ROAD SAFETY AUDIT AT WORKZONES

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ABSTRACT

Accident rate and severity reduction at roadwork sites requires an integrated and systematic approach aimed at identifying and solving the safety problems. An effective approach, which is quickly spreading at international level, is the workzone safety audit. Road safety audit is a formal examination of a future road or traffic project, an existing road, or any project which interacts with road users, where an independent, qualified team reports on the project's potential accident and safety performance, by trying to investigate how the road environment is perceived, and ultimately utilised by different road users.

The paper presents a road safety audit procedure specifically suited for workzones. It is based on detailed checklists and on risk assessment. New risk indicators, that involve the prediction of the number and severity of potential accidents associated with each safety item, have been defined: the Total Weighted Score of the main safety aspects, which relates to the risk factors that may be improved by engineering measures, and the Global Safety Index, which allows the evaluation of the global safety of the workzone and the ranking of workzones in the road network. The proposed safety evaluation procedure is strongly related to the safety consequences of the identified problems, rather than on the standard non-compliance or on the number of deficiencies.

Pilot safety audits, which have been carried out both in urban and rural areas, have identified many safety issues, whose removal or mitigation requires low cost safety measures.

Keywords: workzone safety, road safety audit, risk assessment, checklists.

Road workzones induce problems to the traffic flow, giving rise to a local decrease of the safety level, which depends on a lot of factors, as type of work, type of road, volume, composition and speed of traffic flow, road alignment, weather conditions, and visibility.

At roadwork sites an increase in accident rate and severity occurs. New Zealand accident data (*1*) show that the fatality rate for accidents at workzones is about three times greater than the national one; the number of accidents at workzone sites varies from 1 to 3% of the total road accidents.

Accident rate and severity reduction at roadwork sites requires an integrated and systematic approach aimed at identifying and solving the safety problems of the workzone. An effective approach, which is quickly spreading at international level, is the workzone safety audit in both urban and rural areas. Road safety audit is a formal examination of a future road or traffic project, an existing road, or any project which interacts with road users, where an independent, qualified team reports on the project's potential accident and safety performance. In countries, as Italy, where there are not workzone standards or guidelines related to traffic management and safety aspects, such procedure may be beneficial in providing a general safety improvement in the roadwork practice.

The Audit Team applies the principles of road safety according to a multidisciplinary perspective, taking into account the need of all road users: car drivers, pedestrians, cyclists, motorcyclists, children, elderly people, people with disabilities, truck and bus drivers, public transport users.

The objectives of a safety audit at workzones are:

- to identify potential safety problems for road users and others,
- to ensure that measures to eliminate or reduce the identified problems are fully considered by the Client and those involved in construction and/or maintenance and/or any other road activity, which may affect the normal operating condition of the road.

A safety audit will:

- help minimize the risk and severity of crashes that may be attributed to the presence of workzones,
- improve awareness of safe practices for all on road activities,
- identify, primarily from road user's perspective, those issues and features that give misleading or confusing messages.

ROAD SAFETY AUDIT PROCEDURE

Roles and Responsibilities

Road Safety Audit is aimed at identifying and solving risk factors, by trying to investigate how the road environment is perceived, and ultimately utilised by different road users. Part of the analysis involves a comparison process between the opinions expressed by a team of safety specialists.

Road safety audit procedure provides the involvement of the following professional figures:

- the *Client*, who commissions audits at proper project stages, selects an Audit Team with the appropriate training and experience, reviews the formal audit report and acts upon recommendation whenever appropriate and feasible,
- the *Designer*, who is the responsible of the traffic management scheme on behalf of the Client, and provides the Audit Team with all the background information to the scheme, and who responds to the initial Audit findings on behalf of the Client,
- the *Audit Team*, which should not be a "one man Audit Team" (*1-5*), and should have adequate experience in road safety engineering and practices, accident investigation and prevention, traffic engineering and road design. The Audit Team identifies the safety problems of the project and provides recommendations to eliminate or mitigate them, by reviewing project documentation and drawings, and conducting site inspections.

Process

Workzones are dynamic, constantly changing environments. Therefore, it is vital for the audit process to be a quick mechanism to fast identify and correct unsafe conditions.

