OPTIMIZATION OF THIN ASPHALT LAYERS

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ABSTRACT

A European pooled fund study, through the ERA-NET ROAD-project, has initiated a transnational research project titled "Optimization of thin asphalt layers". A DRI-BRRC-VTI Consortium was trusted with carrying out the project and began with a State-of-the-Art report covering, among other things, a literature study and an inventory of experience with using thin asphalt layers (TAL). The results of this phase of the project are given in this paper.

The main conclusions are that the application of TAL is certainly worthwhile, in particular as a renewable "skin" of a stable road construction having sufficient bearing capacity. The skin serves road users' need for sufficient skidding resistance and other important functions. The use of TAL seems to be increasing due to the needs of road administrations for cost-effective maintenance of the road infrastructure which, in many ways, are consistent with the needs for lower traffic noise levels in residential areas near major roads, which may be one of the positive effects when a TAL is applied.

The environmental impact of road transport CO_2 emission is currently widely discussed. Road surface characteristics are one of the parameters that influence rolling resistance and hence energy consumption and CO_2 emission. TAL offer relatively low rolling resistance because of their favourable surface texture. Therefore they may have a positive impact on the reduction of CO_2 emission.

The report attempts to evaluate the various properties of TAL, comparing with more conventional and traditional surfacings such as dense asphalt concrete 0/11 or SMA 0/11. TAL in general comes out somewhat better than the references in most respects; for example concerning cost, use of nature resources, rolling resistance, and traffic noise emission. However, there are also problems, for example concerning durability under severe traffic, and bearing capacity (very little extra capacity provided by TAL). If studded tyres are used the wear of TAL is usually significantly worse than the wear of thicker pavements with larger chippings.

There are several special types of TAL; not the least a huge variety of commercial products offered on the market; so-called proprietary TAL. A special type of thin layer is the asphalt rubber surfaces, presently under trials in Sweden for adaptation to north European climate and conditions. In USA, some of these layers are paved as thin as half an inch (approximately 12 mm) and yet they provide very good performance.

1. STATE-OF-THE-ART ON THE USE OF AND EXPERIENCE WITH THIN ASPHALT LAYERS: INTRODUCTION

In the first part of this project, a State-of-the-Art report on thin asphalt layers (TAL) was drafted, covering, among other things, a literature study and an inventory of European experience with using TAL. This was later updated in the second part of the project [Sandberg et al, 2010]. This paper summarizes the State-of-the-Art (SoA) report.

2. PRESENT USE OF THIN ASPHALT LAYERS

Policies on applying TAL vary substantially from country to country. For example TAL represents 95 % or so of all new Danish hot mix surface courses, while in Belgium this percentage is much lower and differs between regions. Also in Sweden, there is a substantial difference in the use of TAL between regions; not necessarily correlated with climatic conditions.

The use of TAL in Europe seems to increase, although available statistics make it difficult to distinguish TAL from other hot mix asphalt surface layers. In many countries, there is no statistics regarding TAL use in urban areas; only for the national or regional highways. The EAPA collects information on the production of each type of asphalt classified according to the EN 13108 series of product standards. Data are expressed as a percentage of the total amount of surface courses, and no data are available concerning their nominal layer thickness. In Figure 1 TAL usage statistics are shown for some countries within ERA-NET ROAD. The data shown in the figure have been collected from questionnaires and interviews with experts. Note that according to the interviewed Italian expert, there are no TAL at all in Italy.

