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# **Beyond the Barriers: Road Construction Safety Issues From the Office and the Roadside**

**Ashim Kumar Debnath\*, Tamara Banks, Ross Blackman, Nathan Dovan, Narelle Haworth, and Herbert Biggs**

*Centre for Accident Research and Road Safety-Queensland (CARRS-Q)  
Queensland University of Technology  
130 Victoria Park Road, Queensland 4066, AUSTRALIA*

\* Email: ashim.debnath@qut.edu.au

## **ABSTRACT**

Conceptually, the management of safety at roadworks can be seen in a three level framework. At the regulatory level, roadworks operate at the interface between the work environment, governed by workplace health and safety regulations, and the road environment, which is subject to road traffic regulations and practices. At the organizational level, national, state and local governments plan and purchase road construction and maintenance which are then delivered in-house or tendered out to large construction companies who often subcontract multiple smaller companies to supply services and labor. At the operational level, roadworks are difficult to isolate from the general public, hindering effective occupational health and safety controls. This study, from the State of Queensland, Australia, examines how well this tripartite framework functions. It includes reviews of organizational policy and procedures documents; interviews with 24 subject matter experts from various road construction and maintenance organizations, and on-site interviews with 66 road construction personnel. The study identified several factors influencing the translation of safety policies into practice including the cost of safety measures in the context of competitive tendering, lack of firm evidence of the effectiveness of safety measures, and pressures to minimize disruption to the travelling public.

**Keywords:** Roadwork safety, Work zone, Organizational safety, Roadwork policy analysis, Perceived safety.

## **INTRODUCTION**

The safety of roadworkers is a high priority for occupational health and road safety authorities and, especially, for the workers themselves and the organizations which employ and represent them. There are substantial risks involved in undertaking construction and maintenance in close proximity to moving traffic, and compromises between traffic flow, acceptable risk exposure levels, and equipment and resource levels associated with such tasks. While road construction and maintenance works (commonly known as roadworks) are essential for maintaining and improving the mobility and safety of all road users, the process of building safer roads and roadsides needs to be managed to minimize risks to both the motorists and roadworkers.

Reports from highly motorized countries including the Netherlands, United States and Great Britain show that

around 1-2% of road fatalities occur at roadworks (NWZSIC, 2012a, 2012b; SWOV, 2010). Numerous studies have found that crash rates increase significantly during roadworks compared with pre-work periods (Doege and Levy, 1977; Garber and Zhao, 2002; Khattak et al., 2002; SWOV, 2010; Whitmire II et al., 2011). Roadwork crashes are also reported to be more severe than other crashes (Pigman and Agent, 1990), possibly associated with the relatively high proportional involvement of trucks (Bai and Li, 2006; Krux and Determan, 2000; SWOV, 2010). Compared to some other countries, relatively little is known about roadwork crashes across Australia, primarily because it is difficult to identify roadwork crashes in official records (Haworth et al., 2002). Thus, it is difficult to obtain accurate comparative information on crash rates, crash severity and other variables of interest. Based on New South Wales data (RTA, 2008), it is estimated that nationally each year at least 50 deaths and 750 injuries occur to workers and the public in crashes at roadworks with a cost of more than \$400 million (Debnath et al., 2012).

Because of multiple floods in recent years in the Queensland state of Australia, significant maintenance and rehabilitation works are being undertaken on the state road network. This sharp increase in roadwork activities has been accompanied by a number of roadworker fatalities and injuries in recent times. In addition, it has become a cause of driver frustration - resulting from frequent stopping at roadwork sites and the associated increase in travel time - which might influence driver behavior and compliance with roadwork signage and traffic rules. For example, a recent study of driver speeds in a Queensland work site (Debnath et al., 2014) showed that almost all (97.8%) vehicles drive above the posted speed limit in the activity area of roadwork site. This high rate of non-compliance with roadwork signage poses significant threat to roadworkers as well as to traveling public themselves. To improve safety at Queensland roadwork sites for roadworkers and the traveling public, a large research project is being undertaken using a multidisciplinary approach because the factors ultimately determining safety outcomes at roadworks are complex and have not been systematically explored before.

