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IMPACT OF FLAGGERS ON SAFETY AND MOBILITY OF HIGHWAY WORK ZONES

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Abstract: Standard specifications for road and bridge construction in many Departments of Transportation require that a flagger is utilized at all times to direct traffic in lane closure work zones on multilane highways. Utilizing flaggers as specified by these standards introduces inherent risks and varying effectiveness by positioning flaggers next to the live traffic. This paper presents the findings of a comprehensive study to assess the effectiveness and essential role of flaggers in directing work zone traffic on multilane highways and to consider alternative means of providing this function. The objectives of this study are to conduct a national survey of state DOTs to gather their feedback on the essential roles, effectiveness, and risks of utilizing flaggers to direct work zone traffic on multilane highways. A total of 100 responses were gathered in this national survey that asked respondents to identify the need, benefits, and risks of using flaggers in and around work zones. The main findings of this study on the roles and effectiveness of flaggers for directing work zone traffic control can be used to guide decision makers in changing and/or expanding existing standards and policies to improve work zone safety and mobility.

1 INTRODUCTION

Standard specifications for road and bridge construction in many Departments of Transportation require the use of flaggers on multi-lane highway work zones with a posted speed limit greater than 40 mph when no physical separation is made between the work zone traffic and construction workers, while other state DOTs, such as Massachusetts (MassDOT) and Washington State (WSDOT 2012) prohibit the use of flagger on freeways and expressways. Because of the nature of their duties, which require them to be in proximity to open traffic lanes and often without the protection of physical barriers, flaggers are often exposed to hazardous conditions and to the risk of injuries or fatalities (See et al. 2009). Pratt et al. (2001) reported that two-thirds of the injuries to pedestrian workers occurred from vehicles intruding into marked workspaces and striking workers or flaggers. Zech and Mohan (2008) analyzed work zone crashes that caused 36 fatalities and 3,055 severe injuries in New York State from 1990 to 2001. The study found that 86% of these fatalities and 70% of these severe injuries were caused by five types of work zone crashes: (1) workspace intrusion, (2) worker struck by vehicle inside workspace, (3) flagger struck by vehicle, (4) worker struck by vehicle entering/exiting workspace, and (5) construction equipment struck by vehicle inside workspace. Another study also reported that construction workers were twice as likely to be killed by a motor vehicle as the average worker and that flaggers account for half of pedestrian accidents (Ore and Fosbroke 1997).

A number of research studies have been conducted to evaluate the effectiveness of Temporary Traffic Control (TTC) measures such as flaggers in work zones (Du and Chien 2014, Li and Bai 2007, Fei et al

2016). Li and Bai (2007) evaluated the effectiveness of several commonly used TTC measures using a logistic regression technique and various chi-square statistics. The assessed TTC methods included flagger/officer, stop sign/signal, flasher, no passing zone control, and pavement center/edge lines. Li and Bai (2007) reported that flagger, flasher, and pavement center/edge lines were effective in reducing the probability of fatalities when severe crashes occurred.

2 OBJECTIVE

This paper presents the findings of an online survey of resident engineers and construction personnel in state DOTs in the US to gather their feedback on flaggers use in directing work zone. The survey is designed to identify the effectiveness and risks of using flaggers in work zones with a posted speed limit greater than 40 mph on expressways and freeways and identify effective work zone safety measures that can be used to supplement or replace flaggers in these works zones. In addition to the online survey, a number of work zone field investigations and interviews with Illinois Department of Transportation IDOT resident engineers were conducted to analyze the flagger risks and related traffic hazards. The paper also presents recommendations on the use of flaggers and other safety measures in work zones with a posted speed limit greater than 40 mph on expressways and freeways. These recommendations can be used by DOT to update and/or expand related DOT policies, specifications, and standards to improve work zone safety and mobility.

3 SURVEY RESULTS AND ANALYSIS

The survey was distributed to state DOTs engineers, personnel, and contractors. In the survey, respondents were asked to assess the level of need, effectiveness, benefit, or risk of using flaggers on freeway/expressway work zones using a five-point scale that ranges from “0” to “1”. For example, the level of need can be expressed on a five-point scale ranging from “0” that represents “no need” to “1” representing “greatest need.” Similarly, the level of risk/hazard can be expressed on a scale ranging from “0” to “1,” where “0” indicates “lowest risk” and “1” indicates “highest risk.” Weighted scores were calculated for each question in the survey to compare the average scores obtained from both surveys using Equation 1.