The main steps of the safety audit, which may slightly differ in countries where the process is applied, are the followings (*1-20*):

- the Client selects the Audit Team,

- the Designer provides all necessary documents to the Audit Team,
- a preliminary meeting between all subjects involved is carried out, deciding on the audit objectives and procedures,
- Audit Team examines all project documentation and drawings,
- Audit Team conducts site inspections, both in daytime and in nightime, and both as motorits and as pedestrians,
- the Audit Team, in the office, reviews the results of the site inspections and documentation analysis. Checklists, photographs and videos are an useful prompt for the auditors. The team singles out potential accident scenarios, by prediction of accident types and their contributing factors, and defines possible countermeasures,
- Audit Team writes the Safety Audit report, in "problem/recommendation" format, where the problem is described in terms of an accident risk to a road user, and the recommendation is an engineering solution to the reported problem. Recommendations produced by the Audit Team should indicate the type of measures, without specifying detailed technical issues,
- a completion meeting between all the subjects involved is held and the proposed recommendations are examined and discussed,
- the Designer reviews the Audit report and communicates to the Client his observations,
- the Client examines Audit report and Designer's observations and decides about the implementations of the recommendations,
- the Client responds to the Audit report by writing an Exception report.

The design stage of the safety audit should be followed by the next stages, which can be applied also for workzones not audited in the design stage:

- safety audit at the end of workzone installation,
- safety audit during work, which should be carried out through repeated site inspections without workzone personnel be alerted. The number of inspections depends on the workzone length, traffic volume and risk factors,
- safety audit after the workzone removal, aimed at verifying if risk factors caused by the workzone itself still exist.

The Audit Team examines only aspects influencing users safety, but it doesn't consider other elements, which can refer to other judgment criteria, different from the safety. To this objective, the Audit Team should analyse, for example, if users correctly perceive workzone, not only in daytime, but also in nighttime and in bad weather conditions. If there is an high pedestrian flow, the analyst should simulate all the scenarios in which different types of pedestrian could be, such as an elder with walking difficulties or a child, who could be covered by signals or workzone equipment.

Road safety audit is not a check against standards; however, if roadwork standards non-compliance exist, auditors should outline it.

Checklists

Checklists are a prompt aimed at avoiding that Audit Team overlooks important safety problems. Checklists are not a substitute for knowledge and experience, that is, checklists should aid using safety engineering experience and judgement and should not be used as a "tick" sheets (*9*).

A Checklist specifically suited for workzones has been developed (see table 1). This checklist is splitted in five sections:

- Traffic management. Workzones may induce a re-routing of road users in the network, with effects both on Level of Service and on accidents. Characteristics of the road network affected by the workzone have to be analysed, taking into special consideration vulnerable road users.
- Workzone layout. Workzones consist of five areas (*21*) (see figure 1): advance warning area (which tells motorists what to expect ahead), transition area (which usually is one of the most critical issues for workzone safety), buffer area (which provides a longitudinal and lateral recovery for motorists and workers), traffic area (where traffic flow pass near the work area), termination area (which lets traffic resume normal driving).
- Signs and lighting. The road system must provide adequate visual information to enable the driver to adapt his behavior to the workzone conditions, and also to enable the pedestrian to safely walk

to the intended destination. Permanent and temporary signs and markings must correctly interact each other.

- Roadside obstacles. In the workzones many accidents involve the vehicle leaving the road. Longitudinal safety barriers, their transtions and terminals should provide adequate protection to roadside obstacles whitout giving rise to vehicle's occupants injury.
- Workzone operations. Interaction between work activities and traffic flow may be an accident contributing factor, above all if the buffer area is insufficient.

Risk analysis

Problem's magnitude may be quantified by conducting risk assessments. Various risk assessment procedures may be used.

The easiest approach involves the Audit Team prioritizing the safety issues basing on experience. However, this method is somewhat subjective.

A more objective approach involves the prediction of the frequency and severity of potential accidents associated with each problem identified in the audit report. A risk assessment matrix, where the risk score depends both on the frequency and severity of potential accidents, may be used (see table 2). The auditors would go through the report and give each problem a risk score, making their assessment of risk if nothing is done. The auditors would then go back through their recommendations, and, making the assumption that the recommendation will be carried out, the auditors re-assess the risk. With this procedure, the Audit Team not only looks at the existing road (or project) deficiencies, but also takes into account that those problems could produce road accidents and that the suggested improvements may reduce the accident consequences.

