

## **Characteristics Of Work Zone Crashes And Fatalities In Canada**

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### **Abstract**

Every year across Canada there are approximately 40 fatalities and 2000 non-fatal injuries recorded due to vehicle crashes in work zones. These crashes occur under a combination of road, vehicle, and driver factors that vary for each crash. However, there may be common factors that can be identified that will lead to a better understanding of crash causation and measures for improving work zone safety.

This paper will examine crash data from the Transport Canada TRaffic Accident Information Database (TRAID) which provides details of each crash as recorded by the local jurisdiction. The primary focus will be on the combination of factors present at the occurrence of fatal crashes. Factors considered include crash configuration, driver age, driver sex, weather conditions, and light conditions. Consideration is also given to the role of Intelligent Transportation Systems in addressing work zone safety issues.

Several trends and significant contributing factors to work zone crashes were identified. The most common crash configuration resulting in a fatality was head-on, followed by rear-end. Over 90 percent of the head on fatalities occurred on

undivided roads, 50 percent of which were under snowing conditions. Drivers age 25 – 44 account for the highest number of crashes, as do male drivers, and are over-represented in work zone crashes when compared to all traffic crashes. Snowing conditions were present in 17.3 percent of work zone crashes despite having a low expected frequency of occurrence. The majority of crashes occur during the daytime lighting conditions, followed by dark and artificial light. It appears that crashes are more severe under dark conditions, but there may be other contributing factors such as operating speed of the roadway.

### **Résumé**

## **Introduction**

To meet the highway transportation needs of Canada significant resources are expended each year to build and maintain the highway infrastructure. As our highway system has matured and aged, an increasing share of resources are dedicated to the maintenance and rehabilitation of existing infrastructure compared to the building of new infrastructure. By necessity, much of the maintenance and rehabilitation work is done while attempting to serve ever increasing traffic demands. The need to maintain traffic flow and the conflicting need to perform repair and maintenance work can reduce highway safety and result in motor vehicle crashes.

This paper examines the characteristics of work zone related motor vehicle crashes that result in injuries and fatalities. Specifically, the following characteristics of crashes are considered: road type, road classification, crash configuration, time of day, light conditions, month of year, weather conditions, driver age, and driver sex. The purpose is to provide a broad overview of characteristics that can be used to identify areas of concern and needs for further investigation. Information presented in this paper was obtained primarily from information provided by Transport Canada from its TRAFFIC Accident Information Database (TRAID). No measures of exposure, such as traffic volumes or amount of work zone activity were taken into consideration.

Transport Canada obtains crash data from each province and compiles it into a national database of collision information. This database was used to obtain provincial and national level data for the occurrence of crashes in work zones. A subset of TRAID was obtained from Transport Canada for all provinces between the years 1997 to 2001 with the exception of Alberta, for which data covered 1999 to 2001. Casualty crash records included were those where the condition of “under repair” or “under construction” was indicated in the crash record. Several unusual facts were noted in the

data: no crash data was provided for Alberta in 1997 or 1998, no fatal crashes were recorded in BC for 1997 which averaged 6.5 fatal crashes from 1998 to 2001, and crashes recorded in Prince Edward Island for 2000 and 2001 were less than 10 percent of the average for previous years.

## **Overview of Work Zone Safety in North America**

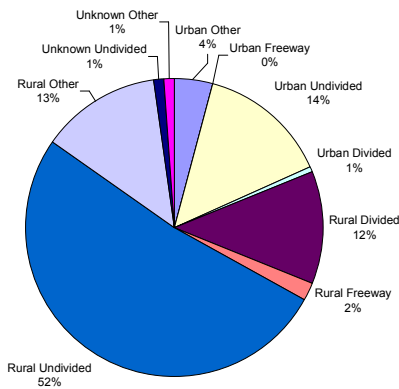
The first stage of this research project looked at the overall characteristics of work zone safety in Canada to provide an overview of the situation. Results of the first stage reported by Bushman, et al<sup>1</sup>. The second stage of this research, as reported in this paper, examines some of the specific factors that may have contributed to the occurrence of a work zone crash.

