Overview of Current Practices on Porous Asphalt on Highway Application

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ABSTRACT

This paper presents an overview of current practice on porous asphalt on highway application. The main reason for considering the application of this particular type of road surfacing is the drainage characteristics of the surface layer. The drainage is made possible by the large percentage of voids up to 20% and that are interconnected, allowing water and air to flow towards the road shoulder. The use of porous asphalt offers a number of advantages such as reducing aquaplaning potential, improving skid resistance at high speed, reducing glare particularly on wet roads and an overall improvement in traffic safety. On the other hand, the disadvantages of porous asphalt compared to traditional road surfacings include short design life, high cost in terms of construction, maintenance and repair. However, porous asphalt has been applied in increasing quantities in European countries such as the Netherlands, France, Italy and Germany.

Keywords : *Highway, porous asphalt, road surfacings*

Introduction

The first porous asphalt application on roads took place in the 1960's (Reichert & Bonnot, 1993). However, after about ten years, the use of porous asphalt has grown rapidly in some countries where the material is used for a large part in road surface maintenance works on highly trafficked roads. Some countries even impose the use of porous asphalt on motorways beyond a certain level of traffic.

Global Application

Historically, porous asphalt was developed to mitigate road accidents but now the prime mover, especially in Europe, on the grounds of traffic noise reduction. The United States of America has some of the earliest initial experience with open mixes. Open-graded friction course (OGFC) has been used since 1950 in different parts of the United States to improve the surface frictional resistance of asphalt pavements (Mallick et. al., 2000). OGFC improves wet weather driving conditions by allowing the water to drain through its porous structure away from the roadway.

The Federal Highway Administration (FHWA) developed a mixed design procedure for OGFC in 1974, which was used by several state departments of transportation. While many DOTs reported good performance, many other states stopped using OGFC due to its unacceptable performance and lack of adequate durability (Smith, 1992). However, significant improvements have been made during the last few years in the gradation and binder type used in the OGFC. Kandhall (1998) from the National Center for Asphalt Technology conducted a survey on the experience of states with OGFC. Although experience of states with OGFC has been varied, half of the states surveyed in this study indicated good experience with OGFC.

In early November 1991, one of the first commercial porous asphalt contracts in the United Kingdom took place in Dorset on a stretch of the A351 Wareham Bypass (Shell Bitumen, 1992). Hampshire County Council had two trial sites on the A31. One short length between Winchester and Airesford and a longer section laid in 1995 on the Bently by-pass (Rushmoor, 1998). Following the use of this material on the centre section of the A331 Blackwater Valley Relief Road by Surrey County Council, excellent noise reduction qualities and markedly less spray in wet weather compared to conventional surfacing were noted.

In the Netherlands, the first application of porous asphalt took place in 1972. The significant potential of this material for improving road safety, coupled with the favourable experience gained during the trials, led to the establishment of a second working party to assess the possibilities for porous asphalt in more detail (Van Der Zwan et al., 1990). Despite the fact that most of the earliest porous asphalt surfacing installed is in the United States and United Kingdom, in Netherlands, all national roads will be surfaced with porous asphalt by the year 2010 (Voskuilen et al., 2004).

State-of-the-art

In the Netherlands, the policy since the end of the 1980s is to apply porous asphalt as a wearing course material on motorways especially to reduce traffic noise, splash and spray. Voskuilen et al. (2004) noted that 60% of the Dutch motorways have incorporated a porous asphalt wearing course and their policy is to approach 100% by 2010. In 2001, the statistics of porous asphalt application in various European countries is shown in Table 1.

Table 1: The Statistics of Porous Asphalt Laid in European Countries (EAPA, 2001)

Countries	Area of Porous Asphalt Laid
Netherlands	48 million sqm
France	43 million sqm
Italy	13 million sqm
Germany	2.5 million sqm

In efforts to reduce traffic accidents, porous asphalts were tried in Malaysia. Several porous pavements were constructed more than a decade ago on expressways and federal roads in accordance with European specifications. However, pores were clogged shortly after in service and ponding water took place. Then, it was decided to carry out a pilot study using the Japanese technology developed under temperate climate. This technology has been successfully modified and applied under Malaysia's tropical monsoon climate (IDI-Japan, 2003).