It is important that safety auditors base their work on sound safety experience, and where possible, have the means to back up the recommendations from documented sources. There are a number of reasons for this (*4*):

- to try to avoid basing Audit comments on road safety "myths",
- to try to avoid basing Audit comments on "gut feelings" about safety,
- to increase cost effectiveness of the recommendations.

THE NEW ZEALAND SHR SYSTEM

In New Zealand, a risk assessment procedure specifically suited for workzone has been developed (*1*). Whitin such procedure, an assessment of the real and/or potential hazards observed at the time of each site inspections is made by the estimation of a Site Hazard Rating (SHR). In relation to the site hazard rating, the workzones risk levels are defined as: satisfactory (SHR=0 to 300), marginal (SHR=301 to 1500), serious (SHR=1501 to 2500) and critical (SHR>2500).

The site hazard rating is assessed by calculation of the factors and parameters recorded for each site inspected, using: site observations, information from the site inspection sheets (which relate to signage, delineation, protection, worksite zone/hazard area, principal zones correct) and the site hazard estimation formula check sheet. The SHR is calculated by the formula:

$$\mathbf{SHR = A \times B \times C} \qquad (1)$$

where:

A = Site condition factor, which is calculated multiplying the number of deficiencies and the numerical pointing given to it. The deficiencies are listed in the site hazard estimation formula check sheet, and are divided into the categories: signs, channelling systems and miscellaneous.

B = Site complexity factor, which is calculated by multiplying three values, which depend on the ADT, highest approach operating speed, intersection factor and footpath users affected by works.

C = Traffic effects factor, which depends on the interaction between traffic and workzone operations.

The SHR system is robust enough to show the difference between the various hazard/risk levels. However, the procedure needs detailed reference standards and guidelines and does not directly take into account the number and severity of accidents caused by the risk factors.

THE GLOBAL SAFETY INDEX

A new risk assessment procedure, specifically suited for workzones, has been defined. The proposed safety evaluation procedure is related to the safety consequences of the identified problems, rather than on the standard non-compliance or on the number of deficiencies.

The procedure requires an Audit Team that consists of at least two members. The auditors, after conducting the site inspection and problems analysis, assess the Risk Score (see table 2) accociated with each item of the checklist (see table 1) independentely each other. For each item, the Average Risk Score is computed. It points out the detailed safety issues. In the report, all the items which result in a high crash risk should be reported.

Since the ARSs computed with this procedure do not allow a synthetic evaluation of the workzone safety, new risk indicators have been defined.

For any section of the checklist (traffic management, workzone layout, signs and lighting, roadside obstacles, workzone operations), the sum of the ARSs, that is the Cumulated Risk Score, is computed. The ratio between the CRS and the maximum theorical CRS (that is equal to the Cumulated Risk Score if the Average Risk Score of each safety item is equal to the maximum value) represents the Weighted Risk Score. It results:

$$\mathbf{CRS_j = \Sigma_{nj}\, ARS_i} \quad \mathbf{(1)}$$

$$\mathbf{WRS_j = 100 \times CRS_j/(n_j \times MaxRS)} \quad \mathbf{(2)}$$

where

CRS_J	=	Cumulated Risk Score of the checklist section j
WRS_j	=	Weighted Risk Score of the checklist section j
ARS_i	=	Average Risk Score of the safety item i
n_j	=	number of safety items of the checklist section j
j	=	number of the checklist section (from 1 to N)
MaxRS	=	Maximum theorical Risk Score value

The Weighted Risk Score evaluates the potential accident consequences associated with the safety aspect under examination. It underlines areas where engineering measures for road safety improvement are needed. The WRS may be explicited by a synthetic judgement, that is the Safety Level (see table 3), ranked from A to F. Similarly to the Level of Service concept, worldwide spreaded and accepted, the Safety Level A depicts the best safety conditions, whilst the Safety Level F depicts the worst conditions.

