

Gernot Sauter, Hugo Bruggeman / Transportation Safety Division, 3M Company

White Paper:

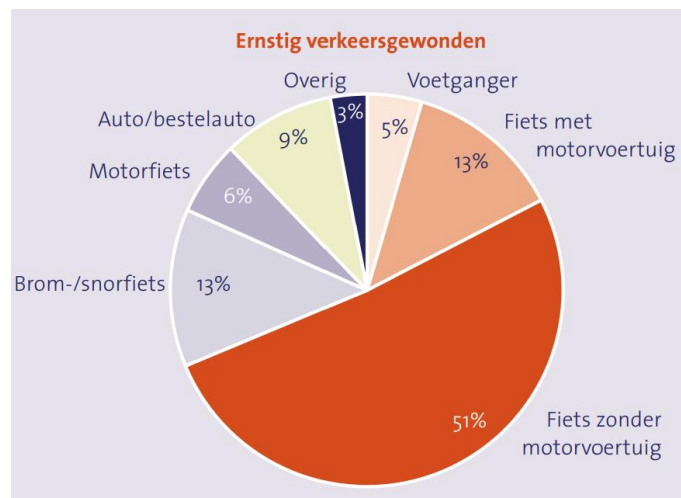
Making Cycling Safer: Cyclists Also Need Pavement Markings

Abstract

A large majority of hospitalized cyclists are victims of *single bicycle crashes*^[5]. Many single bicycle crashes can be related to infrastructure design and cyclists not being able to see curbs, pathway shoulders, and obstacles. Independent studies show that pavement markings may help in making cycling safer^[6,7,8]. Pavement markings allow cyclists to steer around obstacles and stay centered in the bike path or cycle lane while they are using their sharp central vision to look at the road ahead and check on the actions of other road users around them. Agencies in Europe have taken notice and have started to adopt the use of pavement markings into the design guides for their bicycle infrastructure^[8,9].

1 Single Bicycle Crashes are a Leading Cause of Traffic Injuries

While countries promote cycling as a healthy mode of transportation, cycling can lead to serious injury crashes. On roads in the Netherlands, most serious injury crashes that lead to hospitalization involve a bicycle and do not involve a motorized vehicle^[1]. Similar findings have been reported for Sweden^[2] and are consistent with the trend seen across Europe, where injury crashes have increased for biking, while these have decreased for most other transportation modes, including driving and walking^[3].



Source: SWOV rapport R-2019-22

Serious injury crashes on roads in the Netherlands, partitioned by transportation mode. More than half of the serious road injuries (51%) fall among cyclists in accidents without involvement of a motor vehicle^[4]

A systematic review of mostly western countries showed that 60 to 95% of hospitalized cyclists are victims of *single bicycle crashes* ^[5]. These are cyclists who fall or bump into obstacles, without involvement of any other road user. Most common are conditions where the crash of a single cyclist can be related to a lack of maintenance, such as falls due to cyclist losing traction on slippery or uneven pavement surfaces. Other examples are *falls related to infrastructure design*, such as cyclist running into curbs or running off pavement when losing their lane position. This paper discusses crashes related to infrastructure design as these have been linked to visibility issues that can be resolved with pavement markings.

2 Pavement Markings and the Visual Control of Cycling

Cyclists need their sharp central vision to look at the road ahead and to check on the actions of other road users around them. This forces them to allocate much of their steering control to their peripheral vision, which can only detect large structures or structures with high contrast. In a Dutch publication for transportation infrastructure (CROW Fietsberaad) ^[6], den Brinker and Schepers further explain the relevance of high contrast pavement marking for the delineation of bike paths:

When designing the road edge, the very low visual acuity in the periphery of the field of view must be considered. Only large visual structures and structures with a high contrast can be seen in the periphery. The edge of bike path may not be visible unless it is marked with a high contrast marking. The quality of peripheral vision degrades with aging, so for older cyclists the use of high contrast markings is even more important.

To further explain this the authors generated line drawings ^[7] to simulate what cyclists can detect in their “blurred” peripheral vision. The line drawings in this paper are based on den Brinker’s method of applying edge detection in a blurred image. Pavement markings remain a dominant visual structure in these line drawings, consistent with the notion that cyclists can detect these in their peripheral vision.



An example of how pavement markings help cyclists bike safely. The photograph on the left shows a cycle lane approaching a car parked in a designated space. The center image is a blurred version of the same photograph. The line drawing on the right traces the contrast in the blurred image and shows that the large white pavement markings are a dominant visual structure. This helps cyclists steer around the parked car while using their central vision to monitor cars around them and looking at the road further ahead.

3 Safety Study of Single Bicycle Crashes

In a safety study of cycling, Schepers and den Brinker ^[7] studied the sites of single bicycle crashes. They took pictures of 21 crash sites and simulated peripheral vision using the above method of rendering line drawings. This analysis confirmed that the infrastructure at crash sites was not sufficiently visible to guide cyclists safely. That is, falls could be related to cyclists busy checking on other road users and not seeing an obstacle in time or not seeing the edges of their path to maintain their lane position, especially in curves and when paths become narrower.

