SWOV Fact sheet

Roadworks and road safety

Summary
Roadwork activities can cause dangerous situations for both road users and road workers. In 2005, 2% of all serious, registered crashes in the Netherlands happened during roadworks. In addition, roadworks seem to increase the crash rate. National trunk roads count relatively many fatalities during roadworks, and lorries are relatively often involved in these crashes. A number of urban crashes was caused by slow traffic entering a closed off road. Crashes on rural roads relatively often are rear-end collisions, and some crashes involve work vehicles, impact attenuators and other objects. Speeding is probably also involved in these crashes. Speed reduction measures like enforcement, dynamic speed information, and credible limits can help to reduce speeds at roadworks. Impact attenuators and Andreas strips lower the risk and reduce the severity of roadworks crashes.

Background
Roadwork activities can consist of maintenance, reconstruction or new construction (alongside an existing road, like for instance the construction of extra lanes). Most maintenance work recurs annually, e.g. maintenance of trees and other plants, and sweeping the emergency lanes and drainage gutters. Roadwork activities can also consist of cleaning the very porous asphalt, installing detection loops, and the maintenance of signposting and constructions. In addition, large scale maintenance occurs approximately every fifteen years, such as renewal of the road surface (asphalting) or replacement of guard rails. Roadwork activities on or alongside a road cause a discontinuity in the road layout. Roadworks are indicated by the triangular traffic sign in *Figure 1*.

During roadworks the expectations of the road user are disturbed and their driving behaviour is influenced. This can result in unsafe situations for road users as well as for road workers. It can also hinder the traffic flow. Therefore, measures and facilities are necessary during roadworks to limit the negative effects on road safety and traffic flow.

Figure 1. *Traffic sign for roadworks.*

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

What are the Dutch guidelines for roadworks?
For large scale activities it is possible to take all sorts of safety measures that are not used for smaller activities. For example, protection devices can be installed on motorways and roads can be temporarily closed off. It is often difficult to use the same protection during small-scale and short-lasting activities, especially when they are on lower order roads. This may be caused by, for example, lack of space or relatively high costs. In such cases only beacons are placed, but these do not provide any physical protection (Swuste & Heijer, 1999). Mobile barriers can be used for very brief stationary or for dynamic activities.

CROW Technology Platform for Infrastructure, Traffic, Transport and Public Space has drawn up the Dutch guidelines for the uniform preparation, signalling and cordoning off of roadworks (CROW, 1996; 1999). These guidelines state that the work area must be clearly indicated and the traffic must be guided clearly and transparently so that the road user is warned in time and knows what he is

expected to do. There should also be sufficient space or screening between road workers and road traffic. The CROW guidelines are not compulsory at present; deviations are allowed. The road authority is responsible for the safety of the road at all times. In early 2005, the Ministry of Transport published a guideline which includes the policy points of departure and the requirements that follow for the layout and design of roadwork areas on state roads. This guideline is obligatory for everyone carrying out road works on state roads.

How frequent are crashes at roadworks?
During the period 1987-2006, the annual average at roadworks in the Netherlands was approximately 193 severe crashes, of which 21 were fatal (see *Figure 2*). Of all severe crashes registered in 2005, approximately 2% happened during roadworks. Their proportion (roadwork crashes in relation to the total number of severe crashes increased in the last few years.

However, the annual number of roadworks crashes alone does not give a clear indication of how unsafe roadworks are. The annual number of roadworks and time spent in them also need to be taken into account. Because this is not registered very well, the crash rate at roadworks cannot be determined accurately. Research literature does not show an unambiguous picture of the effect of roadworks on the crash rate (Van Gent, 2007). Most studies report an increase of the crash rate (see for instance ARROWS, 1999; Garber & Zhao, 2002). In Great-Britain, however, Freeman et al. (2004) did not find an increase of the crash rate.