Conceptually, roadwork operation and management of safety can be seen in a three level framework. First, at the *regulatory level*, roadworks operate at the interface between the work environment, governed by workplace health and safety regulations, and the road environment, which is subject to road traffic regulations and practices. This may lead to a less than optimal compromise between measures to improve worker safety and measures to maintain traffic flow. Second, at the *organizational level*, national, state and local governments plan and purchase road construction and maintenance which are then delivered in-house or tendered out to large construction companies (or alliances). Many smaller companies then supply services and labor. The lack of a nationally accepted framework for safety management tasks and competencies, in combination with a largely sub-contracted workforce that shifts regularly between organizations, projects and sites, means that workers receive different messages relating to safety performance when they change projects or primary contractors. Reports highlight the confusion caused by the plethora of documents that provide information regarding requirements for traffic control at roadworks (Austroads 2009; Queensland Workplace Rights Ombudsman, 2009). Third, at the *operational level*, roadworks are difficult to isolate from the general public and so it is difficult to implement effective occupational health and safety controls. The credibility and appropriateness of signage and roadworks speed limits are consistently questioned by drivers (MCR, 2009; Highways Agency, 2006) and compliance is low (Debnath et al., 2014).

This multidisciplinary project involves partners at each of the regulatory, organizational and operational levels working together to enhance the safety of roadworkers by: investigating the real and perceived dangers at roadworks; strengthening organizational policies and practices for roadworker safety; testing innovative on-road treatments and educational initiatives to improve driver behavior at roadworks; and developing models of safety management in complex systems that span different regulatory frameworks. The research project is designed to be conducted in two settings: within the organizations that are involved in purchasing and delivering roadworks, and the actual roadwork sites. This ongoing project has completed multiple studies to date in order to understand the various safety issues related to roadworks in light of the three-level framework explained above.

This paper presents the critical safety issues in roadworks identified by taking a structured approach of synthesizing outputs derived from three studies: analyzing (1) regulatory policy documents, (2) opinions of roadwork subject matter experts, and (3) perceived safety of workers involved in roadworks. The findings obtained from these three studies, along with their methodologies, are discussed in the next section. Findings from each study were then synthesized to discuss the common safety issues identified.

# IDENTIFYING SAFETY MANAGEMENT ISSUES IN ROADWORKS

## Analysis of policy documents

The purpose of the review of policy documents was to analyze and critique the documentation specifically pertaining to safety culture and occupational health and safety within four organizations, to more accurately identify the common policies and processes currently being implemented. Generally, construction projects are cooperative ventures between a number of organizations, each bringing their own management process, procedures and safety culture to the project. The extent to which agreement is reached between project partners on safety critical positions, and the allocation of responsibility for safety management tasks are critical to the development and maintenance of the project’s safety culture. Industry partners included in this project, and part of the policy review process, included a major purchaser of road works, a project manager, a construction company and representatives of many of the road construction workers.

The table below lists the selection criteria for the review of policy and procedure documentation. To accurately identify and review the relevant documentation, enquiries were made by the researchers to the partner organizations, requesting any formal or informal policies or procedures currently being implemented with regard to the following list. This list was selected based on best practice risk management approaches identified through a combination of academic and government publications and the Construction Safety Competency Framework (Anderson et al., 1998; Biggs et al., 2012; Dingsdag et al., 2008; Haworth et al., 2000; Haworth et al., 2008; Health and Safety Executive, 2000).

Table 1: List of selection criteria for the review of policy and procedure documentation.

<b>Policy and procedure documents that deal with the following safety requirements</b>
Work schedules are set with consideration of fatigue, high risk periods, adverse weather conditions, other
Equipment is fit for purpose and maintained appropriately
Employees/Subcontractors are competent/capable
Appropriately inducted and/or trained and sufficiently fit and healthy to perform road worker tasks
Risks are identified and controlled
Stakeholders are communicated and consulted with in regards to risk management
Safety program effectiveness is evaluated
Safety responsibilities and the organizations commitment to safety are communicated to employees/subcontractors
Employees/subcontractors are recruited and selected based on safety records and awareness of safety issues
Employees/subcontractors are recognized for good and poor safety behaviors through an official scheme of incentives and disincentives
Incident involvement is recorded and monitored and identified high risks are managed
Relevant components of the OH&S and workers compensation management system are implemented
Ongoing safety culture is developed either through formal training, conferences, or internal processes
Risk management policies should be updated regularly.