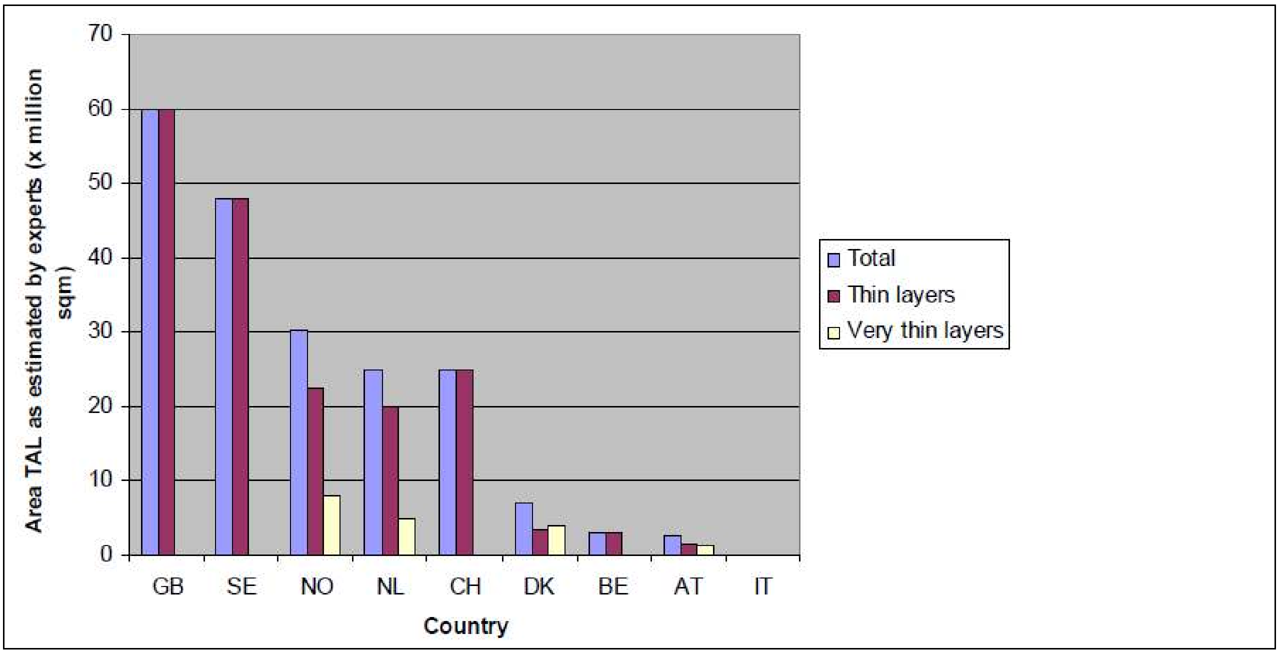

Figure 1. Area in millions of square metres of thin and very thin asphalt layers in some countries. Not all roads in the countries concerned are included in these estimates, so the estimated areas must be considered minimum values.

Figure 2 shows the percentage of the main road network (highways and motorways) covered with TAL for some countries.

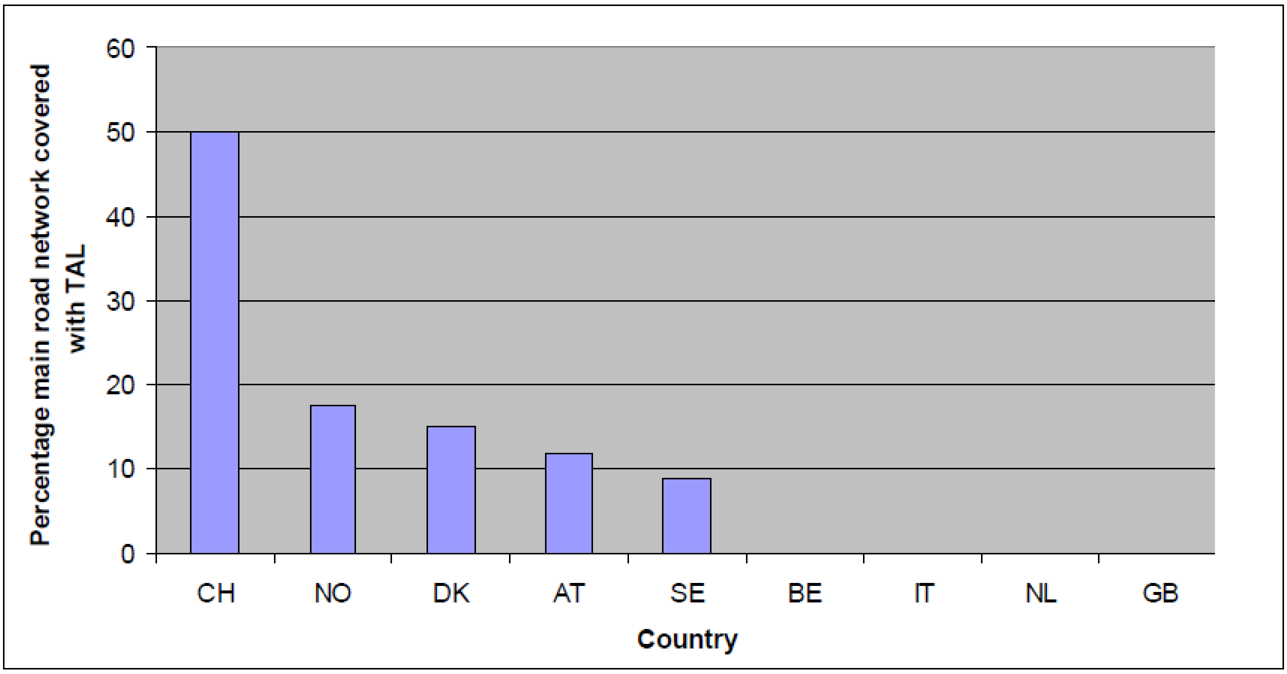

Figure 2. Percentage of the main road network covered with TAL; estimates based on interviewed experts. No data are available for GB. Please use the figure with caution as the underlying statistics may contain inconsistent and arguable classification of TAL.

