	concrete	1.10	3.61	11.70
B-69B (concrete)	3	concrete	0.61	2.00	12.30
B-67	3	concrete	1.93	6.33	
B-63	3	concrete	1.35	4.42	5.40
B-62	3	concrete	0.42	1.38	4.50
B-61	3	concrete	0.26	0.85	17.62
B-54	3	concrete	1.83	6.00	12.40
B-52A	3	concrete	1.30	4.27	
B-52	3	concrete	1.30	4.27	5.70
B-42		concrete	0.20	0.66	10.06
B-41	3	concrete	1.14	3.74	10.50
		Avg. Deflecti	**1.21**	**Average G's**	**9.55**

TABLE 2

Acceptance Code	Test Level	Material	Deflection (meters)	Deflection (feet)	Acceleration (g's)
B-196	3	plastic	2.74	8.99	10.90
B-125	3	plastic	4.78	15.68	8.40
B-97	3	plastic	4.28	14.04	10.00
B-48	3	plastic	6.90	22.64	8.70
B-34	3	plastic	3.40	11.15	12.10
		Avg. Deflection	**4.42**	**Average G's**	**10.02**

If 85% of work zone accidents fatalities are drivers and their passengers, and water filled devices provide a higher degree of safety for the motorists passing through work zones, it would seem logical that water filled devices would be the traffic control device of choice. But these devices are rarely if ever used. In road construction work zones, resistance to change to use of water filled barrier devices (as with many devices new to the transportation infrastructure environment) slows industry-wide adoption of water ballast devices. There is an enduring familiarity with concrete and a tendency to rely on concrete barrier for every use, even when it is not the safest or most appropriate device for the job. Because there is no requirement or incentive for change, engineers simply continue to specify temporary concrete barrier for all traffic control jobs, in spite of the innovation of safer and more effective mechanisms. Findings show that deployment of new devices face roadblocks because (*a*) transportation projects are complex, multifaceted, and interjurisdictional with many players having different interests; (*b*) multiple layers of decision making sometimes lack logic; (*c*) public-sector procurement is driven by competitive, multiple low-bid processes that often infringe on intellectual property rights; (*d*) public agencies resist change; and (*e*) risk-averse executives hesitate to implement new innovations.[7] This research underlines the need for improved communication among researchers, developers, operators, and decision makers.

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

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

To comply with this rule states create itemized lists of work zone devices. Unfortunately, innovative devices are rarely if ever listed. For example, the Longitudinal Channelizing Device, a traffic control device listed in the MUTCD for several years, is not listed in any of the itemized lists published by any State DOT's. As it is, the state views a **lower cost job** as the bid winner. The contractor wants to increase his profit on the job, the state wants a lower cost job (especially now). Imagine if the government made it "profitable" for the contractor to try safer techniques by offsetting any additional costs. At this point the contractor is a willing participant.

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

Although no consensus on specific warrants exist, barriers are usually justified for bridge widening, shielding of roadside structures, roadway widening with edge drop off, and to separate two-lane, two-way traffic on one roadway of a normally divided roadway. [8] Temporary concrete barriers are appropriate in work zones when needed for positive protection, but can create hazards in themselves if used simply for channelization. The Roadside Design Guide calls for concrete barriers to be used:

1) To protect traffic from entering work areas such as excavations or material storage sites
2) To provide positive protection for workers

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[7] Overcoming Roadblocks to Innovation: Three Case Studies at the California Department of Transportation
Lawrence H. Orcutt, Mohamed Y. Al Kadri, Division of Research and Innovation, California Department of Transportation, 1227 O Street, Fifth Floor, Sacramento, CA 95814

[8] Roadside Design Guide, AASHTO, 1996, p. 9-1.