Based on the selection criteria, a total of 22 documents across three organizations were reviewed. One organization reported that they did not have any policies or procedures regarding the safety of road workers. Instead, they accepted that it was the responsibility of the organization and contracting company to ensure roadworker safety by abiding by the minimum Occupational Health and Safety requirements.

The analysis of the supplied policy documentation, relevant to safety culture and Occupational Health and Safety, identified a substantial overlap between the reviewed policies of the project partners. While it was encouraging to identify consistent policies and procedures between the organizations, such as the unified use of the risk management hierarchy of controls, it is also important to recognize that confusion may exist in the industry due to the identified gaps in policies and discrepancies, such as the process for reporting incidents. These gaps and discrepancies in organizational policies could lead to further confusion for road workers, with regard to which organization’s policies and procedures should be adhered to in any given situation.

Preliminary discussions suggested that when a project alliance occurs, road workers are expected to follow the

policies and procedures of the leading project company. Examination of the supplied policy documents from each organization identified that wherever there was a difference between the standard represented in the organizations policy and that same policy of the relevant jurisdiction or Client, the more stringent standard applied. Further to this, there may be greater benefit to construction organizations by including all aspects of the best practice risk management approach framework used as the policy selection criteria. For example, none of the provided policy documents indicated that awareness of safety issues and a consideration of safety records were factors in the recruitment and selection of employees and subcontractors. Organizations that proactively recruit and select safe employees may achieve better safety performance records compared to organizations that do not consider safety when recruiting and selecting employees. It is important to note that with the review of the organizational policies and procedures it was unclear the extent to which policy affected workplace practices. This was identified and further addressed in Phase 3 of the project.

## **Subject matter expert interviews**

Phase 3 of the project focused on the identification of safety critical positions and safety management tasks required to be undertaken on projects involving roadworkers. This process involved discussions with each of the partner organizations, and employees across various levels and job titles, specific to the safety of roadworkers. The development of these discussions was structured around the identified information obtained from the preliminary review of organizational policies, and a previously developed generic safety competency framework for the construction industry by Dingsdag et al. (2006).

In total, 24 employees across the 3 partner organizations participated in the discussions, with their job positions ranging from safety managers, project leaders, project managers, safety coordinators, supervisors, engineers and health and safety representatives. The diversity of the participants' job roles was considered to be an accurate representation of the organizations, with their responses in the discussions considered to be reflective of the current processes and procedures undertaken to ensure the safety of roadworkers. It is important to note, that while the job positions are similar to employees interviewed in previous phases, the purpose of these discussions were to look at the organizational level, taking a top-down approach to roadworker safety. In groups of 5-10, participants were asked to identify the safety management tasks required to be undertaken on worksites within the organization. They were also asked to identify, within their own organizations, the safety critical positions and the processes and strategies currently implemented by their organization to better assist in the shared responsibility of the safety management tasks across these positions as well as similar processes and strategies implemented between organizations for the improvement of safety to their roadworkers. Further, participants were also asked to identify what could be done at an organizational level to better improve the safety of roadworkers.

Based on the discussions with participants, key themes began to emerge. The main initial concern identified was that the cost of improving the safety of roadworkers needed to be considered against the reality of the task. A major concern raised by participants also involved training and development. It was a commonly held notion that this was needed not only for staff and workers who were present onsite, but that there would also be great benefit in further public education campaigns. Recurring themes for training for the organizations' employees included performing gap analysis of what they were currently missing and tailoring the appropriate training to meet their needs. There was also an increased demand for more education and training for employees to better understand how to properly utilize safety essentials for worksites, including physical barriers and proper road signage. In addition, there was consensus that there needed to be greater accountability and empowerment from the general worker with regards to safety.