[1] Wi =$\sum wj * rij$

Where;
W_i is the average weighted score for each (i = function/need/benefit/risk)
W_j is the weight given by the survey respondents for effectiveness/need/risk on a scale of 0 to 1 scale for each function.
r_{ij} is the percentage of respondents selected each weight level w_j for each effectiveness/need/risk.

Table 1 Example of Weighted Score of Survey Calculation

	Percentage of respondents selecting level of need for flagger functions (%)					
	No Need *w1*=0.0	*w2*=0.25	**Moderate Need** *w3*= 0.5	*w4*=0.75	**Greatest Need** *w5*=1.0	**Weighted Score** 0.0→1.0
1- Alert road users approaching the work zone	17.5 (r_{11})	6.3 (r_{12})	17.5 (r_{13})	11.3 (r_{14})	47.5 (r_{15})	**W1=0.66**

3.1 Need for Flagger Functions

Survey respondents were asked to identify the level of need for a flagger to perform a set of functions including slowing down the speed of traffic, alerting road users approaching the work zone, warning workers of errant drivers, and directing traffic when construction trucks enter and exit the work zone. The results of the weighted scores for each of these functions are shown in Figure 1. The two functions that received the highest weighted score were “Warn workers of errant drivers and vehicle intrusion into work zone” and “Direct traffic when construction trucks enter the work zone,” which received a score of only 0.3 each.
The average score for the need of flaggers to perform various safety and mobility functions on freeway and expressway work zones was only 0.256, as shown in Figure 1. This indicates that state DOTs reported the level of need for flaggers in this type of work zone to be between “No Need” and “Moderate Need,” as shown in Figure 1. In addition, a number of state DOTs added that they do not use flaggers in this type of work zone, including Florida, Minnesota, Michigan, and Virginia DOTs.

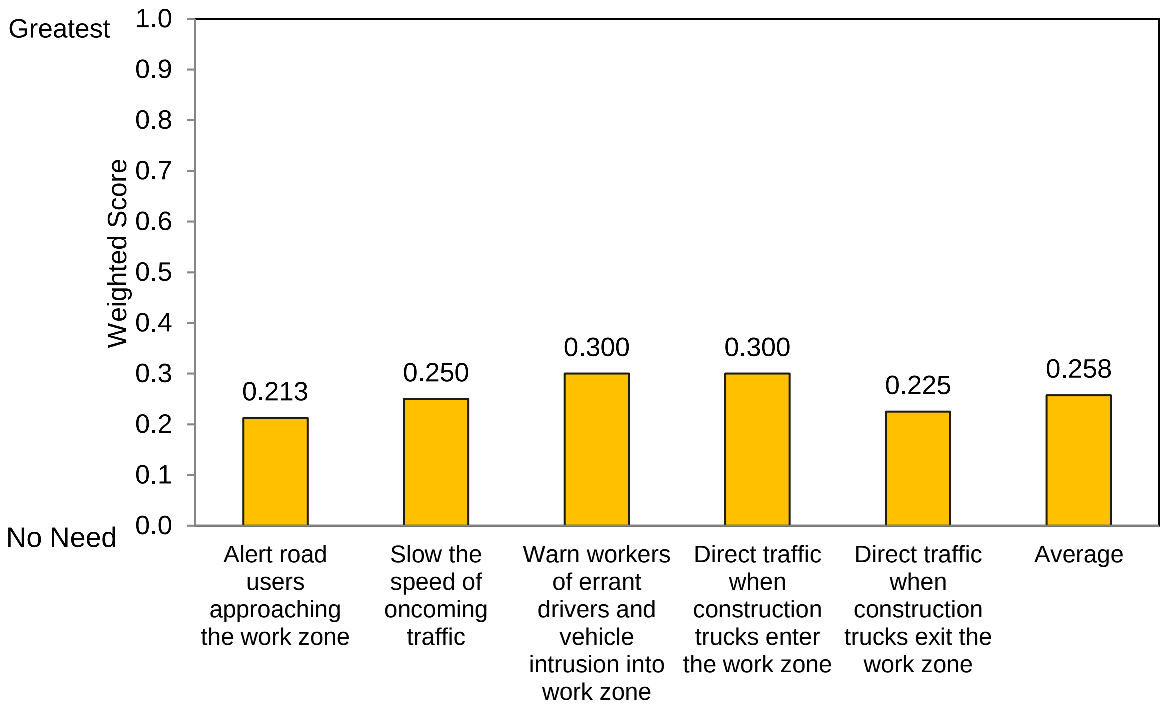

Figure 1: Weighted scores for the need of flagger functions.