In Malaysia, porous asphalt was first applied about 14 years ago and took place along Jalan Cheras-Beranang. In 1996, there were 16 locations along the Federal Routes that had been resurfaced with porous asphalt and another 25 locations in 1997 had been identified for implementation. These efforts are to ensure rainwater do not form puddles on road surface and guarantee improved riding comfort to road users (HPU, 1998). Other sites where porous asphalt have been applied include Jalan Tebrau in Johor Bharu, the Federal Highway, the Kerinchi Link and numerous patchy applications along the North-South Highway.

Advantages of Porous Asphalt

According to Lefebvre, (1993), porous asphalt offers a number of advantages which is explained as follows:

Reduce aquaplaning potential

One of the major hazards when driving in the rain is aquaplaning. A layer of water builds up between the tyre and the road, breaking the contact between the two. The tyre will float on the water, coefficient of skid resistance is almost non-existent and consequently it is quite impossible to steer and brake. Severity of aquaplaning depends primarily on the amount of rain and the drainage capacity of the road, apart from the driving speed and to a certain extent the tyre profile. On porous asphalt, even when the passages are cluttered with debris and dirt, aquaplaning does not occur at normal speeds. For this reason, porous asphalt was first introduced on airfield runways.

Improved skid resistance at high speed

Even when no aquaplaning takes place, rain may reduce the skid resistance of road surfaces considerably. Porous asphalt may counteract this effect, even when the surface stays humid. This implies that the effect of the microtexture, that contributes to a considerable degree to the skid resistance on dry roads, will be reduced. The skid resistance of a wet porous asphalt at high speeds will be higher than that of a wet traditional asphalt, but not equal to that of a dry road.

Reduction of splash and spray

Rolling wheels throw up water from pools on the surface (splash) additionally, they will mist the surface water (spray). Physically speaking, the two phenomena are quite different but in practice they can be discussed together, particularly since they usually occur together. The water droplets reduce the visibility in the atmosphere in the same way as rain and fog. The reduction in visibility is usually much more severe than in real fog.

Light reflection

While at the wheel, motorists must observe the road ahead at all times. At normal driving speed, the road must be viewed from a considerable distance ahead of the vehicle. As the driver's eye height in car is about 1.2 m above the road surface, the road is observed under a glancing angle of 1 degree or less. When viewed under such angles, most surfaces reflect the incident light very strongly. On the other hand, when the surface is smooth, it usually looks like a mirror. This is notably the case when water is present on road surfaces. With porous asphalt, even when pavement surface is wet, a predominantly diffuse reflection and even when observed under a glancing angle. The diffuse reflection is important both during daylight and in darkness. Furthermore, all surface characteristics of the road disappear under the reflected light, particularly road markings tend to be invisible. Porous asphalt reduces the amount of water on the road and the situation can be improved even further by applying profiled road markings (corrugated lines or retroreflecting road studs). Finally, a diffuse reflecting road surface enhances the economy of road lighting installations by ensuring a higher road surface luminosity and a better uniformity.

Noise Reduction

On the average, the noise level resulting from porous asphalt is about 3 dB(A) lower than on traditional asphalt. There are reasons to believe that the noise reduction goes down as the surface gets older, probably due to clogging of the voids.

Stability of the Construction

Despite its high voids and a relatively high binder content, porous asphalt displays a high resistance to permanent deformation. Porous asphalt is often considered as an "anti-rut course".

