SWOV Fact sheet

Roadworks and road safety

Summary
Roadworks can cause dangerous situations for both road users and road workers. In the period 2000-2009, 2% of all registered fatal crashes in the Netherlands took place at roadworks. In addition, roadworks seem to increase the crash rate. Lorries are relatively often involved in crashes at roadworks. Especially in urban areas cyclists are insufficiently taken into consideration at roadworks. Therefore, a number of urban crashes was indeed caused by slow traffic entering a closed off road. Crashes at roadworks on rural roads are relatively often rear-end collisions, while some crashes involve work vehicles, impact attenuators and other objects. Speeding is likely to be involved in these crashes. Speed reduction measures, such as enforcement, dynamic speed information, and credible limits can help to reduce vehicle speed at roadworks. Impact attenuators and Andreas strips lower the risk and reduce the severity of roadworks crashes.

Background and content
Roadworks can consist of maintenance, reconstruction or new construction (alongside an existing road, for example the construction of extra lanes). They are indicated by the triangular traffic sign in *Figure 1*. Roadworks disturb the expectations of the road user and influence driving behaviour. This can result in unsafe situations for road users as well as road workers. It can also impede the traffic flow. Therefore, measures and facilities at roadworks are necessary to limit the negative effects on road safety and traffic flow.

Figure 1. *Traffic sign for roadworks*.

This fact sheet discusses road safety at roadworks in the Netherlands and looks at the circumstances under which these roadworks crashes occurred. The crash causes are used to describe possible measures.

How frequent are crashes at roadworks?
During the period 2000-2009, an annual average of 18 fatal crashes happened at roadworks in the Netherlands (see *Figure 2*). This amounts to 2% of all fatal crashes.

However, only the annual number of roadworks crashes does not give a clear indication of how unsafe roadworks are. The annual number of roadworks and time spent on them also need to be taken into account. Since this is not registered very well, the crash rate at roadworks cannot be determined accurately. The literature does not sketch an unambiguous picture of the effect of roadworks on the crash rate, although most studies report an increase of the crash rate (Van Gent, 2007).

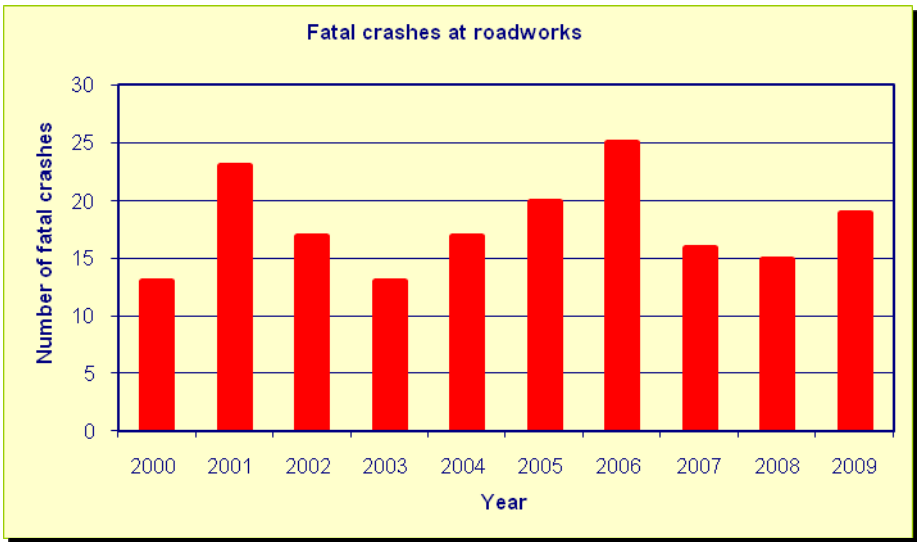

Figure 2. *Fatal crashes at roadworks per year (source: BRON)*

At which locations and under what circumstances do roadworks crashes happen?
The work zone appears to be the most risky area at roadworks. A study of international literature (Van Gent, 2007) shows that intersections where traffic from a side road joins a main road with a work zone are relatively dangerous in urban areas. However, an analysis of Dutch crash data (Janssen & Weijermars, 2009), makes clear that the proportion of roadworks crashes at intersections hardly exceeds that at road sections. In rural areas, roadworks crashes often occur in the vicinity of approach roads and exits (ARROWS, 1999). Moreover, the number of serious[1] roadworks crashes (compared to the total number of serious crashes) is relatively high on national roads (Janssen & Weijermars, 2009). Roadworks that are carried out over a longer period and that cover a longer work zone seem to have a lower crash rate (Van Gent, 2007).