3.2 Benefit of Flagger Functions

In the survey, the level of benefits that can be gained from using flaggers in freeway/expressway work zones received very low weighted scores ranging from 0.2 to 0.338, where a score of 0.0 represents “No Benefit,” and a score of 1.0 indicates “Greatest Benefit” as shown in Figure 2. The flagger benefit that received the highest weighted score in the survey was “Enhance road users safety” and “Improve workers safety” with a score of 0.338. The flagger benefit with the lowest weighted score was “Improve compliance with traffic speed limit” with a score of 0.2. The average score for the benefits that can be gained from using flaggers on freeway and expressway work zones was 0.2, as shown in Figure 2. This indicates that state DOTs identified the level of benefits from using flaggers in this type of work zone to be between “No Benefit” and “Moderate Benefit.”

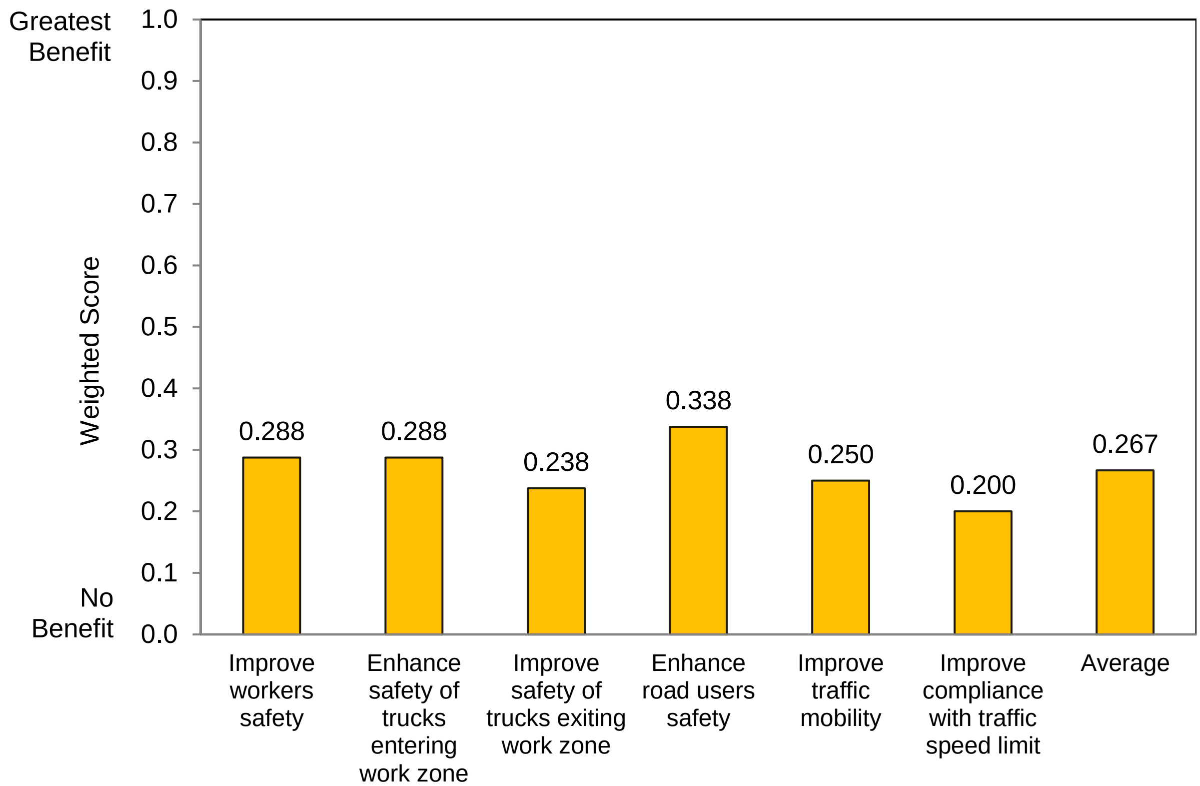

Figure 2 Weighted scores for the level of benefit of flagger.