The procedure computes N Safety Levels, one for each section of the checklist. The Safety Levels are independent each other. The global evaluation of the workzone safety is made by computing the Global Safety Index, using the formula:

$$\mathbf{GSI = 100 - (\Sigma_N\, WRS_j)/N} \quad \mathbf{(3)}$$

where

GSI	=	Global Safety Index of the workzone
WRS_j	=	Weighted Risk Score of the checklist section j
N	=	Number of checklist sections

GSI ranges from 0 to 100. The greatest the GSI, the better the workzone safety. GSI equal to 0 means that the workzone safety is critical and all the safety issues need remarkable improvements. GSI equal to 100 means that the workzone safety is satisfactory.

PILOT WORKZONES SAFETY AUDITS

Pilot workzones safety audits have been performed both in urban and rural area, according to the procedure described in the previous paragraphs. Each site has been inspected twice by a team of two members, once in day-time and once in night-time, both as motorists and as pedestrians. The site visits were not announced and workzone drawings were not available.

The safety audits have identified many problems, whose elimination or mitigation require low cost safety measures as insertion of longitudinal and transversal buffers, better markings and signing, adjustement of road restraint systems and construction of pedestrian facilities. Main results are reported below.

Urban Area

Two workzones in Naples (Italy) have been audited. Both workzones are in carriageway (see figure 2). In the site no.1, the workzone takes up one of the two lanes with alternate one way traffic managed by signals. In the site no.2, the workzone takes up a 3-way intersection and is located in a sharp bend.

The Global Safety Index scored 31,9 for workzone no.1 (see table 4), and 21,8 for workzone no.2 (see table 5).

Many traffic management problems were encountered. They relate also to the formation of queues, because of the presence of the workzones. In workzone no.1 it has been noticed the presence of a queue at the traffic lights which regulate the alternate one-way. Vehicles arriving at the traffic lights could not see the queue, because of the presence of a bend. Furthermore, in the bend there is a sign ("we are working for you") in the center of the lane that compels the users to a diversion to the outer lane, causing potential head-on accidents. Similar problems were encountered also in workzone no. 2, where workzone warning signs completely miss. A relevant problem is the absence of continuity of pedestrian routes (see figure 3), both on workzones 1 and 2. It implies that the pedestrians can't understand the safe route to pass through the workzone. The Safety Level for traffic management rated C for workzone no.1 and E for workzone no.2.

The workzone layout is usually the most relevant safety aspect. The audited workzones scored E and F since the lack of both longitudinal and transversal buffer areas (see figures 3 and 4) and the wrong configuration of the transition areas.

Signing and lighting scored in both workzones Safety Level E. In most cases, the lack of warning signs and markings has been noticed. The existing signs and markings carry wrong colours, and don't provide adequate information to the users. Signs maintenance is often poor and it can be seen out of position signs too. In most cases it can be advised the lack of delineation along the path of the workzones. Combined with the presence of bends, it is a contributing factor for nighttime accidents.

In both workzones, resulting roadside obstacles Safety Level was equal to F, that is, great safety problems arise from inadequacy of the safety barriers. In several cases the lack of any protection device, or the lack of continuity of the restraint systems, is accompanied by the presence of an open excavation (see figure 4).

Workzone operations scored in both workzones Safety Level E. A common problem is that the works are carried out very close to the traffic flow. Accesses to the work place are often positioned in a dangerous manner. They can create conflicts points with the traffic flow (see figure 3).

Rural Area

Two workzones in rural area have been audited. Workzone no.3 is a two lane rural highway, sited in Pozzuoli (Naples). It interests the roadside and a part of one of the two lanes, and causes the narrowing of both lanes. Workzone no.4 is on the A3 Naples-Salerno motorway. It is made by a succession of workzones with an extension of several kilometres.

Most of the safety problems encountered in urban area have been advised in rural area too. Main differences relate to the greater travel speed, which increases both number and severity of accidents.

On the motorway there are many problems related to the limited capacity of the road. Often, there are queues whose extension can get over the workzone alert signs. Congestion problems induce many users to use adjacent roads with lower geometrical and functional characteristics. As global result, road accidents in the network may increase.

Buffer areas are generally absent in rural area too. The encountered problems related to signs are those regarding the lack of workzone alert signs, wrong horizontal markings, out of position or out of order signs. On the motorway signs are often positioned in a wrong way. In most cases, it has been advised the coexistence of permanent and temporary markings, which can mislead arriving users about the right route to follow.