Road workers experience working at night as dangerous (Swuste & Heijer, 1999). Literature indeed shows that at roadworks the night hours generally have an increased crash rate, which means there are more crashes per 'unit', for example kilometres or hours, of the roadwork (Van Gent, 2007). The *number* of roadworks crashes, however, is higher during daytime: about two thirds of the roadworks crashes happen in the daytime and the proportion of nightly roadworks crashes is not higher than that of daytime crashes. However, it is likely that fewer roadworks are carried out at night than during the day, so that the nightly crash rate may be higher than the crash rate at daytime.

Who are involved in roadworks crashes?
Dutch crash data shows that freight traffic is relatively often involved in roadworks crashes. Overall, a freight vehicle is involved in 6% of the serious crashes; but the average for roadworks crashes is 13% over the period 2000-2009. Other studies confirm this (Van Gent, 2007). Although the number of casualties among road workers is small, the work of road workers has been found to be relatively unsafe compared to that of industrial workers (Swuste & Heijer, 1999; Venema et al., 2008).

What are the causes of roadworks crashes?
International literature shows that roadworks crashes are relatively often rear-end collisions (Van Gent, 2007). Analysis of Dutch crash data confirms this (Janssen & Weijermars, 2009): 31% of all rural roadworks crashes are rear-end collisions; in comparison, this is the case for 15% of all rural crashes. Short headway distances and speeding play an important role in the occurrence of rear-end collisions. Furthermore, a number of rural crashes involve work vehicles and road blocks. In these situations speeding probably is also one of the causes.

An extensive literature study on road user behaviour in the vicinity of roadworks was carried out in the European ARROWS project (ARROWS, 1999). The European PREVENT project has summarized the main findings, and more recent literature has been studied (PREVENT, 2003). The most consistent finding is that speeding is common at roadworks. The majority of drivers drive too fast when approaching roadworks. Often, drivers only reduce their speed if the traffic situation immediately in

[1] In this fact sheet, a serious crash is defined as a crash with at least one fatality or serious road injury (MAIS2+).

front of them requires them to do so (just before an abrupt change of circumstances), and consequently brake too hard. Although 'fast' drivers (with a high initial speed) reduce their speed more than 'slow' drivers, their end speed is still higher. In addition, changing lanes is left rather late when a lane is closed off (Schuurman, 1991).

In a number of urban crashes in urban areas, especially slow traffic enters a blocked road and then collides with roadworks traffic, falls, or rides into a ditch (Janssen & Weijermars, 2009). Evaluation of fifty roadworks locations shows that cyclists are insufficiently considered. The work zone is sometimes closed off badly, it is not always clear which adjustments in behaviour are required of cyclists, and the sign ‘cyclists dismount’ is sometimes applied incorrectly (Weijermars, 2009).

Roadworks are not always a factor in the occurrence of roadworks crashes (Janssen & Weijermars, 2009). In 2005, 20 of the 58 Dutch roadworks crashes of which the crash reports were studied would probably also have occurred if no roadworks had been carried out. For example, this is the case for a crash caused by a road user ignoring a stop sign. At the time of the crash roadworks were being carried out, but this probably did not have an effect on the vehicle ignoring the stop sign on the intersecting road.

Which measures can be taken?
There are several ways in which road safety measures can be used to improve road safety during roadworks (Van Gent, 2007):
- demarcating the work area for traffic;
- guiding traffic through the work area;
- making roadworks and road workers visible for road users;
- simplifying the driving task.

Generally, traffic cones and barriers are used to demarcate the work zone. In addition, they guide the traffic, as do (temporary) markings and vehicle mounted arrow boards. Impact attenuators are primarily used to protect road workers.

Measures such as road signs, variable message signs, conspicuous clothing for road workers, and orange lighted equipment warn road users that roadworks are being carried out. In the United States 'flaggers' are used in addition to this. Flaggers are people who wear conspicuous clothing and use a flag to warn road users of roadworks ahead.

