TRAFFIC SAFETY IN ROAD CONSTRUCTION WORK ZONES

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Road workers' safety is at risk in road construction areas, as their work occurs alongside moving vehicles. Furthermore, there is a paucity of literature relative to this aspect of safety, which constitutes the research gap. Respondents to three descriptive surveys included engineering consultants, contractors, traffic safety officers, road construction workers, and random motorists. Findings include road users are not cognizant of the risk to workers in the work zone; signage and advance warning signs alone are not sufficient to slow motorists' speed, and plant operator visibility in terms of being able to see the areas around the plant, is an issue. Recommendations include: the public should be educated regarding the risks associated with a work zone; contractors should monitor road users' speed prior to the work zone; contractors should install sensors or cameras on the rear and side panels of plant, so that plant operators have all round vision, and workers should be educated regarding the dangers related to using their mobile phones inside work zones.

Keywords: construction; road; safety; traffic; work zone

INTRODUCTION

The South African construction industry generates a high level of injuries relative to construction industries globally. Based upon a total of 297 829 workers insured by The Federated Employers Mutual Assurance Company (RF) (Pty) Ltd (FEM) (2024) for the year 2022, the fatality rate (FR) was 17.5 / 100 000 workers, the accident rate (AR) was 2.11 / 100 workers, and the disabling injury incidence rate (DIIR) was 0.22 or 0.22 / 100 workers. The FR does not compare favourably with the FRs of the Australian and United Kingdom (UK) construction industries, namely 2.1 for 2021 (Safe Work Australia, 2023), and 2.1 in 2022 / 2023 (Health and Safety Executive, 2024), respectively (Table 1).

Table 1: Comparison of construction fatality rates for Australia, South Africa, and the UK

Country	FR
Australia	2.1
South Africa	17.5
United Kingdom	2.1

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No South African or developing country statistics are available for road construction, and therefore to contextualise the issue, American statistics are cited. According to Wang, Katz, and Dong (2018), 532 American construction workers were killed while undertaking road construction between 2011 and 2016, which is more than double the total for all other industries combined. Furthermore, approximately 50.0% of road construction site fatalities were attributable to workers being struck by a vehicle or mobile equipment (Wang *et al.,* 2018). Construction workers working as crossing guards and paving / surfacing operators at road construction sites had the highest risk of fatal injuries (Wang *et al.,* 2018).

Furthermore, there is a paucity of South African scientific literature relative to road construction safety, and particularly safety relative to road construction work zones. However, the document 'Road Safety near Construction Zones / Roadworks' courtesy of Arrive Alive (2024) addresses a range of issues and informs regarding the importance and criticality of the subject within the context of South Africa. Reference is made to 'thousands of people' being killed when traffic must pass through road construction or maintenance works every year.

Given the paucity of literature relative to the subject, and anecdotal evidence, a study was conducted, the aim being to determine practices, perceptions, and behaviour relative to traffic safety in road construction work zones in South Africa, which essentially constitutes the research gap. The objectives include, inter alia, to determine:

- the problems confronting road construction and general routine road maintenance in terms of the safety of workers, as well as relative to traffic safety
- whether controls implemented are peculiar to site risk
- whether signage and road marking are sufficient to decrease the focal ratio of traffic through road works, and
- whether the separation of workers and traffic is an effective mechanism for the protection of workers

LITERATURE REVIEW

Statistics

According to Wang, Katz, and Dong (2018), in terms of event or exposure, the most common cause of American road construction deaths between 2011 and 2016 was pedestrian vehicular incidents where a worker (non-occupant of a vehicle) was struck by a vehicle or mobile equipment (50.2%), followed by roadway incidents that occurred while a worker was operating a vehicle (13.2%), and struck by object / equipment (10.0%). Then, in terms of pedestrian vehicular incidents, 61.4% were due to a worker (non-occupant of a vehicle) being struck by a forward-moving vehicle in the work zone, followed by being struck by a vehicle backing up in the work zone (24.7%), and struck by vehicle propelled by another vehicle in work zone (9.4%).

Hazards in Road Construction Work Zones

Within the context of South Africa, Arrive Alive (2024) states that road construction work zones present a deadly hazard for workers, motorists, and pedestrians, brought about by motorists traveling at high speeds, impatience on the part of motorists, and widespread traffic congestion.