Roadside obstacles problems are common to both urban and rural area. However, in rural area the greater speed increases the accident consequences. In the motorway a common problem is the absence of separation between opposite carriageways (see figure 5).

Workzone operations are carried out very close to the traffic flow (see figure 6).

The Global Safety Index was very poor also for the audited rural workzones: 30,2 for workzone 3 (see table 6) and 17,0 for workzone 4 (see table 7). The worst safety aspects were roadside obstacles and workzone operations, which were rated with a Safety Level equal to F.

CONCLUSIONS

Road safety audits are an effective approach for improving safety at workzones. The road safety audit procedure presented in the paper is specifically suited for workzones. It is based on detailed checklists and on risk assessment.

New risk indicators, that involve the prediction of the number and severity of potential accidents associated with each safety item, have been defined: the Total Weighted Score of the main safety aspects, which relates to the risk factors that may be improved by engineering measures, and the Global Safety Index, which allows the evaluation of the global safety of the workzone and the ranking of workzones in the road network. The proposed safety evaluation procedure is strongly related to the safety consequences of the identified problems, rather than on the standard non-compliance or on the number of deficiencies.

Pilot safety audits, conducted both in urban and in rural area, have identified many safety issues, whose removal or mitigation requires low cost safety measures.

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TABLE 1 Checklists

Traffic management	
1	Does the workzone induce the detour of traffic flows to roads which geometrical and functional characteristics can produce an increase in accident rate?
2	Are improvements on the road network affected by the workzone needed?
3	Can traffic volumes and workzone position generate queues not visible at an adequate distance?
4	Is the distance between two or more consecutive workzone adequate to the flow stabilization?
5	Are pedestrian and cycle routes continuous?
6	Have been carried out necessary measures for vulnerable road users?
Workzone layout	
7	Is there an adequate longitudinal and transversal buffer area?
8	Do users correctly perceive transition area?
9	Are there frequent and unexpected workzone geometry changes, which may contribute to mislead road users?
Signs and lighting	
10	Are the warning signs adequate?
11	Are the speed limits coherent with risk factors and user's expectatives?
12	Are the operating speeds adequate to the road geometry and risk factors?
13	Are the speed limit signs well perceived?
14	Are signs and markings coherent with the users correct routes?
15	Is the integration between temporary and permanent signs and markings correct?
16	Have the permanent signs incoherent with the route been removed, covered or modified?
17	Are there old, not completely removed signs and markings, which can create confusion?
18	Is the transition between temporary and permanent signs and markings well perceived?
19	Are there elements that limit signs visibility?
20	Is the signs and markings visibility adequate, also in nighttime and in bad weather conditions?
21	Are signs and markings colours coherent with the presence of workzone?
22	Is the end of workzone clearly perceived?
23	Is it necessary to illuminate critical points?
24	Are the risk factors well signed?
Roadside obstacles	
25	Are the workzone road restraint systems adequate to the type of road, traffic volumes, risk factors and available spaces?
26	Are contraflows separated by effective restraint systems?
27	Are the barrier's terminals sited in protected positions or realized with energy absorbing devices?
28	Are the transitions between barriers of different typology realized with elements, which allow a gradual change of containment capacity and stiffness?
29	Are risk factors adequately protected?
30	Are there localized, unprotected risk points?
31	Is there enough space for the deformation of the barriers?
Workzone operations	
32	Is the work carried out at enough distance from the traffic flow?
33	Are there interferences between work activities and traffic flow?
34	Is there safe access to the work place?
35	After the workzone removal, have the original circulation conditions been completely restored?