A breakdown of fatalities, injuries, and road class and type for each province and territory is provided in Table 1. In total there were 190 fatalities and 10,677 non-fatal injuries recorded over the five year study period. More than half of all fatalities, 55 percent, occurred in Ontario, followed by 14 percent in British Columbia and 9 percent in Quebec. When injury crashes in work zones are considered, the three most populous provinces are the location of the highest number of injuries. Ontario is again the highest province with 60 percent of work zone injuries occurring there, followed by Quebec with 12 percent and British Columbia with 7 percent. These figures are based on the number of crashes and do not take into account obvious differences in exposure rates and higher expected traffic volumes in these provinces, which are the three most populated provinces in Canada.

Work zone related fatalities over the period of 1997 to 2001 were quite consistent, averaging almost 40 fatalities per year. Over the study period, the number of licensed drivers in Canada increased by 3.6 percent to a high of 20.9 million in 2001. Over the five year period, there were a total of 14,702

highway fatalities recorded in Canada (Transport Canada<sup>2</sup>). The percent of all traffic fatalities that were work zone related was 1.3 percent in Canada, compared to 2.8 percent in United States in 2001 (National Center for Statistics and Analysis<sup>3</sup>).

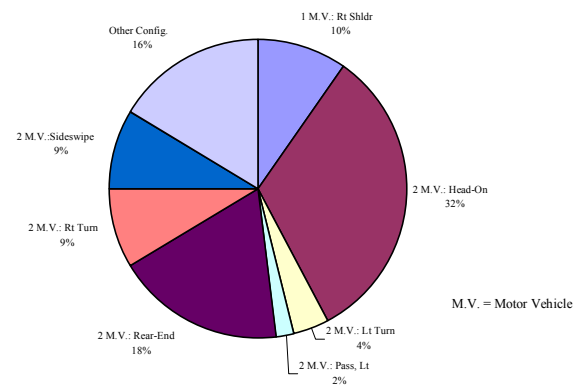
A breakdown of fatalities according to the type of road where the crash occurred is provided in Figure 1. Across Canada 79 percent of all work zone related fatalities occurred on rural roads, with 52 percent occurring on rural undivided highways. It is also seen that 67 percent of all fatalities occurred on undivided roadways. Only one percent of fatalities occurred on urban divided and urban freeways, which would typically be expected to have the highest volumes of traffic and only 15 percent occurred on divided roads of any type. In comparison, 37 percent of the work zone fatalities in the United States in 2002 occurred on roadways classified as either Interstate or freeway / expressway. Detailed information for each province and territory about road class and road type can be found in Table 1. For all provinces and territories, except the Yukon, the majority of fatalities occurred on roads classified as rural and with a road type of undivided.



**Figure 1** Percent of work zone fatalities by road type and classification: 1997 to 2001

The distribution of various types of crash configurations for work zone related fatalities are illustrated in Figure 2. The most common collision configuration, 32 percent of all fatalities, is head-on

collisions. Rear-end crashes contributed 18 percent of all fatalities and was the second most common. Right shoulder configurations, right turn, and side swipe crashes accounted for ten, nine, and nine percent of crashes respectively. “Other Config” is a coding option when crashes are reported and do not fall into any of the other categories, so no other information is available on these crashes. Speeding and driving too fast for conditions stated as a contributing causal factor was also investigated and it was found that excessive speed was a factor in 30 percent of the fatalities that occurred.



**Figure 2** Crash configuration of work zone related fatalities: 1997 to 2001.

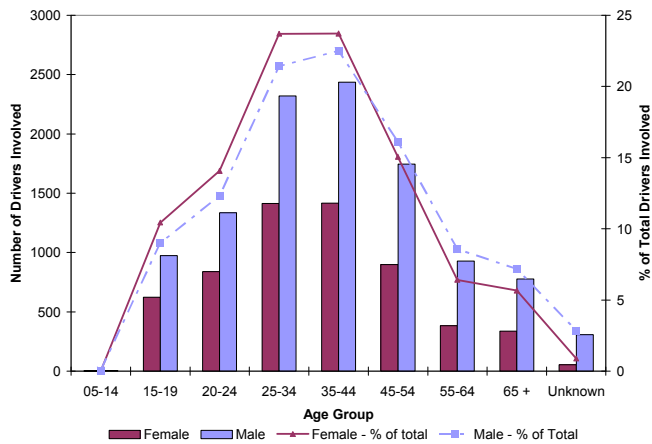
### Characteristics of Crashes in Work Zones

The second stage of this study, as presented in this paper, was to examine specific characteristics and possible contributing factors in the occurrence of work zone crashes and fatalities. The factors considered are driver age, driver sex, light conditions, and weather conditions at the time of crash.