Causes of Fatalities and Injuries in Road Construction Work Zones

According to Arrive Alive (2024), within the context of South Africa, the following are the causes: speeding traffic, which is the primary cause; inadequate signposting and lighting; drivers failing to notice road workers; drivers not paying attention to work zone signs or flaggers indicating they should slow down or stop; drivers being distracted by mobile phone calls, conversations, and activities at the roadside, and not merging properly, and drivers not merging in an appropriate manner, and then trying to force themselves in, and if not able to, entering the work zones and endangering the lives of workers.

Planning and Managing Road Construction Work Zones

The nature of road construction work zones is exacerbated by exposure to the public in the form of motorists, and amplifies the need for detailed planning, training, staffing, and controlling, and implementing the requirements of the Construction Regulations (RSA, 2024). Therefore, the process should be initiated by a comprehensive client BRA, 'designer' H&S specification, designer report, 'contractor' H&S specification, and a response to the latter in the form of an appropriate H&S plan. The H&S plan should include a comprehensive road traffic management plan (RTMP), which includes the traffic management team, how the RTMP will be communicated to the principal contractors' and subcontractors' workers via training in the form of H&S induction and toolbox talks.

Arrive Alive (2024) focuses on the following in terms of how effective management can limit the risk of accidental road accidents: the need for signs to be kept clean and well maintained to be effective; the role of press and radio releases in terms of warning drivers of what to expect at a site, thus minimising impatient and dangerous behaviour; training of traffic controllers and the need for appropriate actions on their behalf; the importance of two-way radio communication between traffic controllers; the wearing of suitable reflective personal protective equipment (PPE); the of use temporary traffic signals to control traffic; the avoidance of unnecessary traffic control signs or road markings which tend to confuse motorists and make them careless; interaction between traffic controllers and motorists, and consistency of speed limits safe site operations and traffic movements.

Legislation and Regulations

In terms of the South African Construction Regulations (Republic of South Africa, 2014), clients are required to, inter alia, prepare an H&S specification based on their baseline risk assessment (BRA), which is then provided to designers. Designers in turn are required to, inter alia: consider the H&S specification; submit a report to the client before tender stage that includes all the relevant H&S information about the design that may affect the pricing of the work, and the geotechnical-science aspects; inform the client of any known or anticipated dangers or hazards relating to the construction work, and make available all relevant information required for the safe execution of the work upon being designed or when the design is changed; modify the design or make use of substitute materials where the design necessitates the use of dangerous procedures or materials hazardous to H&S, and consider hazards relating to subsequent maintenance of the structure and make provision in the design for that work to be performed to minimise the risk. To mitigate design originated hazards, requires hazard identification and risk assessment (HIRA) and appropriate responses, which process should be structured and documented.

Thereafter, clients must include the H&S specification in the tender documentation, which in theory should have been revised to include any relevant H&S information included in the designer report. Thereafter, they must, inter alia: ensure that potential principal contractors (PCs) have made provision for the cost of H&S in their tenders; ensure that the PC to be appointed has the necessary competencies and resources; ensure that every PC is registered for workers' compensation insurance cover and in good standing; discuss and negotiate with the PC the contents of the PC's H&S plan and thereafter approve it; take reasonable steps to ensure that each contractor's H&S plan is implemented and maintained; ensure that periodic H&S audits and documentation verification are conducted at agreed intervals, but at least once every 30 days; ensure that the H&S file is kept and maintained by the PC, and appoint a competent person in writing as an agent when a construction work permit is required.

In addition to the abovementioned interventions required of contractors, contractors must identify the hazards and the risks to which persons may be exposed, analyse, and evaluate the hazards and the risks using a documented method, and produce a plan and applicable safe work procedures (SWPs) to mitigate, reduce, or control the hazards and risks. This process is emphasized throughout the Construction Regulations, and although it is a continuing process, initial construction HIRA is initiated for and documented in the PC's H&S plan. A range of other interventions are required, inter alia: notification of intention to commence construction work; the appointment of a construction manager who is responsible for the management of H&S on a project; appointment of a full-time or part-time H&S Officer, which is a staff function in that it is an advisory role; conducting of medicals; appointment of competent persons to supervise specific activities; training; provision of H&S information to workers; environmental monitoring; conducting of audits and inspections; record keeping, and storage and handling.