TABLE 2 Risk Assessment Matrix

Accident severity \ Accident frequency	Low frequency	Medium frequency	High frequency
Low severity	0	1	2
Medium severity	1	2	3
High severity	2	3	3

TABLE 3 Safety Levels

Total Weighted Score	Safety Level
0 to 10	A
11 to 25	B
26 to 40	C
41 to 60	D
61 to 80	E
81 to 100	F

TABLE 4 Rating of Workzone No. 1

Checklist Item	Auditor 1			Auditor 2			Average Risk Score	Cumulated Risk Score	Weighted Risk Score	Safety Level
	Accident severity	Accident frequency	Risk Score	Accident severity	Accident frequency	Risk Score				
Traffic management										
1	1	1	*0*	1	1	*0*	0			
2	1	1	*0*	1	1	*0*	0			
3	3	1	*2*	2	2	*2*	2	5,0	33,3	**C**
4	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
5	3	1	*2*	2	1	*1*	1,5			
6	3	1	*2*	2	1	*1*	1,5			
Workzone layout										
7	3	3	*3*	3	3	*3*	3			
8	3	3	*3*	3	3	*3*	3	6,5	72,2	**E**
9	1	1	*0*	1	2	*1*	0,5			
Signs and lighting										
10	3	3	*3*	2	2	*2*	2,5			
11	3	1	*2*	2	2	*2*	2			
12	3	1	*2*	2	2	*2*	2			
13	2	2	*2*	3	2	*3*	2,5			
14	3	3	*3*	3	3	*3*	3			
15	2	1	*1*	2	2	*2*	1,5			
16	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
17	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	22,0	61,1	**E**
18	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
19	2	2	*2*	2	1	*1*	1,5			
20	2	1	*1*	3	3	*3*	2			
21	3	1	*2*	1	1	*0*	1			
22	1	1	*0*	1	1	*0*	0			
23	3	1	*2*	1	1	*0*	1			
24	3	3	*3*	3	3	*3*	3			
Roadside obstacles										
25	3	2	*3*	3	3	*3*	3			
26	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
27	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
28	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	11,5	95,8	**F**
29	3	3	*3*	3	3	*3*	3			
30	3	3	*3*	3	3	*3*	3			
31	3	1	*2*	3	3	*3*	2,5			
Workzone operations										
32	3	1	*2*	3	3	*3*	2,5			
33	3	1	*2*	3	1	*2*	2	7,0	77,8	**E**
34	3	3	*3*	3	1	*2*	2,5			
35	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
									Global Safety Index	**31,9**

TABLE 5 Rating of Workzone No. 2

Checklist Item	Auditor 1			Auditor 2			Average Risk Score	Cumulated Risk Score	Weighted Risk Score	Safety Level
	Accident severity	Accident frequency	Risk Score	Accident severity	Accident frequency	Risk Score				
Traffic management										
1	1	1	*0*	2	2	*2*	1			
2	1	2	*1*	1	2	*1*	1			
3	3	2	*3*	1	1	*0*	1,5	9,5	63,3	**E**
4	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
5	3	3	*3*	3	3	*3*	3			
6	3	3	*3*	3	3	*3*	3			
Workzone layout										
7	3	3	*3*	3	3	*3*	3			
8	3	3	*3*	3	3	*3*	3	8,0	88,9	**F**
9	2	2	*2*	2	2	*2*	2			
Signs and lighting										
10	3	2	*3*	2	3	*3*	3			
11	2	1	*1*	3	1	*2*	1,5			
12	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
13	2	2	*2*	2	1	*1*	1,5			
14	2	2	*2*	3	3	*3*	2,5			
15	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
16	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
17	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	21,0	77,8	**E**
18	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
19	2	2	*2*	2	2	*2*	2			
20	2	3	*3*	3	3	*3*	3			
21	2	3	*3*	3	3	*3*	3			
22	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
23	2	1	*1*	2	2	*2*	1,5			
24	3	3	*3*	3	3	*3*	3			
Roadside obstacles										
25	3	3	*3*	3	3	*3*	3			
26	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
27	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
28	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	10,0	83,3	**F**
29	3	3	*3*	3	3	*3*	3			
30	2	2	*2*	3	3	*3*	2,5			
31	2	2	*2*	2	1	*1*	1,5			
Workzone operations										
32	2	2	*2*	3	3	*3*	2,5			
33	2	2	*2*	2	1	*1*	1,5	7,0	77,8	**E**
34	3	3	*3*	3	3	*3*	3			
35	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
Global Safety Index 21,8										