Reducing the maximum speed is intended to simplify the driving task. In addition, it also reduces the risk of a crash and lessens its severity. Supplementary measures, such as enforcement and dynamic speed information (which presents feedback of individual speeds), can be used to realize compliance. In 2006, the Dutch Ministry of Transport started a new trial to reduce speed at roadworks. Road users were given immediate feedback on their speed, while their vehicle registration number was shown. This direct feedback appears to result in speed reduction (AVV, 2007).

The lower a speed limit is, the more it is exceeded. A speed limit seems to be more acceptable and complied with more often if it is credible. Therefore, in 2005 the Dutch Ministry of Transport introduced new speed regulations during roadworks on motorways. The maximum speed is now 90 km/h and this is only lowered to 70 km/h where the lanes are narrow or when road workers are working right next to the lanes without any barriers. When signalling above the road is present, speeds can be differentiated between lanes or for time of day.

Impact attenuators and Andreas strips reduce the risk of crashes and lessen their severity. Barriers lower the risk of a road user driving into the work zone, but they increase the possibility of a crash with a rebounding vehicle. Physical barriers must therefore only be placed when absolutely necessary (Van Gent, 2007). Finally, an extensive educational programme which is aimed at improving traffic behaviour at roadworks has been developed in the framework of the European research project PREVENT (Twisk & Mesken, 2007).

What are the current roadworks guidelines?
In the Netherlands, there are guidelines for uniform preparation, indication and signalling of roadworks (CROW, 2005). According to these guidelines, the indications of the work zone and the guidance of traffic must be simple and clear, thus both ensuring that the road users are aware of the roadworks

ahead in time and that they know what is expected of them. Furthermore, sufficient distance or a barrier between road workers and traffic is required. The guidelines are no legal provision, so it is allowed to deviate from them. The road authority remains responsible for road safety at all times. In 2005, the Dutch Ministry of Transport released the requirements for design and layout of work zones on national roads (AVV, 2005). These requirements are obligatory for anyone involved in roadworks on national roads.

Are the guidelines implemented correctly?
Evaluation of fifty roadworks locations (Weijermars, 2009) shows that only few locations follow the guidelines completely. The most common deviations are: 1) missing signs or signs that are insufficiently legible/visible, 2) roads/bicycle paths that are closed off badly or with unsafe barriers and 3) markings that are missing, insufficiently visible, or confusing. Not following the guidelines, however, does not always lead to less expected road safety. In addition, a 2009 inspection by the labour inspectorate shows that the road worker is in danger of being crashed into by a vehicle at almost 30% of 223 inspected locations (Dutch Labour Inspectorate, 2010). In 21 situations, risks were so high that the work had to be stopped.

Conclusions
Every year, an average of 18 fatal crashes take place at roadworks in the Netherlands. This amounts to around 2% of all fatal crashes. Based on literature, no unequivocal statement can be made about the effect of roadworks on the crash rate; most studies, however, find an increased crash rate at roadworks.

The highest risk is in the work zone. Roadworks that take longer and cover a longer distance seem to have a lower crash rate. Lorries are relatively frequently involved in roadworks crashes, and literature shows a generally higher crash rate during the night hours.

Especially on rural roads many of the roadworks crashes are rear-end collisions. Also, crashes take place involving vehicle mounted arrow boards and barriers. Speeding is likely to play a role in this type of crash. One of the reasons for urban roadworks crashes is that especially slow traffic enters a road that is closed off. These crashes are partly due to a lack of consideration for cyclists. The work zone is sometimes closed off badly, it is not always clear which adjustments in behaviour are expected of cyclists, and the sign ‘cyclists dismount’ is sometimes applied incorrectly.

Speed measures like enforcement and dynamic speed information (feedback) can help to reduce speeds at roadworks. In addition, the Dutch Ministry of Transport has introduced new, more credible speed limits for roadworks on motorways. The speed limit can also be differentiated across the lanes or for time of day. Impact attenuators and Andreas strips reduce the risk of roadworks crashes and their severity.

There are guidelines for uniform preparation, indication and marking of roadworks. It is important that these guidelines are not only followed for large, but also for smaller roadworks. However, evaluation of fifty roadworks locations shows that the guidelines are only followed completely at few locations.

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