METHOD

Research Method and Sample Strata

Given that the lead author works in the construction sector as a construction H&S agent (CHSA), and his involvement in projects entailing road construction work zones, a convenience sample was adopted. The quantitative method was adopted and included three primary studies, preceded by an exploratory study, which was conducted to pre-test the questionnaire used for primary study 1. Two of the three primary study sites were situated on the Sipetu Road project near Mount Frere. The first entailed a survey of client representatives, the principal agent, the principal contractor (PC), and appointed contractors, including workers. Of the 80 questionnaires distributed, 20 were e-mailed and 60 were handed out. Of the 20 e-mailed questionnaires, only five were mailed back and four were collected - a total of nine. Of the 60 handed out, a total of 40 questionnaires were collected. This equates to a response rate of 61.3%. The second study, which entailed road users' opinions, was situated on the R61, 20 kilometres outside Mthatha on route to Queenstown, Eastern Cape province, South Africa. 50 questionnaires were printed onto cardboard and were completed by drivers 'stopped' and 'waiting' at the 'Stop-and-Go' with the help of traffic safety officers (TSOs). The site was divided into two - 25 questionnaires were completed by motorists traveling in each direction.

The third study entailed the measuring of motorists' speed through a work zone, but this was not possible on any of the sites on which the lead author worked. However, when the road works commenced on the N2 adjacent to the new Bay West Mall, Port

Elisabeth, South Africa, part of the 'traffic accommodation' included the use of a speed measuring device which alerted motorists to the speed at which they were traveling through the work zone. Thus, this site became an additional site of data collection in terms of the efficacy of speed measuring devices. The speed of 616 motor vehicles was measured.

FINDINGS

Table 2 indicates the degree of concurrence, or agreement / disagreement, with 18 statements by respondents during the primary study in terms of percentage responses to a scale of strongly disagree to strongly agree, and MSs between 1.00 and 5.00.

The MSs of 4 / 18 (22.2%) statements are $> 4.20 \leq 5.00$, which indicates that the concurrence is between agree to strongly agree / strongly agree. The concurrence with the statement 'Law enforcement should assist contractors to reduce the speed of motorists through the work zone' is consistent with the findings emanating from the literature as one of the major contributors to accidents and incidents in the work zone. The following statements: 'Plant operators should undergo regular alcohol and drug testing', 'Plant operators are trained and are mindful of workers', 'Plant operators obey road signage and slow down when entering work zones' are all related to the competency of operators and how plant operator behaviour can influence the risk to workers and road users, as noted in the literature.

The MSs of 8 / 18 (44.4%) statements are $> 3.40 \leq 4.20$, which indicate the agreement is between neutral to agree / agree. The statements 'All plant operators must undergo annual medical examinations', 'Plant on site is in good condition with adequate warning devices', 'Completing daily plant inspection checks can minimise plant breakdowns, incidents and accidents' and 'Mature plant operators are less likely to take risks than their younger counterparts' relating to the plant, the plant operators, and their behaviour. The statements 'Motorists will only slow down sufficiently if threatened with speeding fines' and 'Placing rumble strips through the work zone would assist to reduce the speed of motorist' reflect opinions on strategies to lower the speed of motorists passing through the work zone. The literature does not support or challenge this as in South Africa, no law enforcement in work zones occurs. Internationally, however, a double fine system exists where the amount of the fine is doubled for speeding in the work zone. The statement 'Workers working adjacent to passing traffic are the most vulnerable' is situated in the middle of the MS range. The statement 'The use of mobile phones should not be allowed within the road works area' is a relatively new problem, which exists in the work zone where workers become distracted from the risks around them and noted in the literature.

The MSs of 4 / 18 (22.2%) statements are $> 2.60 \leq 3.40$, which indicates the agreement is between disagree to neutral / neutral. The statements 'Motorists tend to only slow down when entering the transition area just before road works start', 'Motorists adhere to the speed limit when passing workers in the work zone', and 'Motorists understand signage and react to the advance warning signs to slow down' are related to motorists' understanding of road signage and how they react. Speeding is the main reason for accidents and fatalities in road works as noted in the literature. The next statement 'Employers separate workers and traffic with adequate separation barriers based on risk not budget' is deemed to be of great importance in the literature but was scored low by respondents. This statement, however, entailed the highest level of uncertainty.

The MSs of 2 / 18 (11.1%) statements are > 1.80 ≤ 2.60, which indicates the respondents strongly disagree to disagree / disagree with the statements. 'Motorists are aware of risk to road workers and slow down through the work zone' is ranked low compared to the evidence of bad behaviour of motorists noted in the literature. The statement 'It is acceptable to use a TLB or excavator as a lifting device without having the machine load tested' attracted limited concurrence, possibly due to the lack of knowledge among workers as this requirement would only be known to those working or managing the machine.