TABLE 6 Rating of Workzone No. 3

Checklist Item	Auditor 1			Auditor 2			Average Risk Score	Cumulated Risk Score	Weighted Risk Score	Safety Level
	Accident severity	Accident frequency	Risk Score	Accident severity	Accident frequency	Risk Score				
Traffic management										
1	1	1	*0*	1	1	*0*	0			
2	1	1	*0*	1	1	*0*	0			
3	1	1	*0*	1	1	*0*	0	6,0	40,0	**C**
4	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
5	3	2	*3*	3	2	*3*	3			
6	3	2	*3*	3	2	*3*	3			
Workzone layout										
7	3	3	*3*	3	3	*3*	3			
8	2	2	*2*	3	3	*3*	2,5	5,5	61,1	**E**
9	1	1	*0*	1	1	*0*	0			
Signs and lighting										
10	3	3	*3*	3	3	*3*	3			
11	2	2	*2*	2	1	*1*	1,5			
12	2	1	*1*	2	1	*1*	1			
13	2	1	*1*	2	1	*1*	1			
14	2	2	*2*	2	2	*2*	2			
15	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
16	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
17	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	16,0	53,3	**D**
18	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
19	2	2	*2*	2	1	*1*	1,5			
20	2	2	*2*	2	1	*1*	1,5			
21	1	1	*0*	1	1	*0*	0			
22	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
23	2	2	*2*	2	1	*1*	1,5			
24	3	3	*3*	3	3	*3*	3			
Roadside obstacles										
25	3	3	*3*	3	3	*3*	3			
26	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
27	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
28	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	12,0	100,0	**F**
29	3	3	*3*	3	3	*3*	3			
30	3	3	*3*	3	3	*3*	3			
31	3	3	*3*	3	3	*3*	3			
Workzone operations										
32	3	3	*3*	3	3	*3*	3			
33	3	3	*3*	3	3	*3*	3	8,5	94,4	**F**
34	3	3	*3*	3	1	*2*	2,5			
35	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
							Global Safety Index		**30,2**	

TABLE 7 Rating of Workzone No. 4

Checklist Item	Auditor 1			Auditor 2			Average Risk Score	Cumulated Risk Score	Weighted Risk Score	Safety Level
	Accident severity	Accident frequency	Risk Score	Accident severity	Accident frequency	Risk Score				
Traffic management										
1	1	1	*0*	3	3	*3*	1,5			
2	1	1	*0*	3	3	*3*	1,5			
3	1	1	*0*	2	2	*2*	1	6,0	50,0	**D**
4	2	2	*2*	2	2	*2*	2			
5	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
6	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
Workzone layout										
7	3	3	*3*	3	3	*3*	3			
8	2	2	*2*	3	3	*3*	2,5	8,5	94,4	**F**
9	3	3	*3*	3	3	*3*	3			
Signs and lighting										
10	2	2	*2*	2	2	*2*	2			
11	2	2	*2*	3	2	*3*	2,5			
12	3	3	*3*	3	2	*3*	3			
13	2	2	*2*	3	2	*3*	2,5			
14	2	2	*2*	2	2	*2*	2			
15	2	2	*2*	2	2	*2*	2			
16	3	2	*3*	2	2	*2*	2,5			
17	3	2	*3*	2	2	*2*	2,5	33,0	73,3	**E**
18	3	2	*3*	2	2	*2*	2,5			
19	3	3	*3*	3	3	*3*	3			
20	1	1	*0*	2	2	*2*	1			
21	2	2	*2*	2	2	*2*	2			
22	3	3	*3*	2	2	*2*	2,5			
23	1	1	*0*	1	1	*0*	0			
24	3	3	*3*	3	3	*3*	3			
Roadside obstacles										
25	3	3	*3*	3	3	*3*	3			
26	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
27	3	3	*3*	3	3	*3*	3			
28	3	3	*3*	3	3	*3*	3	17,5	97,2	**F**
29	3	3	*3*	3	3	*3*	3			
30	3	3	*3*	3	3	*3*	3			
31	2	2	*2*	3	2	*3*	2,5			
Workzone operations										
32	3	3	*3*	3	3	*3*	3			
33	3	3	*3*	3	3	*3*	3	9,0	100,0	**F**
34	3	3	*3*	3	3	*3*	3			
35	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.			
									Global Safety Index	**17,0**