3.3 Risk/Hazard Caused by Using Flaggers

In this question, survey respondents reported the level of risks that can be caused by using flaggers in freeway/expressway work zones. The weighted score for the listed risks were all above 0.5 where a score of 0.0 represents “No Risks,” and a score of 1.0 indicates “Greatest Risks,” as shown in
Figure 3. The risk that had the highest score was “Exposure of flaggers to traffic hazards and injuries” with a score of 0.8. This highlights the high level of exposure to hazards that flaggers experience in this type of work zone. The risk that had the second highest score was “Flaggers encroach into open traffic lanes” with a score of 0.737 in the survey.

The average score for the risks and hazards that can be caused by using flaggers on freeway and expressway work zones was 0.68, as shown in
Figure 3. This indicates that respondents from state DOTs identified the level of risks caused by using flaggers in these types of work zones to be between “Moderate Risks” and “Greatest Risks.”

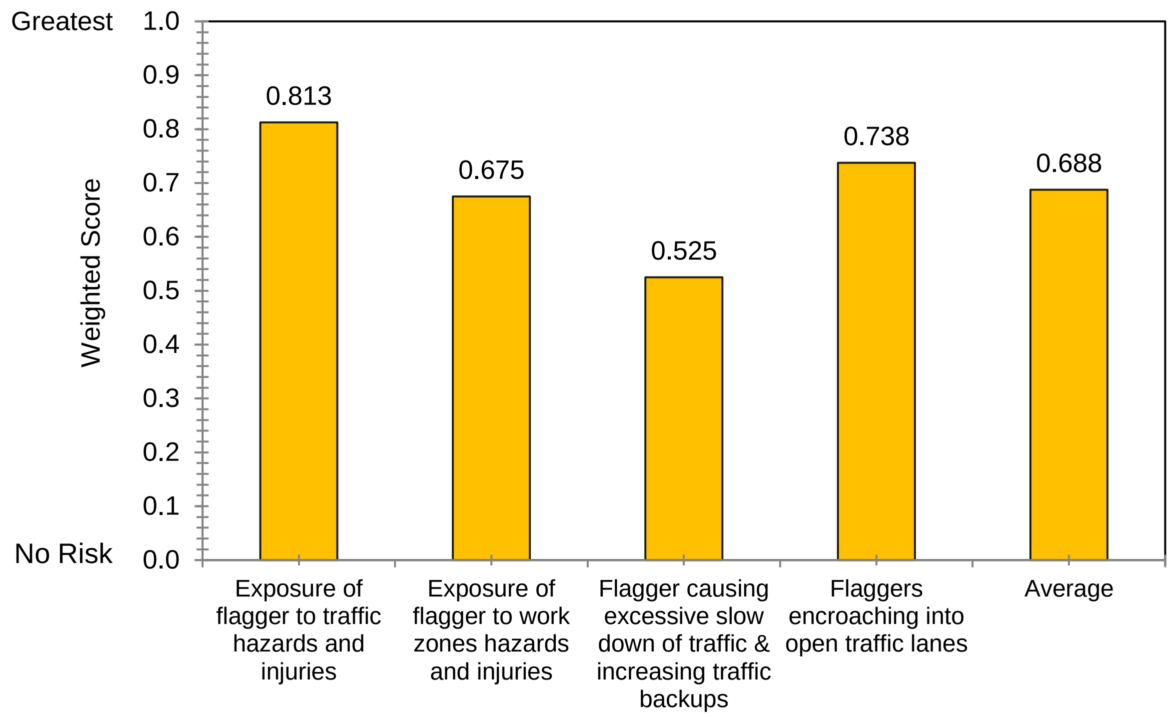

Figure 3 Weighted scores for risk/hazard caused by using flaggers.

3.4 Risk/Hazard to Flaggers in Different Work Zone Conditions

In this question, respondents were asked to identify the level of risk to flaggers in different work zones, as shown in Figure 4. Daytime work zones received the lowest weighted scores of 0.475 in the survey. The work zones that had nighttime work, and curves and hills received the highest weighted scores of 0.85, 0.775, and 0.775 in the survey. This highlights the increased level of risks in these types of work zones and the need to find alternative and safer solutions to control and minimize this risk/hazard to flaggers in these types of work zones.