Table 2: Degree of concurrence with 18 statements (Primary Study 1)

Statement	Response (%)						
	Unsure	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	MS
Law enforcement should assist contractors to reduce the speed of motorists through the work zone	2.0	6.1	2.0	8.2	28.6	53.1	4.41
Plant operators should undergo regular alcohol and drug testing	0.0	8.2	0.0	16.3	6.1	69.4	4.29
Plant operators are trained and are mindful of workers	4.1	4.1	0.0	18.4	18.4	55.1	4.26
Plant operators obey road signage and slow down when entering work zones	4.1	6.1	8.2	8.2	16.3	57.1	4.24
All plant operators must undergo annual medical examinations	6.1	8.2	0.0	14.3	14.3	57.1	4.11
Motorists will only slow down sufficiently if threatened with speeding fines	6.1	14.3	6.1	14.3	16.3	42.9	3.98
Plant on site is in good condition with adequate warning devices	6.1	10.2	2.0	10.2	22.4	49.0	3.96
Completing daily plant inspection checks can minimize plant breakdowns, incidents, and accidents	4.1	4.1	8.2	12.2	20.4	51.0	3.94
Workers working adjacent to passing traffic are the most vulnerable	4.1	14.3	4.1	12.2	14.3	51.0	3.87
Placing rumble strips through the work zone would assist to reduce the speed of motorists	4.1	12.2	4.1	10.2	24.5	44.9	3.81
The use of mobile phones should not be allowed within the road works area	4.1	22.4	2.0	4.1	18.4	49.0	3.72
Mature plant operators are less likely to take risks than their younger counterparts	8.3	14.6	4.2	16.7	10.4	45.8	3.59
Motorists tend to only slow down when entering the transition area (just before road works start)	0.0	24.5	4.1	16.3	30.6	24.5	3.33
Employers' separate workers and traffic with adequate separation barriers based on risk not budget	12.5	14.6	12.5	14.6	16.7	29.2	3.16
Motorists adhere to the speed limit when passing by workers in the work zone	2.0	14.3	22.4	32.7	6.1	22.4	3.06
Motorists understand signage and react to the advance warning signs to slow down	2.0	26.5	16.3	16.3	22.4	16.3	2.80
Motorists are aware of risk to road workers and slow down through the work zone	0.0	38.8	12.2	20.4	16.3	12.2	2.56
It is acceptable to use a TLB or excavator as a lifting device without having the machine load tested	4.1	67.3	2.0	2.0	10.2	14.3	2.07

Table 3 indicates the degree of concurrence with five statements by road user respondents during the third study (Stop-and-Go) in terms of percentage responses to a scale of strongly disagree to strongly agree, and MSs between 1.00 and 5.00. The statements all have MSs > 4.20 ≤ 5.00, which indicates the concurrence with the statements is between agree to strongly / strongly agree.

'Road signage is clear and easy to understand', elicited a high level of agreement (MS = 4.94). Such signage should be clear and in accordance with the related guidelines.

The next statement 'Deviations clear to understand and easy to steer through', has the second highest MS (4.56). This indicates that road users are satisfied with the way the road deviations are structured and that they are easy to negotiate. This status can mitigate road user-related accidents.

The statement 'Road works activities cause build-up of traffic that leads to driver frustration' has the third highest MS (4.36), which is not unexpected.

The statement 'Lanes are wide enough for steering through the road works comfortably' has the third highest MS (4.54) with no uncertainty noted. This indicates that road users were satisfied with the width of the lanes provided during construction, which can mitigate road user-related accidents.

The statement 'Construction vehicles are considerate and give the right of way to motorists' is self-explanatory (MS = 4.28), but important as if this is not the case, drivers may overtake recklessly. The positive and friendly attitude of plant drivers contributes greatly to the smooth flow of traffic and reduces frustration and road rage that might be associated with a project.

Table 3: Road users' concurrence with five statements (Primary Study 2)

Statement	Response (%)						
	Unsure	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	MS
Road signage is clear and easy to understand	0.0	0.0	0.0	2.0	2.0	96.0	4.94
Deviations are clear to understand and easy to steer through	0.0	2.0	2.0	4.0	22.0	70.0	4.56
Road works' activities cause build-up of traffic that leads to driver frustration	0.0	4.0	0.0	10.0	28.0	58.0	4.36
Lanes are wide enough for steering through the road works comfortably	0.0	4.0	4.0	2.0	14.0	76.0	4.54
Construction vehicles are considerate and give the right of way to motorists	0.0	2.0	10.0	6.0	22.0	60.0	4.28

Table 4 indicates the speed of vehicles as they approached the speed measuring device during primary study 3, which was not related to study 1 or study 2. It should be noted that the speed restriction in the speed measuring zone was 60 km/h. It is notable that 88.6% of the vehicles measured exceeded the speed limit. 57.9% of motorists traveling through the work zone were traveling between the ranges of $> 60 \leq 70$ km/h (35.2%), and $> 70 \leq 80$ km/h 140 (22.7%).