To make cycling safer Schepers and den Brinker recommended that pavement markings should be applied to the edges of bike paths and cycle lanes. Two-way paths should also include a center skip line (long lines with short breaks) to create separate lanes. In addition, pavement markings should be profiled when obstacles are placed on the path, to help announce these obstacle haptically.



Example of a scene that could be made safer by the application of an additional pavement marking. The photograph on the left shows a bike path formed by large gray pavers and a large obstacle that blocks one third of the cycle track. The line drawing in the center image shows that the white line is the dominant visual structure of the bike path. Other than the obstacle itself, no visual structures are visible to help guide cyclists around the obstacle. This situation may be improved by adding a pavement marking that curves around the obstacle. The line drawing on the right show the impact of the additional marking in helping cyclists steer safely around the nearby obstacle while using their central vision to check on the second obstacle further down the path or on the actions of other users on the path.

4 Specification for Pavement Markings on Bike Paths and Cycle Lanes

Specifications for pavement marking typically follow the national regulation. The European Norm EN 1436 'Road marking materials – Road marking performance for road users and test methods' describes the relevant test methods and the performance levels for the visibility characteristics of pavement marking in dry, wet and rainy condition. Type II road markings have special properties intended to enhance the retroreflection in wet or rainy conditions. National regulations apply the performance classes for their territory.

In the Netherlands, the national manual for the uniform design of pavement markings includes a separate chapter on cycling infrastructure. Since 2015, the use of pavement markings is standardized for bicycle paths and cycle lanes ^[8], with high priority for lanes that curve or become narrower, as well as unlit bike paths or paths in wooded areas

A German guideline for high-speed bike paths ^[9], published by the ministry of transport of the federal state of North Rhine-Westfalia, also has specific rules for the design and performance of pavement markings. A distinction is made between the use of white high contrast markings for delineating edge and skip lines and a green line to mark the path as a cycle highway. Per traffic code, the white markings are 12 cm wide and both white and green markings must provide skid resistance in wet conditions. White markings must be retroreflective and of 'Type II' performance according to EN 1436.



Application of pavement markings on a high-speed bike path or cycle highway ('Radschnellweg' RS1). The photograph on the left shows a section of this path with white edge lines and skip lines. The green line indicates the status of the path as 'Radschnellweg'. The line drawing on the right identifies the white edge lines and center skip lines as the dominant visual structures on the bike path to support safe cycling.

5 About 3M

3M Transportation Safety Division is dedicated to improving transportation infrastructure and mobility so that road users can arrive at their destinations more safely. Our high-performance materials help you bring the best roadway systems into reality. For over 80 years, we have shared in your mission to make our roadways safer.

3M's retroreflective technology has raised the bar on visibility and durability in road pavement markings for the modern world. As we continuously improve our products, we will evolve with changing modern technology to help keep roads safe, day or night, wet or dry. Our easy-to-apply pavement markings can help you efficiently and effectively improve traffic safety in urban areas for drivers, pedestrians, cyclists, and all. High performance pavement markings provide urban road users the visual guidance they need in a wider range of conditions — day or night, rain, or shine.



References:

- 1.) Weijermars, Bos, and Stipdonk, 2016. Serious road injuries in The Netherlands dissected. *Traffic Injury Prevention*, 17:1, 73-79, DOI: 10.1080/15389588.2015.1042577
- 2.) Werneke J, Dozza M, 2014. Integrating Road Safety Data for Single-Bicycle Crash Causation, IRCOBI Conference 2014, IRC-14-52
- 3.) D. Adminaité-Fodor, and G. Jost, 2020. How Safe Is Walking and Cycling in Europe? PIN Flash Report 38, European Transport Safety Council (ETSC), Brussels, Belgium (2020)
- 4.) Weijermars (2019). Monitor Verkeersveiligheid, SWOV rapport R-2019-22, Den Haag
- 5.) Schepers P, Agerholm N, Amoros E, et al., 2015. An international review of the frequency of single-bicycle crashes (SBCs) and their relation to bicycle modal share. *Injury Prevention*, 21: e138–e143.
- 6.) den Brinker and Schepers, 2018. Bouwstenen voor een comfortabel en vergevingsgezind fietspad, CROW Fietsberaad.
- 7.) Schepers and den Brinker, 2011. What do cyclists need to see to avoid single-bicycle crashes? *Ergonomics*, 54(4), 315-327.
- 8.) Richtlijnen voor de bebakening en markering van wegen 2015, CROW publicatie 207, <http://www.crow.nl/207>
- 9.) Radschnellverbindungen in NRW, Leitfaden für Planung, Bau und Betrieb, 2019. Ministerium für Verkehr des Landes Nordrhein-Westfalen, www.radschnellwege.nrw