The need for greater accountability and responsibility from the workers to safety extended to the initial project planning stages too, with a common belief that there needed to be better incorporation of safety management tasks during this process, with an increased demand for more safety management stipulations to be inserted into initial contracts with clear and transparent terminology. These tasks needed to then be clearly communicated to all personnel on the worksite, with start-up and toolbox meetings critical to the communication of safety expectations on site. In doing so, participants believed that it would better assist with the governance of the project, ensuring that, as a minimum, work was carried out to an agreed upon standard. Again, these standards needed to be clearly communicated and imposed on all workers onsite during initial inductions.

Additionally, it was made clear that it was important for workers to have a thorough understanding of the Manual of Uniform Traffic Control Devices (Queensland Government, 2010), as it better assisted with drawing up the site and helping with resourcing. Participants also identified that safety onsite could be further improved by continued supervision and inspections of sites, with regular risk assessments to be carried out. There was also a belief that assessing Key Performance Indicators for safety would also be important.

Following on from this, additional semi-structured focus groups will be carried out to better identify the actual safety management tasks allocated to each crucial safety position, mapping these requirements across organizational and operational roles and responsibilities.

## **Perceived safety of roadworkers**

As mentioned previously, accurate and reliable data on incidents and injuries in roadwork zones are difficult to obtain in official records in Australia, and the limited available data are often fragmented and incomplete. In such cases supplementary data are particularly valuable, including data sourced from surveys and interviews. A specific phase of the current study sought to gain an understanding of workplace hazards from the perspective of people directly involved in road construction, maintenance, and traffic control activities. Subsequently, 66 road work personnel were engaged in semi-structured interviews, including 25 traffic controllers, 15 laborers/machinery operators, 21 managers/engineers/supervisors, and 5 directors/planners/designers. As their descriptions suggest, these personnel were occupied in distinctly different roles and spent different proportions of their working time in the field where they could be exposed to work zone hazards. Interviews were conducted individually and face-to-face over an average period of 20 minutes, with the exception of three interviews which were conducted by telephone.

Participants were asked to recall and discuss any safety-critical incidents that they had experienced or witnessed personally, or heard about directly through colleagues. A range of incidents were subsequently recounted in varying amounts of detail. The most frequently recounted type of incident involved a public vehicle intruding into the work area in a roadwork zone. This was mentioned by 38% (n=25) of the 66 participants. The next most reported incident type was a traffic controller being hit by a vehicle, recalled by one third (n=22) of participants. Rear end crashes were the third most frequently reported incident type, mentioned by 29% (n=19) of participants. Reversing incidents (a work vehicle or machinery reversing onto another work vehicle, machinery, object, or worker) were also mentioned relatively frequently, with 23% (15) of participants having witnessed or heard directly about this type of event.

A public vehicle was typically involved in the three most commonly mentioned types of incident (work zone intrusion, hit traffic controller, rear end crash). The fourth most frequently noted incident, reversing incidents, usually involved a work vehicle or mobile machinery. Whether involving the travelling public, workers only, or a combination of motorists and workers, human error was the main causative factor cited in the majority of these incidents.

The most common causes of incidents according to participants were vehicles ignoring signage and traffic controllers (n=26), distracted driving (n=14), driver error (n=6) and drink driving (n=5). With regard to drivers ignoring signage, this is a behavior that results in speeding through work zones and as such is directly related to arguably the most common and problematic hazard in work zones where public traffic must be accommodated. Ignoring traffic controller instructions (e.g., stop/slow) can result in vehicles driving into work-area/closed-lanes, rear end crashes with vehicles stopping/stopped near traffic controller, or head-on crashes with oncoming vehicles when violating a 'stop' instruction. Distracted driving, often due to drivers observing work zone activities or using mobile phones and in-vehicle devices, is likely to cause rear end crashes with preceding vehicles. Drunk driving was reported to be associated with speeding and consequently not complying with 'stop' traffic controls. It is evident from the reported causes of incidents that roadworkers perceive that most incidents in work zones occur because of driver error.

