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Road safety effects of porous asphalt: a systematic review of evaluation studies

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Abstract

This paper presents a systematic review of studies that have evaluated the effects on road safety of porous asphalt. Porous asphalt is widely used on motorways in Europe, mainly in order to reduce traffic noise and increase road capacity. A meta-analysis was made of six studies, containing a total of eighteen estimates of the effect of porous asphalt on accident rates. No clear effect on road safety of porous asphalt was found. All summary estimates of effect indicated very small changes in accident rates and very few were statistically significant at conventional levels. Studies that have evaluated the effects of porous asphalt on nine different risk factors associated with accident occurrence were also reviewed. It was found that four of the risk factors were favourably influenced by porous asphalt, three were adversely influenced, and two were not influenced by porous asphalt. The net impact of these changes in risk factors on accident occurrence cannot be predicted. On the whole, the research that has been reported so far regarding road safety effects of porous asphalt is inconclusive. The studies are not of high quality and the findings are inconsistent.

Keywords: Road safety; Evaluation study; Porous asphalt; Meta-analysis; Risk factors

1. Introduction

Porous asphalt is used in many European countries, mainly in order to reduce traffic noise and increase road capacity. Porous asphalt differs from ordinary dense asphalt concrete by having an open structure with approximately 20–25% air filled pores. The open structure of porous asphalt reduces traffic noise, drains water from the road surface and reduces thermal conductivity.

As part of a European research project (SILVIA = Silenda Via = Sustainable Road Surfaces for Traffic Noise Control), a systematic review has been made of studies that have evaluated the effects of porous asphalt on road safety. The objective of this paper is to present the results of that systematic review. The main questions that were asked in the review were:

1. What are the effects on road safety of porous road surfaces?
2. Do the effects on road safety of porous road surfaces vary according to accident severity and road surface condition?
3. Do the effects on road safety of porous road surfaces vary across countries?
4. How long do the effects on road safety of porous road surfaces last?

In order to answer these questions, studies that have evaluated the effects of porous asphalt on accident occurrence and on risk factors associated with accident occurrence have been reviewed (Elvik and Greibe, 2003).

2. Systematic review of evaluation studies

2.1. Study retrieval

A search was made for relevant studies in the TRANSPORT literature database using the combination of "road safety" and "road surfaces" as search terms. This literature database contains all references found in TRIS, IRRD

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and TRANSDOC. In addition, a previous literature review (Greibe, 2000) was used as a source. A total of 16 studies that have evaluated effects on accidents of road surface treatments, and that have been published after 1990, were retrieved. Porous asphalt was not widely used before 1990. Four main types of road surface treatments have been evaluated in these studies:

1. Ordinary resurfacing of roads.
2. Laying of high friction road surfaces.
3. Treatment of rutting or unevenness.
4. Laying of porous asphalt.

In this review, only studies that stated explicitly that porous asphalt had been laid were included. A supplementary search for studies was made within the research team carrying out the SILVIA-project. In total, six studies that have evaluated the effects of porous asphalt on accidents were identified.

Based on the previous review (Greibe, 2000), we were concerned that the evidence on the safety effects of porous asphalt provided by just six studies could be inconclusive. It was therefore decided to review studies that have evaluated the effects of porous asphalt on risk factors associated with accident occurrence, in addition to the studies that have evaluated effects on accidents. A total of 13 studies that have evaluated the effects of porous asphalt on risk factors were found, by searching the TRANSPORT literature database and partners in the SILVIA research team.

2.2. Assessing study quality

An attempt was made to formally assess the quality of studies that have evaluated the effects of porous asphalt on accidents. The assessment of study quality was based on the following criteria:

1. The specification of the road surface conditions to which estimates of effect apply.
2. The specification of the severity of accidents to which estimates of effect apply.
3. The extent to which a study controls for confounding factors that may influence estimates of the effects of porous asphalt.
4. Whether a study used appropriate statistical techniques to analyse data.

The effects of porous asphalt may depend on road surface condition. By draining water from the road surface, porous asphalt reduces splash and spray, thus improving visibility when driving on a wet road surface. On the other hand, reduced thermal conductivity may lead to lower skid resistance in winter. Hence, a good study should specify the effects of porous asphalt according to road surface condition, preferably by stating effects for: (a) A dry road surface, (b) A wet road surface, and (c) A road surface fully or partly covered by snow or ice.

The costs to society of road accidents, and the suffering they bring to victims, depend strongly on accident severity. It is therefore important to know if the effects of porous asphalt vary according to accident severity. Ideally speaking, an evaluation study ought to specify effects for: (a) Fatal accidents, (b) Accidents involving serious injury, (c) Accidents involving slight injury, and (d) Accidents leading to property-damage-only.

Road accidents are usually the outcome of a highly complex interaction of a large number of risk factors. In an evaluation study, we would ideally want to estimate the effects of a road safety measure only, and not of all the other factors affecting the number of accidents. The factors whose effects we want to control for (i.e. remove) are usually referred to as confounding factors (Elvik, 2002). The most practical way to assess the quality of a study with respect to control for confounding factors is to list the most important confounding factors and to check for each of them whether or not the study controlled for that factor.

In before-and-after studies, the most important potentially confounding factors include: (a) *Regression-to-the-mean*, which means that if sites have been selected for treatment because of an abnormally high number of accidents, one may expect the number of accidents to go down even if the treatment has no effect, (b) *Long-term trends* in the number of accidents, which refers to a tendency, observed during several years, for the number of accidents to increase or go down, (c) *Site-specific changes in traffic volume*, departing from the overall trend for the region or the country as a whole (the overall trend of all factors influencing accidents, including traffic volume, are assumed to be captured by a comparison group), (d) *Other specific events*, such as the introduction of other road safety measures whose effects can be mixed up with the road safety measure that is of primary interest in a study.

In case-control studies or other studies employing a cross-section design, it is rather more difficult to list the most important confounding factors than for before-and-after studies. Very many more confounding factors can threaten the results of a case-control study than of a before-and-after study. In case-control or cross-section studies, effects are usually estimated in terms of the accident rate ratio, rather than the number of accidents, which is the most common denominator for safety effects in before-and-after studies. Hence, the potentially confounding factors are all factors that can influence accident rates. These factors can be divided into three main categories: (A) *Total traffic volume*: Accident rates are not independent of traffic volume. Ideally speaking, therefore, mean traffic volume ought to be identical on case road sections and control road sections. (B) *Traffic composition*, which refers to how traffic is made up of small cars, large cars, motorcycles, pedestrians, and so on. Different mixes of types of vehicles and groups of road users tend to produce different accident rates. (C) *Road design and traffic control parameters*. These include type of road (motorway, non-motorway), number of lanes, speed limit, access control, alignment and a number of other factors, which have been found to be statistically associated with accident rates.