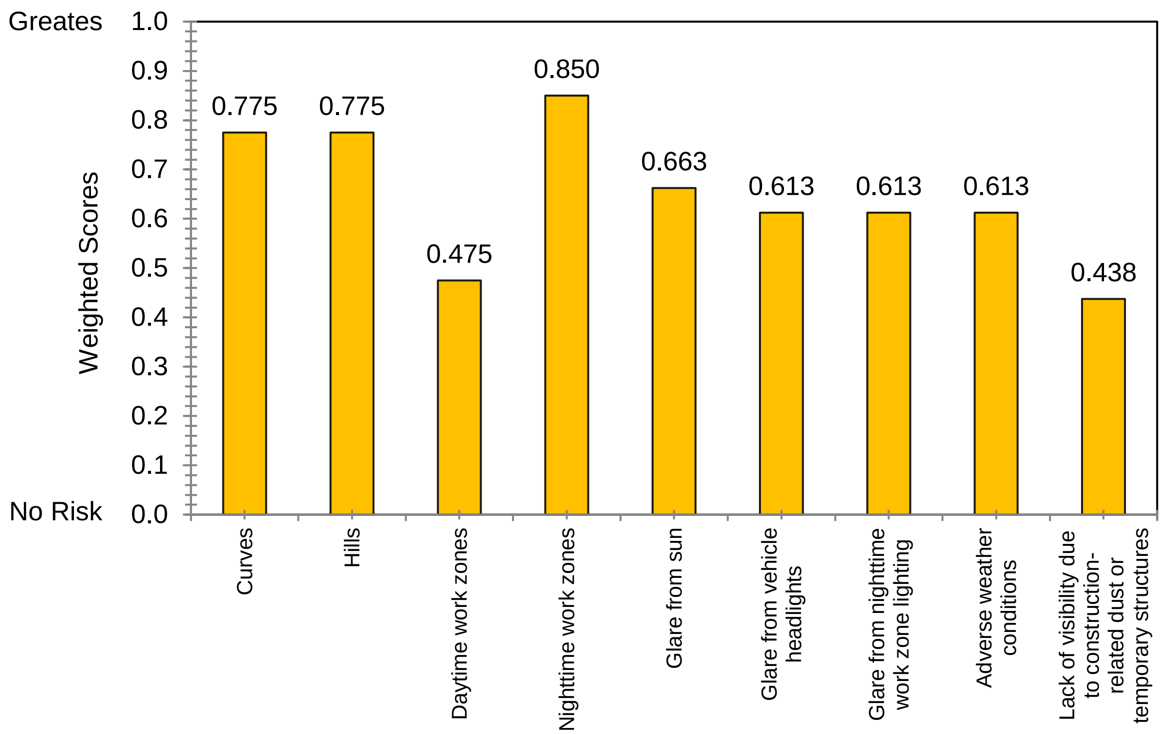

Figure 4 Weighted scores for the level of risk/hazard to flaggers in work zone-conditions

3.5 Effectiveness of Temporary Traffic Control (TTC) Devices

In this question, respondents were asked to identify the level of effectiveness of various temporary traffic control (TTC) devices that can replace the tasks of flagger on highway work zones such as intrusion alarms, portable changeable message signs (PCMS), temporary rumble strips, speed displays, truck-mounted attenuators (TMAs), radar drones, police patrol, automated flagger assistance devices (AFAD), and mobile barriers, as shown in Figure 5. The top four effective measures were TMAs, PCMS, police patrol, and mobile barrier, which received a weighted score ranging between 0.891 and 0.796, respectively, as shown in Figure 5.