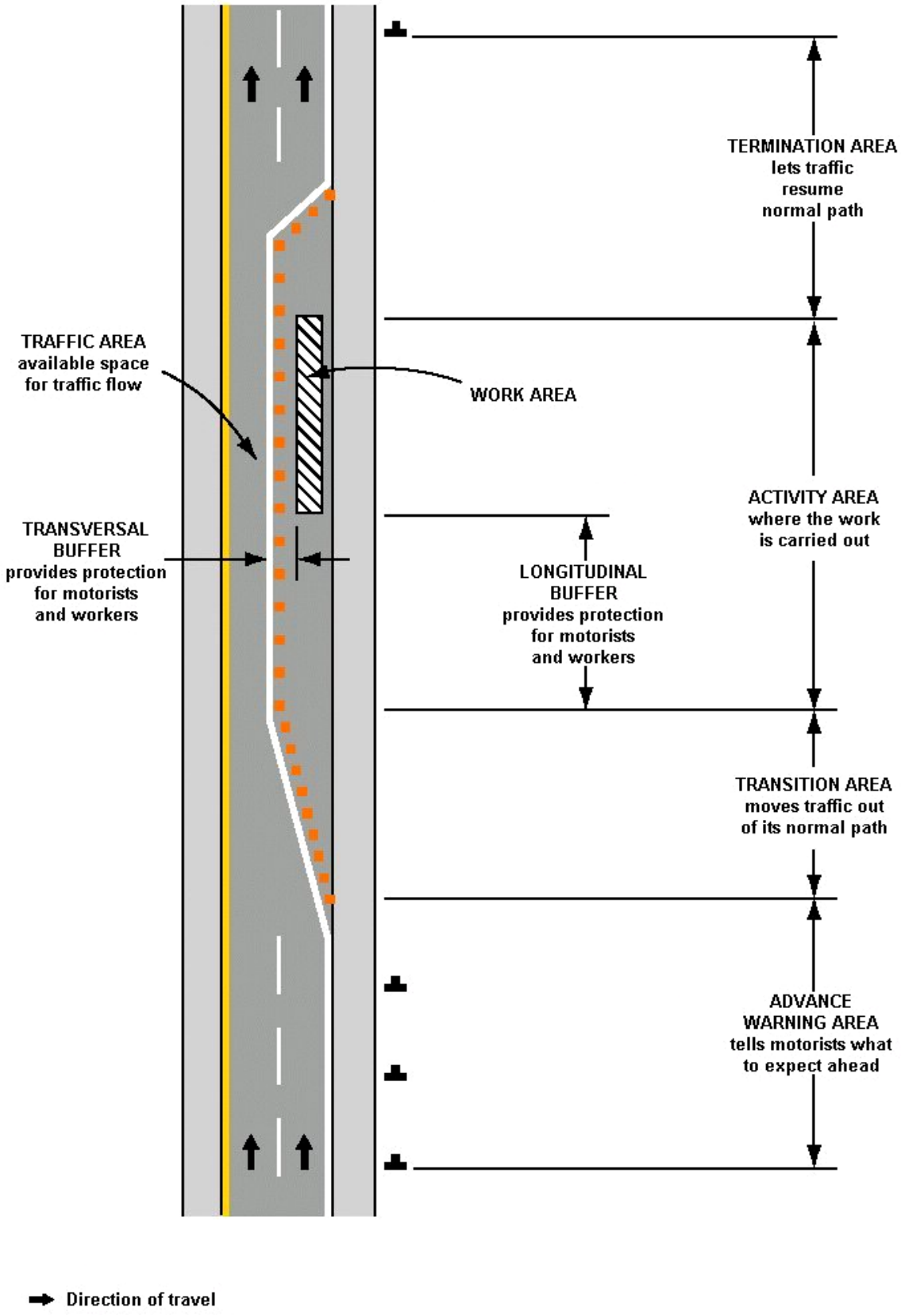

FIGURE 1 Most common workzones layout (*21*).

FIGURE 2 Urban workzones layout.

FIGURE 3 Interrupted sidewalk.

FIGURE 4 Wrong use or lack of safety fences.

FIGURE 5 Unseparated opposite carriageways.

FIGURE 6 Unprotected crane close to the traffic flow.