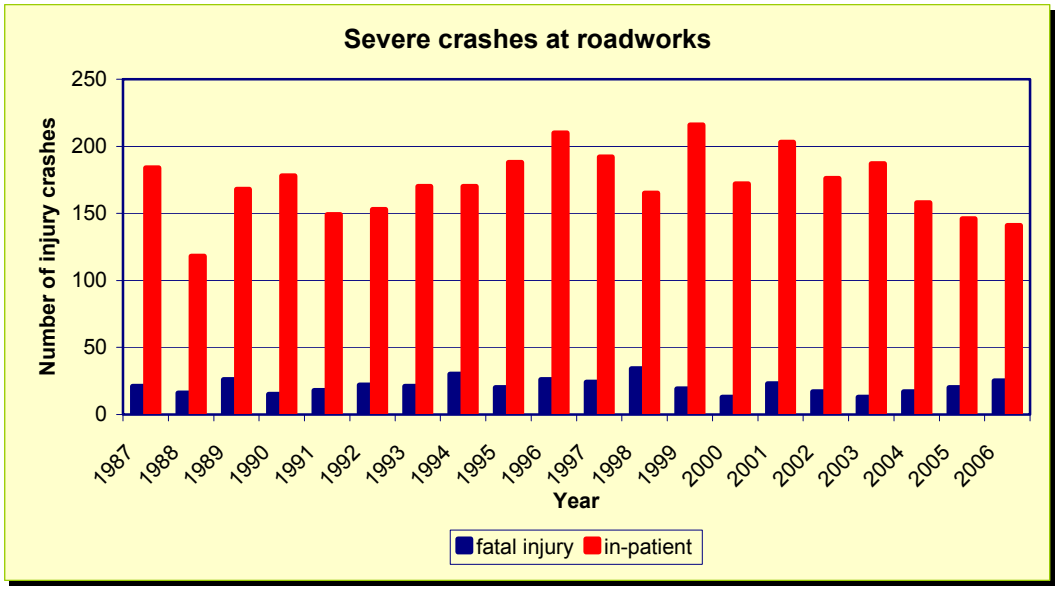

Figure 2. *Numbers of severe crashes at roadworks (crashes with a minimum of one in-patient) in the period 1987-2006 in the Netherlands (source: BRON).*

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 the international literature (Van Gent, 2007) shows that locations where traffic from a side road joins a main road with a work zone are relatively dangerous in urban areas. An analysis of BRON data, however, makes clear that the proportion of roadworks crashes for intersections does not substantially/hardly exceed that for road sections. In rural areas, roadworks crashes often occur in the vicinity of slip roads (ARROWS, 1999). An analysis of 58 reports of Dutch roadworks crashes showed that these crashes mostly happen when the roadworks are carried out on the carriageway (Janssen & Weijermars, to be published). Roadworks that are carried out over a longer period and that cover a longer work zone are found to have a lower crash rate (Van Gent, 2007).

In the period 1987-2006 slightly more than half (54%) of the serious Dutch roadworks crashes happened on rural roads. The proportion of roadworks crashes in relation to the total number of annual crashes is roughly the same on rural and urban roads. Annually, an average of 54 severe crashes occurs at roadworks on state roads. This makes the proportion of roadworks crashes in relation to all severe crashes on state roads significantly higher than on other roads (4.2% in 2005 in relation to 2.0% on provincial roads and 1.5% on lower order roads).

Road workers experience working at night as being dangerous (Swuste & Heijer, 1999). Literature indeed shows that at road works the night hours generally have an increased crash rate (Van Gent, 2007). The *number* of roadworks crashes, however, is higher during the day: more than two thirds of the roadworks crashes happen in the daytime and the proportion of nightly roadworks crashes is barely higher than that of daytime crashes. This is probably due to the fact that roadworks are more frequently carried out during the day, rather than at night.

Serious roadworks crashes relatively often happen in the months June, September, October, and November. The explanation may be that more roadworks are carried out during these four months. More than two thirds of the roadworks crashes happen in dry weather and on a dry road surface. This largely agrees with the general picture of all crashes in the Netherlands and is therefore not specific to roadworks crashes.

Who are involved in roadworks crashes?

In by far the most roadworks crashes only road users are involved. Crashes involving road workers form only a small part of all roadworks crashes (Hagenzieker, 1998). Although the number of casualties among road workers is limited, there are more work hazards for road workers than for industrial workers (Swuste & Heijer, 1999). Venema et al. (2008) also conclude that the risk of a fatal accident is probably higher for road workers than for the building trade in general. It has also been shown that half the road workers always or often feel unsafe during their working hours.

A crash analysis using BRON data shows that freight traffic is relatively often involved in roadworks crashes. Overall, a freight vehicle is involved in 6% of the crashes; this is 14% for roadworks crashes. Other studies confirm this picture (Van Gent, 2007).