Table 4: Analysis of speed measurement (Primary Study 3)

Speed	%	No.
$> 50 \leq 60$ km/h	11.4	70
$> 60 \leq 70$ km/h	35.2	217
$> 70 \leq 80$ km/h	22.7	140
$> 80 \leq 90$ km/h	15.9	98
$> 90 \leq 100$ km/h	10.2	63
$> 100 \leq 110$ km/h	3.1	19
$>110 \leq 120$ km/h	1.3	8
$>120 \leq 130$ km/h	0.2	1
Total	100.0	616

Table 5 indicates the mean speed was 74 km/h, the lowest speed 54 km/h, and the highest speed 123 km/h.

DISCUSSION

Firstly, the limitations of the findings, which originate from three case studies based upon compliance with legislation, regulations, and standards should be acknowledged i.e., they are not representative, but indicative. However, given the subscription to legislation, regulations, and standards by the projects assessed, the resultant findings can be deemed to be confirmatory.

Table 5: Mean, minimum, and maximum speeds recorded (Primary Study 3)

Measure	%
Mean	74.3
Minimum	54
Maximum	123

The degree of concurrence with 18 statements posed during primary study 1 indicates congruence between the empirical findings and the findings in the literature (Arrive Alive, 2024). Key issues include speeding by motorists and responding thereto; the condition of construction plant; the training, medical assessment, and checking of substance abuse by construction plant operators, and their operational practices; the vulnerability of workers; the behaviour of motorists in terms of adherence to the speed limit, recognition of hazards and risks, and the separation of workers from traffic.

The road users' degree of concurrence with five statements during primary Study 2 indicates that the road construction work zone interventions and stop-and-go process were optimum, however it is based upon one project.

The speed measuring during primary study 3 confirms the findings expressed in the literature, namely that motorists exceed the speed limits when approaching and transiting road construction work zones (Arrive Alive, 2024). This is underscored by the degree of concurrence, namely between disagree to neutral / neutral relative to the following primary study 1 statements: 'Motorists tend to only slow down when entering the transition area (just before road works start)'; 'Motorists understand signage and react to the advance warning signs to slow down', and 'Motorists are aware of risk to road workers and slow down through the work zone'.

CONCLUSIONS

Work zone H&S is a major challenge, and a concern that requires more attention to reduce the risk of fatalities and injuries to workers within the work zone, and motorists driving through the work zone. Motorists are not concerned with the H&S of workers in the work zone. Furthermore, motorists do not perceive the hazards and risks within a work zone and in general, there is a lack of risk perception on the part of motorists while driving through a work zone. Consequently, signage alone is not sufficient to slow road users down to the recommended speed before passing through a work zone.

Planning of the work zone layout is important for the H&S of workers working within the work zone, plant operating within, and passing motorists, which amplifies the need for a comprehensive RTMP to be included in the H&S plan.

All-round visibility for plant operators is a major concern as the size and configuration of several types of construction plant creates many blind spots.

The use of mobile phones in work zones distracts workers and places them at risk when working alongside passing traffic and construction plant. Furthermore, the separation of workers from passing traffic and construction plant is critical.

The public needs to be educated as to the risks associated with speeding through a work zone. The distribution of 'awareness' pamphlets to drivers 'stopped' and 'waiting' at 'Stop-and-Go' points, constitute a potential related intervention. Furthermore, electronic speed measuring devices should be placed prior to the work zone to make road users aware of their speed, and the speed required in the work zone. The speed limit should be reduced in stages in relation to the required work zone speed limit. Furthermore, transgressors of speed restrictions should be sanctioned, which will require enhanced traffic policing.

Efforts to separate workers from passing traffic should be enhanced due to the hazard and risk posed by passing traffic.

Sensors and cameras must be installed on the rear and side panels of construction plant for operators to have all round vision.

The use of mobile phones by workers while working must be banned, and a mobile phone booth must be erected for workers to use when needing to use a mobile phone.

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