3) To separate two-way traffic
4) To protect construction such as falsework for bridges and other exposed objects
5) To separate pedestrians and vehicular traffic

In general, a temporary barrier system has to satisfy two operational requirements. First it must provide sufficient deflection during the impact event so that vehicle deceleration and hence occupant impact severity is low. Secondly the system must provide sufficient restraint and redirection so that people and materials behind the barrier are protected. These two requirements are somewhat in conflict with each other so a compromise solution has to be found. Average deflections for concrete barrier run 1.21 M, where the same average deflection for plastic water filled devices is 4.42 M. By definition, temporary concrete barriers should only be deployed to protect traffic from entering work areas such as excavations or material storage sites, to provide positive protection for workers, to separate two-way traffic, to protect construction such as falsework for bridges and other exposed objects, and to separate pedestrians and vehicular traffic. Plastic water filled barriers are also appropriate for most of the temporary barrier applications listed above and provide a much safer environment for the motoring public when compared to temporary concrete barrier. What must be considered is the higher degree of lateral deflection allowed by the water filled plastic devices versus the concrete barrier. If the clear zone; an unobstructed, relatively flat area beyond the edge of the traveled way that allows a driver to stop safely or regain control of a vehicle that leaves the traveled way; cannot accommodate the deflection required of the plastic, water filled devices, then concrete barrier is the only option. If deflection can be accommodated, then portable plastic barrier should be used in an effort to improve work zone fatalities.

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

For applications outside these specific operational requirements, temporary barrier should not be used, and alternative traffic control devices that do not pose a hazard to the motoring public should be considered. Where guidance emphasis will suffice, a Longitudinal Channelizing Device is ideal. Longitudinal Channelizing Devices are lightweight, plastic, water-fill able devices that form bright, visually-compelling, continuous walls in the manner of concrete but without the lethal potential to impacting vehicles. The Federal Highway Administration recognizes the need for Longitudinal Channelizing Devices and the Manual on Uniform Traffic Control Devices (MUTCD) has been updated to reflect the useful and effective deployment of Longitudinal Channelizing Devices as an alternative traffic control device. See Section 6F.66. MUTCD

The Roadside Design Guide urges temporary **concrete barrier be placed only parallel to traffic**.[9] **Most catastrophic accidents involving vehicles moving through the work zone and temporary concrete barrier occur when the barrier is struck at a high angle. Deploying temporary concrete barrier in work zones to close roads or to act as channelizing/delineating devices exposes vehicles and occupants to the possibility of engaging a massive object that can cause substantial injury and death. In this case, Longitudinal Channelizing Devices, which are designed to channel traffic without the risk associated with impacting a temporary concrete barrier, should be used.**

[9] Ibid, p.9-10.

Although plastic water ballast barriers and plastic water ballast channelizing devices look similar and are often used interchangeably, there is a critical distinction between the two. By definition, a traffic barrier is designed to contain and redirect an impacting vehicle although some deflection of the barrier is both allowed and expected for freestanding, temporary applications. A longitudinal channelizing device, on the other hand, is considered to have no significant containment capabilities, even when several units are connected to form a solid line.

For decades, road transportation departments, consulting engineers, and others who specify safety equipment in roadway construction projects have had few choices in traffic control devices. Historically, engineers have specified temporary concrete barriers as a “one solution fits all” solution, and a culture has developed leaving temporary concrete barrier as the default option for positive protection and channelizing delineation. In order to reduce the number of work zone fatalities, these transportation professionals are urged to examine and consider new products offering vehicle occupants a safer environment. Preventing accidents and protecting workers, pedestrians, and motorists is a national concern. The way to ensure elimination of these tragedies is to encourage and require the use of the safest product for each specific job instead of relying on the most familiar traffic control devices or those devices already on hand for the project.

Only when road transportation departments and practitioners begin to look beyond the familiar traffic control products will work zone safety be improved. The individuals most often overlooked when making traffic control decisions are the occupants of vehicles traveling through work zones. They are frequently exposed to the dangerous practice of utilizing temporary concrete barrier as a delineator or to close a road, elevating exposure to high angle impacts or required to drive through a confusing array of delineators, risking head-on collision. Those vehicle drivers and occupants could be your family or mine, so we must ask ourselves if we are really considering all of the available traffic control devices and how the proper deployment of these devices can create safe work zones, preventing injuries and perhaps saving lives. Surely, it is worth consideration.

For more information on non-traditional traffic control devices, visit the water barrier manufacturers association at www.waterbarriers.org or contact us at 423 South 600 West, Salt Lake City, UT 84101
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