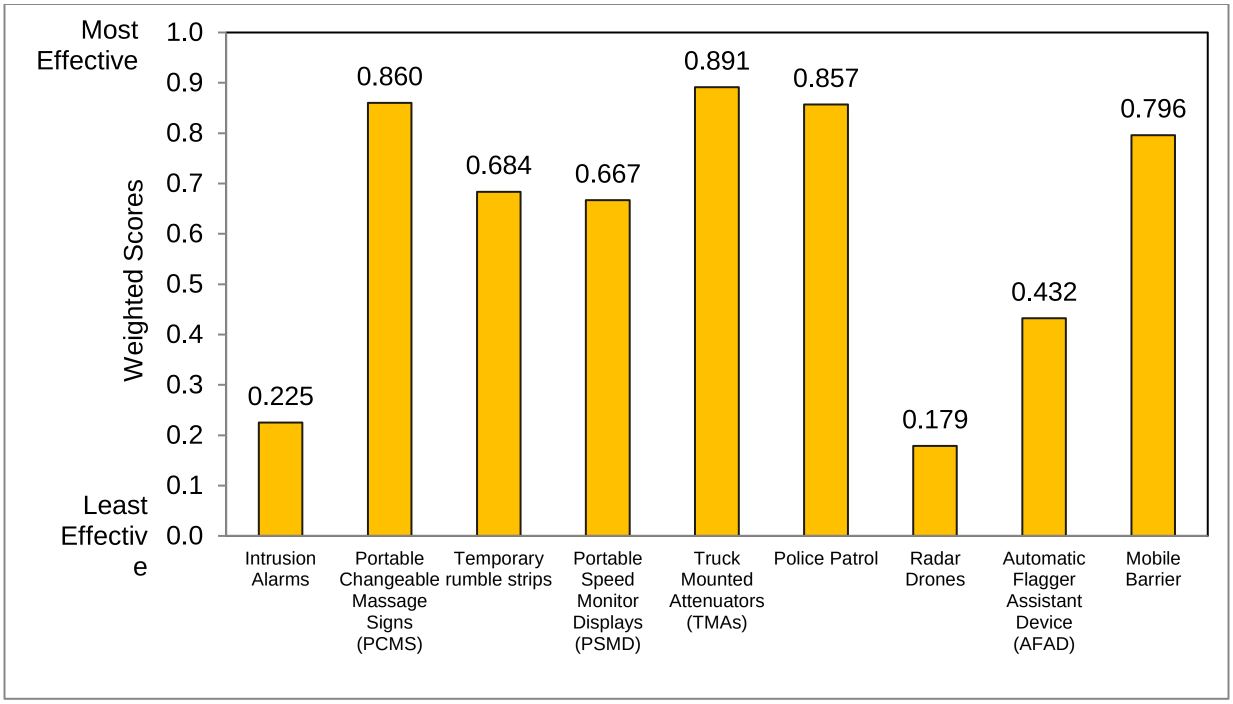

Figure 5. Effectiveness of TTC devices.

3.6 Risks Caused by Flaggers

Based on the comments from survey respondents and the interviews with resident engineers, the two main risks that can be caused by flaggers are (1) backup and rear-end crashes; and (2) pushing the traffic to shoulder. Respondents mentioned excessive slowing down increases traffic delays and backups. For example, a resident engineer stated that "there is an increased level of traffic accidents when flaggers try to slow down traffic too much on freeways." Another one stated that "could be a major cause of preventable accidents that often result in multiple fatalities for a function that provides zero benefits." A survey respondent stated "some flaggers disrupt traffic flow on freeways causing unsafe conditions for motorists which can result in unsafe conditions for flagger and workers. Flaggers can also be hard to see in lane closures that require drums or barricades." Another survey respondent stated, "contractors have become accustomed to using flaggers in an aggressive stance, pushing traffic onto the shoulder and slowing traffic - all at great risk to the flagger and traffic." Another risk that can be caused by aggressive flaggers is pushing traffic onto the shoulder, causing hazardous driving conditions and potential damages to the shoulder. This risk was observed during work zone site visits and was mentioned as a serious risk in the meetings with resident engineers.

4 Survey Findings and Conclusions

A comprehensive study was conducted to assess the effectiveness and essential role of flaggers in directing work zone traffic on multilane highways and to consider alternative means of providing this function. A total of 100 responses were gathered in this national survey and its mainfindings include: (1) the need for using flaggers on highway work zones with speed limits greater than 40 mph (65 kph) received low weighted scores that ranged from “no need” to “moderate need”; (2) the benefit of using flaggers on highway work zones received a low weighted score ranging between “no benefit” and “moderate benefit”; (3) the potential risks to flaggers in these work zones was ranked by survey respondents to range between “moderate” and “high”; (4) the highest risk to flaggers were reported in nighttime work zones and in areas that are located on hills or curves; (5) other TTC such as TMAs, PCMS, police patrol, and mobile barrier were reported to be effective in controlling traffic in work zone areas and can be used to minimize or replace flaggers; and (6) untrained or aggressive flaggers were reported to cause backup and rear-end crashes and can push the traffic to the shoulder causing damages to the highway shoulder.

5 References

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