### Driver Sex and Age

The distribution of drivers involved in work zone casualty crashes is illustrated in Figure 3 below. The columns show the total number of drivers involved recorded for each age group as indicated on the left axis. The lines represent the percentage

of total crashes occurring within each age group as indicated on the right axis.



**Figure 3** Age and sex distribution of drivers involved in work zone crashes

In cases where driver sex was recorded, 35.5 percent of involved drivers were female, while almost twice as many drivers involved, 64.5 percent, were male. For comparison, involvement in all traffic crashes in United States was 56.9 percent for male drivers and 43.1 percent for female drivers, as reported for 2003 by the National Highway Traffic Safety Administration (NHSTA<sup>4</sup>). When only fatal crashes are considered the difference in involvement proportion by sex between all traffic crashes and work zone related crashes is even more pronounced. A male driver was involved in 81.9 percent of fatal work zone crashes, while only 18.1 percent involved a female driver. According to NHSTA statistics, fatal crashes of all types involve a male driver 73.7 percent of the time and a female 26.3 percent.

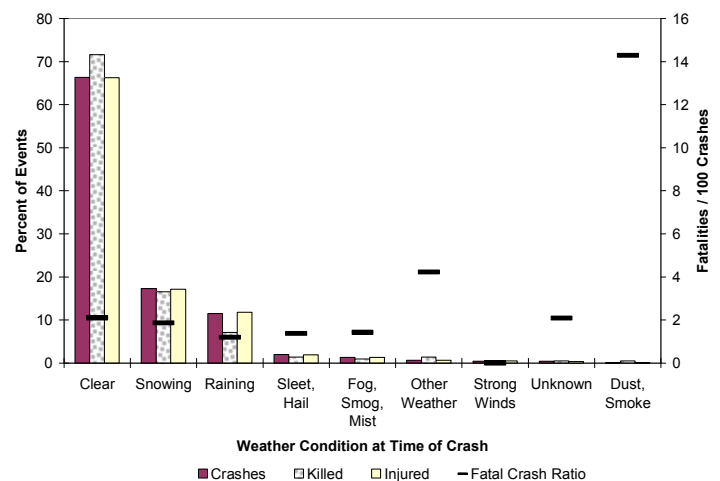
The age trends are generally similar for male and female, but with a slightly higher proportion of female involvement in crashes under age 44 and a higher proportion of male involvement in crashes over age 44. The highest number of crash involvement occurs between the ages of 25 and 44, representing 45.2 percent of all crashes. The pattern of higher crash numbers for these age categories is typical but slightly higher for those occurred in work zones than for all traffic crashes. Crash data

recorded by the NHSTA in 2003 showed that when all traffic crashes are considered, 40.5 percent of crashes involved drivers between age 25 and 44, 4.7 percent lower than work zone crashes in Canada.

Traffic crash information has shown that the highest number of crashes occur with drivers aged 25 to 44 and that male drivers are more commonly involved than female drivers. The work zone data presented here follows these trends, but shows a greater representation of the 25 to 44 age group and of male drivers. Further investigation is required to determine the cause of the increased representation of male drivers and drivers in the 25 to 44 age range in work zone crashes.

### Weather Conditions

Weather conditions appear to be a contributing factor to crash occurrence and but not crash severity in a work zone. Figure 4 illustrates the breakdown of crashes, injuries, and fatalities for nine weather related categories. The left axis indicates the percent of total crashes, fatalities, and injuries that occurred within each weather category. The right axis indicates the ratio of fatalities to crashes in each category, which is a measure of the relative severity of crashes.



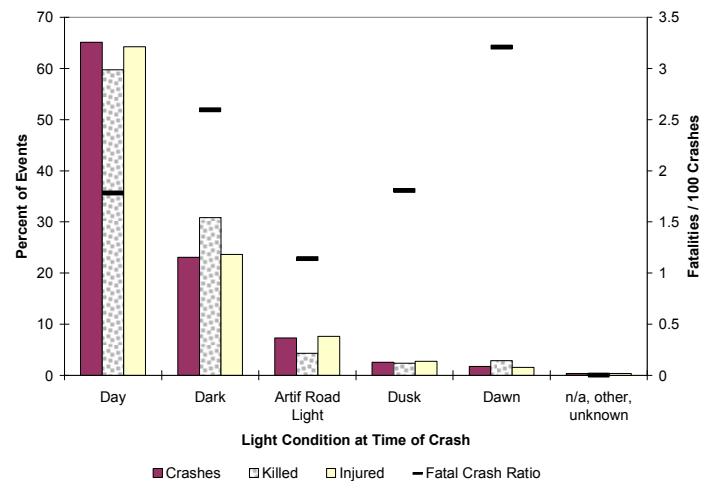
**Figure 4** Work zone crash occurrence and severity over range of weather conditions