What are the causes of roadworks crashes?

The international literature shows that roadworks crashes are relatively often rear-end crashes (Van Gent, 2007). Recent Dutch crash data confirm this: 31% of all rural roadworks crashes are rear-end crashes, in comparison with 15% of all rural crashes. Short headway distances and speeding play an important role in the occurrence of rear-end crashes. In addition, a number of rural crashes involve work vehicles and road blocks (Hagenzieker, 1998; Janssen & Weijermars, to be published). Also in these cases speeding probably is one of the causes.

An extensive literature study of 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 has studied more recent literature (PREVENT, 2003). The most consistent finding is that speeding is common at roadworks. The majority of drivers drive too fast when approaching road works. Drivers often do not reduce their speed until the traffic situation immediately in front of them urges them to do so (just before an abrupt change of circumstances) and consequently brake too hard. Although 'fast' drivers (with a high initial speed) have a relatively larger speed reduction than 'slow' drivers, their end speed still is higher. In addition, changing lanes is left rather late when a lane is closed off (Schuurman, 1991).

In a number of urban crashes, especially slow traffic enters a blocked road and then collides with works traffic, falls, or rides into a ditch (Janssen & Weijermars, to be published). Lack of clarity about the diversion and the lack of distinct marking of the work area seem to contribute to these crashes occurring.

Roadworks activities are not always a factor in the occurrence of roadworks crashes (Hagenzieker, 1998; Janssen & Weijermars, to be published). 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 which happened because a road user ignored 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 increase road safety during roadworks (Van Gent, 2007):

- demarcating the work area for traffic;

- guiding traffic through the work area;
- making the roadworks and the road workers visible for road users;
- simplifying the driving task.

Enclosures by, e.g. traffic cones, and barriers, are used to demarcate the work area. In addition, like markings and vehicle mounted arrow boards, they guide the traffic. Impact attenuators are primarily used for the protection of road workers.

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

Reducing the maximum speed is intended to ease the driving task. In addition it also reduces the risk of a crash and lessens its severity. Supplementary measures like enforcement and dynamic speed information can be used to actually exact compliance. Dynamic speed information is a measure which is used to measure the actual speed of each individual vehicle and communicate it to the driver (feedback). Research has shown that this causes drivers to lower their speed (Geluk et al., 2003). In 2006, the Ministry of Transport started a new trial to reduce speed at roadworks. Road users were given immediate feedback on their speed, and at the same time their vehicle registration number was shown. This direct feedback seemed to have speed reduction as a result (AVV, 2007).

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

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

Conclusions

Every year, an average of 193 serious injury crashes of which 21 are fatal occur at roadworks locations in the Netherlands. In 2005, approximately 2% of all registered Dutch serious crashes happened during roadworks. This proportion has increased in recent years. Based on the international 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.

Most crashes occur during work on the roadway and the work area has the highest risk. Roadworks of a longer duration and covering a longer distance seem to have a lower crash rate. Relatively many roadworks crashes occur on national trunk roads and lorries are relatively frequently involved in roadworks crashes. Furthermore, the literature shows a generally higher crash rate during the night hours.

Especially on rural roads many of the roadworks crashes are rear-end crashes. There are also crashes involving vehicle mounted arrow boards and barriers. Speeding most likely plays a role in this type of crash. A literature study into road user behaviour at roadworks locations shows that speeding is frequent. One of the reasons for urban roadworks crashes is that especially slow traffic enters a road that is closed off. These crashes seem partly due to unclarity about the deviation and the failure to place barriers correctly. It must however be noted that the roadworks themselves cannot always be blamed for the occurrence of roadworks crashes.

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 the uniform preparation, indication and marking of roadworks. It is important that these guidelines are not only followed for large, but also for smaller roadworks. The work area must be indicated and the traffic must be guided clearly and unambiguously, so that the road user is informed about the roadworks in time and knows what he is expected to do. There also must be sufficient space or barriers between road workers and traffic.

Presently, SWOV is carrying out a study of road safety at roadworks on request of the Information and Technology Platform for Infrastructure, Traffic, Transport and Public space, CROW. The study consists of three phases: a literature study, a crash data analysis, and visits to roadworks locations. The first phase has already been concluded and is reported in Van Gent (2007). The second phase is about to be rounded off and will be reported in Janssen & Weijermars (to be published) and the results of the third phase are expected in the course of 2008.

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