With regard to reversing incidents, participants reported that although there are often measures in place to prevent these, including reversing beepers and spotters, they are not always effective. In particular, reversing beepers are sometimes turned off, ignored or fail to be noticed because workers become desensitized to frequent alarms. In regard to spotters, there are accounts of their instructions being misinterpreted and also ignored by drivers working on site. Interested readers are referred to Debnath et al. (2013) where the common work zone incidents and their causes are described in detail.

In addition to the common incidents and their associated causes, participants were asked to describe the situations at work when they feel unsafe in order to gain a better understanding of the work zone hazards. The commonly reported unsafe situations include excessive vehicle speeds in work zones (n=40), working in wet weather (n=20), driver frustration and aggression towards roadworkers (n=18), working close to live traffic lanes (n=14), working during night, dawn and dusk hours (n=14), and drivers on mobile phones leading to distracted driving (n=11). While these reported unsafe situations include factors related to the working environment (e.g., weather, visibility, and traffic), drivers actions (e.g., speeding, aggression, and distraction) are again reported to create a significant share of

the unsafe situations in work zones.

Participants were asked to describe the specific hazards in the situations they reported to feel unsafe. Excessive speeding, particularly in the absence of enforcement, poses significant hazards to roadworkers as speeding is directly related to severity of incidents. The hazards in working in wet weather include reduced visibility and slippery surfaces, which reduce skid resistance and require greater stopping distances, so the chances of not noticing signage/traffic controllers and underestimating required stopping distances are higher. These eventually could lead to failing to stop properly under stop/slow directions and being involved in rear end crashes with vehicles stopped ahead. Although working under rainy conditions is not common, sometimes workers need to continue working in order to meet deadlines and/or to reopen the road to traffic as soon as possible. Driver frustration and aggression was reported as hazardous mainly by the traffic controllers. It was reported that the form of aggression can range from verbal abuse to throwing objects, spitting, and threatening roadworkers. The reported hazards in working close to traffic lanes include throwing of loose materials from pavement by passing traffic, inability to see oncoming traffic properly (often in the hilly and windy roads), and not having an adequate escape path. Reduced visibility and higher numbers of fatigued drivers were the common hazards reported for working during night, dawn and dusk hours. Distracted driving due to mobile phone use - also reported as a cause of work zone incidents - was reported as a significant hazard as this often results in motorists disobeying or not noticing traffic lights and signage.

Findings from the commonly reported work zone incidents, their causes, and unsafe situations at work show that driver actions are responsible for creating most of the hazards in work zones. Speeding, noncompliance with traffic signage and traffic controller instructions, and distracted driving were the common hazardous behaviors in work zones. Other sources of hazards include improper working environment (e.g., working in wet weather, inadequate escape path) and not maintaining safety practices (e.g., tampering with reversing beepers). It is believed that construction companies and workplace safety regulators have the potential to control workers' compliance with safety practices and treat hazards related to improper work environment. However, changing driver behavior in work zones is more difficult. A wide range of safety measures (e.g., speed control measures, physical barriers and speed humps, travel information and advisory systems, enforcement measures) are used to control drivers' behavior in work zones, but none have been proven to change driver behavior significantly (though some are useful for short-term). Discussion on the effectiveness of these safety measures, which was beyond the scope of this paper, can be found in Debnath et al. (2012) and Edara et al. (2013).

## **DISCUSSION**

This paper identifies safety issues in road construction and mitigation approaches from the regulatory, organizational and operational levels. At the regulatory level, the examination of policy documents showed that there were indeed two explicit foci: worker safety and the safety of members of the public travelling through worksites. In general, the policies of the road construction companies focused on worker safety while those of the road authorities had a greater emphasis on road safety for the public.

At the organizational level, the factors influencing the impact of the policy documents on practices were examined in the management discussion groups. These group discussions revealed that the cost of safety measures was an important consideration in their adoption. Road construction companies are competing on price in tendering for work, wherein safety (particularly traffic control) is a significant component of the cost and therefore subject to downward pressure. The lack of good data on the relative effectiveness of different approaches to achieving safety objectives was identified as a barrier to selecting and justifying what were judged to be the best safety measures. The evaluations of the effectiveness of on-road safety measures that we will be conducting in a later part of the program of research will provide valuable input into addressing the concerns expressed at the organizational level of needing more objective information to assess the cost-effectiveness of particular safety measures.