The vast majority of crashes (66.3 percent) occurred under clear conditions which can be linked to exposure as clear conditions are the prevailing pattern in many jurisdictions and construction operations are often halted during adverse conditions. However, 17.3 percent of crashes occurred under snowing conditions. Although no study of exposure was conducted, given the fact that most construction occurs during spring, summer, and fall when snow is infrequent, snow appears to contribute strongly to increased crash potential.

The fatal crash ratio is defined as the number of fatalities that occur per 100 casualty crashes. Considering the weather conditions most commonly present during a crash, clear conditions had the highest crash ratio, 2.1 fatalities / 100 crashes. Snowing conditions had the second highest ratio at 1.9 fatalities / 100 crashes. Crashes under raining conditions were measured with a fatal crash ratio of 1.2, the lowest of the common weather conditions. This data suggests that crashes under clear conditions are more severe and more likely to result in a fatality than if it is raining or snowing. When weather conditions were categorized as dust / smoke there were 14.3 fatalities / 100 crashes, but this is based on 1 fatality and 7 total crashes and therefore the sample size is too small to be significant. For comparison, the fatal crash ratio for all types of injury and fatal crashes reported by NHSTA in 2003 was 1.6 fatalities / 100 crashes, slightly less than the rate for work zones.

### Light Conditions

Light conditions at the time of crash occurrence, as recorded in the TRAIID database, were categorized into one of the following: day, dark, artificial road light, dusk, dawn, and not applicable / other / unknown. The distribution of crashes under each of the light conditions is illustrated in Figure 5, along with the distribution of fatalities and injuries. The left axis indicates the percent of total crashes, fatalities, and injuries that occurred within each lighting category. The right axis indicates the ratio of fatalities to casualty crashes in each category, which is a representation of the relative severity of crashes.



**Figure 5 Work zone crash occurrence and severity over range of lighting conditions**

The majority of crashes (65.1 %) occurred during the day. Crashes occurring under dark conditions (23.0 %) and artificial road lighting (7.3 %) were the next most common, with infrequent occurrences of crashes at dawn and dusk. The fatal crash ratio for day conditions is 1.8 fatalities per 100 crashes compared to 2.6 fatalities per 100 crashes under dark conditions and 1.1 fatalities per 100 crashes under artificial light. While this would suggest that artificial road light results in the least severe crashes and dark conditions the most severe, it is important to remember that other factors may be involved. Artificial road light typically occurs in urban areas and may occur at locations with reduced speed limits. On the other hand, roadway sections without lighting are typically rural in nature and are most often operating at high speeds.

### Head – on Crashes

As identified earlier, 32 percent of all crashes resulting in a fatality were head-on collisions. Since this is the most common crash configuration resulting in a fatality, it was investigated in more detail. The vast majority (91.4 percent) of these crashes occurred on undivided roads. This means that 29.2 percent of work-zone related fatalities are the result of head-on collisions on undivided roads. When the weather conditions for head-on collisions

on undivided roads were examined, it was found that snowing was the weather condition at the time of 50 percent of the fatalities. The fatal crash ratio for head-on collisions was 7.1 fatalities / 100 casualty crashes, significantly higher than the ratio when all crash configurations are considered.

### **Applications of Intelligent Transportation Systems in Work Zones**

Efforts to improve work zone safety can take on many forms including marking and guidance, barriers and protection, education, enforcement, demand management, and construction phasing and timing. An emerging tool to improve safety and mobility in work zones is the application of Intelligent Transportation Systems (ITS) technology. ITS systems gather real-time information on current conditions such as traffic and weather and use this information to manage traffic flow by providing information to the public. The information may include advisories of expected delays and alternate routes, reduced speeds, or guidance for appropriate merging behavior.