Disadvantages of Porous Asphalt

The disadvantages of porous asphalt over traditional asphalt are summarised below by Lefebvre (1993):

Construction costs

It is difficult to give a general indication on the differences in construction costs between porous asphalt and traditional asphalt. It is generally assumed that porous asphalt is more expensive to build than traditional asphalt due to the requirements for using high quality aggregates, modified binder, modified tack coat and more stringent construction quality control. However, as road authorities, designers and contractors gain more experience in applying porous asphalt, this extra cost factor may decrease. Furthermore, the seemingly high cost of aggregates may vary from one country to another. On the other hands, porous asphalt requires more aggregate with high Polished Stone Value than a surface treatment, as it is used throughout the mixture and not only in the rolled-in top layer but the mean value of PSV might be lower. Finally, for reasons that are equally obvious, the comparison depends on the reference surface. Another factor that may influence the construction costs of porous asphalt is the need to adapt the road markings. Since part of the road marking material is drained away, more material is needed. On the other hand, as a result of the greater macrotexture, road markings may have a longer practical life, even if the top of the markings is worn off rapidly. There is a suggestion that ordinary painted road marking on porous asphalt is almost as good as thermoplastic markings on traditional asphalt. Summarising, in general, the construction of porous asphalt seems to be more expensive than that of traditional asphalt. There are, however important exceptions to this rule. Furthermore, it is not clear how large the difference may be, nor whether this is a permanent state of affairs.

Design life

Another cost increasing aspect is the shorter design life of porous asphalt as compared to traditional asphalt. In the Netherlands, it is often stated as a rule of thumb that porous asphalt must be reconstructed after about nine years, whereas the conventional coarse dense asphalt concrete may have a life of about twelve years. Obviously, this depends to a considerable extent on the types of roads and their traffic environment. This relates to the construction life of the surface, its limit being reached when cracks and rutting are so severe that a complete reconstruction is necessary. For other functions, particularly for the reduction of splash and spray as well as noise reduction, a considerably shorter life is sometimes quoted (from 60 to 70%) as the drainage passages tend to silt up. On the other hand, as a result of the type of construction, rutting is not common in porous asphalt, contrary to traditional asphalt. In this respect, the life is longer. It seems that a harder aggregate and also a better thermal insulating property that result from the drainage passages are advantageous. Thus, it is not possible to speak of "the" life of a porous asphalt surface, as may be done for a conventional dense mix. It is, therefore, difficult to include the life duration in cost assessments.

Maintenance and Repair

Another factor that may result in cost differences between porous asphalt and conventional mixes is the more expensive maintenance of the former. Repair is often more expensive because it is necessary to approach the original mixture more precisely in order not to loose the drainage properties. Furthermore, repair patches show more clearly than on traditional asphalt. This might lead in the long run to an earlier resurfacing.

Conclusion

The application of porous asphalt was originally designed to improve traffic safety when used as a pavement surfacing material. It is normally used as material for the wearing course to prevent ponding water thereby reduce splash and spray, minimize aquaplaning potential, diminish headlight glare in wet weather and improve the skid resistance. The major disadvantage of using this material is the relatively short service life particularly on heavily trafficked sites. However, porous asphalt has been applied in increasing quantities in European countries such as the Netherlands, France, Italy and Germany.

References

IDI Japan. (2003). Infrastructure development institute. *Japanese Infrastructure Newsletter*, No.27

Lefebvre G. (1993). Porous asphalt. *Technical Committee on Flexible Roads and on Surface Characteristics*. PIARC.

Mallick, R. B., Kandhal, P. S., Cooley, L.A. Jr. & Watson D.E. (2000). Design construction and performance of new generation open-graded friction courses. *NCAT Report No.2000-1*.

Highway Planning Unit, Ministry of Works, Malaysia. (1998). *Road Traffic Volume Malaysia.*

Shell Bitumen. (1992). *Shell Bitumen Review 66.* Bitumen/Polymer-Special Edition

Van der Zwan, J. T. V., Goeman, T., Gruis, H. J. A. J., Swart, J.H. & Oldenburger, R. H. (1990). Porous Asphalt Wearing Courses in the Netherlands: State of the Art. *Transportation Research Record 1265.* pp. 95-110.

Voskuilen, J. L. M., Tolman, F. & Rutten, E. (2004). *Do modified porous asphalt mixtures have a longer service life?*. 3rd Eurasphalt & Eurobitume Congress Vienna. pp. 1261-1271.

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