The interviews with workers revealed how the goal of the road authorities to minimize disruption to the travelling public influenced operational decisions with potential safety consequences. To maintain traffic flow, many works on high volume roads are undertaken at night, with workers consequently less visible to drivers and more exposed to drunk drivers and fatigued drivers.

Driver frustration and aggression, ranging from verbal abuse to throwing objects and physical assault, was reported by roadworkers as a common cause of feeling unsafe. This was not mentioned as a safety issue in any of the policy documents or in the interviews with management. Thus, it seems that some safety issues experienced at the operational level are not feeding back into programs and policies to mitigate their harm at the organizational or regulatory levels.

Several important conclusions can be drawn from the perspective of people at the operational level who are directly involved in construction, maintenance, and traffic control activities. Firstly, public vehicles and related driver behavior issues pose the greatest perceived challenge with regard to minimizing roadwork risks and hazards. The perceptions of workers are supported to a large extent by the work zone safety literature. While the considerable risks and hazards directly associated with construction activities, such as mobile plant, tools and machinery, hazardous materials and other environmental factors are clearly recognized, they are seen to be more within the control of workers and also management. Speeding, driver distraction, lack of awareness, driver fatigue, impairment and driver aggression are thus all key concerns of those who are exposed to public vehicle traffic in and around work zones.

Many of the incidents that workers described in the interviews occurred in the approach to roadworks, where traffic controllers are the group most exposed to risk of injury. The traffic controllers are commonly employed by sub-contractors. While the regulatory framework states that the prime contractor is responsible for their safety, the occurrence of ongoing incidents involving injuries to traffic controllers suggests that more attention is needed to improve their safety. This was supported by the comments from management of the need for continued inspection and supervision of sites. The management comment also was consistent with worker interviews reporting that some workers ignored spotters or tampered with reversing alarms.

In both the discussions with management and the interviews with workers, respondents proposed that public education campaigns should be undertaken to improve driver behavior at roadworks. Similar suggestions have been made in earlier studies (Haworth et al., 2002; Pratt et al., 2001) but there remains a need for formal and reliable program evaluations (Arnold Jr, 2003; Haworth et al., 2002; MVA Consultancy, 2006; Ross and Pietz, 2011). While other categories of safety measures have been evaluated objectively in terms of the extent of speed reduced, evaluations of educational measures have typically relied on public perceptions of their effectiveness obtained from surveys. For example, after a five-year advertising and awareness campaign in Queensland, almost all drivers surveyed (97%) agreed that the campaign encourages drivers to slow down and 93% agreed that the campaign helped them to realize the potential consequences of speeding at roadworks and of disregarding traffic control signals and directions (TMR, 2009). Yet no measures of the effects on speeds at roadworks were collected.

The transportation and construction sector stands to benefit substantially from increasing collaboration on the development of a more standardized approach to increasing the safety around road works. The information identified in this paper will be used to inform trials of a series of safety interventions, collaboratively agreed upon by our industry partners. The findings may also be applied internationally to inform the development of policies and procedures to enhance road construction safety globally.

## CONCLUSIONS

Attempts to control the full suite of roadwork risks and hazards are largely developed, refined and formalized at the organizational and regulatory levels, with the implicit (and often explicit) objective of achieving 'zero harm' outcomes. At the operational level, however, there appears to be widespread acceptance that working on roadways is inherently dangerous, largely due to the unpredictability of traffic, to the extent that not all risks and hazards can be controlled absolutely. In this sense it could be argued that there is something of a divide between organizational and operational perspectives, and that much of the resultant gap is bridged by the regulatory frameworks, procedures and requirements provided by the appropriate organizations. A range of factors influences the translation of safety policies into practice, including the cost of safety measures in the context of competitive tendering, lack of firm evidence of the effectiveness of safety measures, and pressures to minimize disruption to the travelling public.

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