The study of work zone crash characteristics identified several issues where ITS may be a part of the solution. Rear-end crashes were the second most common configuration. A system that provides advisories to motorists of slow or stopped traffic ahead may increase driver awareness. Travel information systems that manage traffic flow and reduces queue lengths by providing delay and alternate route information may also reduce the occurrence of rear-end crashes. A study of a dynamic lane merge system in Michigan showed a significant reduction in aggressive lane changes, which contributes to smoother traffic flow and may result in reduced rear-end accidents (FHWA<sup>5</sup>)

Excessive speed was identified as a factor in 30 percent of fatal crashes. Normal speed enforcement techniques can be difficult to apply in work zones due to high traffic volumes and space constraints to safely and effectively stop motorists. Several

jurisdictions are planning automated speed enforcement programs specifically for work zones. Speed display trailers that advise motorists of their current speed are also being used. In a variation of this, a study is currently underway in New Brunswick to investigate the use of a speed display device for moving operations such as patching and crack filling.

### **Summary and Conclusions**

The research focused on characteristics of crashes and fatalities in Canada and identified several factors for further consideration. Further investigation including exposure, work zone traffic control, operating speeds, etc. would need to be considered to better define the results. However, the study does provide insight and direction for further study. Some of the findings that may merit further investigation include:

- The most common crash configuration resulting in a fatality was head-on (32 percent), followed by rear-end (18 percent).
- Head on crashes on undivided roads accounted for 29 percent of all fatalities, and 50 percent of these occurred under snowing conditions.
- Excessive speed was a contributing factor in 30 % of fatal crashes.
- Drivers age 25 – 44 account for the highest number of crashes, and are over-represented in work zone crashes when compared to all traffic crashes.
- The percentage of male drivers involved in crashes and fatalities is higher in work zones than in all traffic crashes.
- Clear was the most common weather condition at time of crash occurrence, followed by snowing. Snowing conditions were present in 17.3 percent of work zone crashes despite having a low expected frequency of occurrence.
- Crash conditions appear to be more severe under clear conditions, more often resulting in a fatality.

- The majority of crashes occur during the daytime lighting conditions, followed by dark and artificial light. It appears that crashes are more severe under dark conditions, but their may be other contributing factors such as operating speed of the roadway.

2. Transport Canada, 2003. Canadian Motor Vehicle Traffic Collision Statistics: 2001, TP3322, Cat. T45-3/2001E-IN.

3. National Center for Statistics and Analysis. *Fatal Accident Reporting System*. Accessed March 2004. <http://www-fars.nhtsa.dot.gov> .

4. National Highway Traffic Safety Administration, Traffic Safety Facts 2003, DOT HS 809 775

5. FHWA, ITS in Work Zones, A Case Study: Dynamic Lane Merge System, FHWA-HOP-04-033, EDL# 14011, October 2004

## References

1. Bushman R, Chan J, Berthelot C, A Canadian Perspective On Work Zone Safety, Mobility And Current Technology, Proc. CSCE 5<sup>th</sup> Transportation Conference CD-ROM

*Table 1. Summary of work zone crash data from TRAIID by province/territory*

Province	Fatalities by Year					Average Injuries /Year *	Fatalities by Road Class			Fatalities by Road Type		
	1997	1998	1999	2000	2001		Rural	Urban	Unknown	Divided/ Freeway	Undivided	Other
Alberta	n/a	n/a	2	2	2	131	5	1	0	1	0	5
BC	n/a	9	4	3	10	146	25	1	0	3	22	1
Manitoba	0	2	1	0	0	52	3	0	0	0	3	0
New Brunswick	0	1	0	1	1	53	2	1	0	0	3	0
Newfoundland	1	0	1	1	0	40	2	1	0	0	0	3
Nova Scotia	1	0	1	0	0	100	2	0	0	0	0	2
NW Territories	0	0	1	0	0	4	1	0	0	0	1	0
Ontario	22	16	26	24	19	1284	82	25	0	23	82	2
PEI	4	6	2	0	0	117	12	0	0	0	9	3
Quebec	5	3	2	4	4	251	10	6	2	0	0	18
Saskatchewan	0	2	1	2	3	45	6	0	2	1	6	1
Yukon Territory	0	0	1	0	0	7	0	1	0	0	1	0
Total	33	39	41	38	39	2232	150	36	4	28	127	35

\* Average injuries for 1997 to 2001 with following exceptions: Alberta average injuries for 1999 to 2001, PEI average injuries for 1997 to 1999, and Yukon average injuries for 1998 to 2001.