3. QUESTIONNAIRE AND INTERVIEWS

The project group sent out a questionnaire to a number of experts and received rather limited response. A subsequent round of interviews was slightly more successful. Respondents often mentioned noise reduction as their primary motivation for applying TAL. Cost reduction and fast paving operations also seem to be important motivation, like good resistance of TAL to skidding and rutting. A few respondents mentioned durability problems as a disadvantage.

4. PROPERTIES PROMOTING THE USE OF THIN ASPHALT LAYERS

The use of TAL seems to be increasing due to the needs of road administrations for cost-effective maintenance of the road infrastructure which, in many ways, coincides with the need for lower traffic noise levels in residential areas near major roads. See an example in Figure 3. This may be one of the positive effects when a TAL is applied.

The environmental impact of road transport CO_2 emission is currently widely discussed. Road surface characteristics are one of the parameters that influence rolling resistance and hence energy consumption and CO_2 emission. TAL may offer relatively low rolling resistance because of their favourable surface texture, provided relatively small aggregates are used and that high quality paving work ensures an even surface. In such cases, TAL will normally have either a neutral or a positive reducing impact on CO_2 emission; depending on aggregate sizes and construction, and depending on which thicker surfaces that are used as references. This needs further research. Furthermore, since TAL only requires a thin skin of material, superior materials can be used in smaller quantity, thus reducing CO_2 emission associated with the extraction, manufacturing and transport of these materials.

Figure 3. Example of a surface of a proprietary thin asphalt layer called "Microflex" paved on Kasteelenlaan in the Dutch city of Ede; four years old here; aggregate size 2-6 mm. Paved primarily due to its noise-reducing capability. Note that chippings have a flat surface facing upwards.

In the "perpetual pavement" concept, the philosophy is that the pavement base has eternal bearing capacity and is paved with a thin long-lasting "skin" of surface layer which eventually – due to moisture damage, wear from traffic, ageing and other climatic action – must be renewed from time to time.

The TAL as a "skin" provides favourable functionalities such as noise reduction potential, relatively low rolling resistance, some anti-spray properties and efficient light reflection. This has accelerated the use of general product categories and proprietary products addressing these demands, also implying relatively high sustainability and low construction as well as maintenance costs. The fast laying of TAL implies shorter closure to traffic and this favours the use of TAL. Provided the pavement base is of appropriate quality, TAL offer solutions for many of the functionalities mentioned above and this is probably why there is immense interest in products of this nature.

The full SoA report gives general advice and a few examples of published life cycle costs (LCC) compared with the cost of thicker overlays; which are generally favourable for TAL. Nevertheless, this topic needs further investigation, since the LCC of TAL cannot be assessed with any accuracy until TAL lifetime and performance over time has been documented.

5. PROPERTIES LIMITING THE USE OF THIN ASPHALT LAYERS

Despite the favourable properties mentioned above, one shall not forget problems and limitations associated with TAL. For example, their contribution to bearing capacity is marginal in many cases. To obtain resistance to wear from studded tyres, large maximum aggregate sizes are required. Open-textured or even porous kinds of TAL may offer very good noise properties, but at the expense of limited durability under heavy traffic load; for example in sharp curves or at steep gradients. Their air voids will also quickly get clogged by dirt.

Another problem worth mentioning is that it may be difficult with the techniques at hand to dismantle TAL by cold milling without downgrading the material. Such milling yields additional fines, which strongly hamper their reuse in a new TAL mix, since margins for the grading curve are narrow. Nevertheless, TAL recycling remains feasible in other asphalt mixes used as binder or base course. Warm milling (about 100 °C at milling depth) as utilized in repaving and remixing, could possibly overcome the downgrading observed during cold milling, although the feasibility of such warm milling has yet to be demonstrated in practice.

Mostly, TAL were found to have good skid resistance properties, although exceptions were reported. Very little information, however, was found on the durability of skid resistance and noise reduction. Consequently, there is a need to study time series in the future.

The sensitivity of TAL to weather conditions during paving has been mentioned as a major disadvantage. Road administrations and contractors are often forced – due to numerous factors - to apply TAL during cold weather and then the durability may be reduced. Perhaps this can be counteracted by optimizing the laying process.

6. ASPHALT RUBBER PAVEMENTS: RELATIVELY THIN LAYERS WITH PROMISING PERFORMANCE

The report also discusses the concept of using Asphalt Rubber (AR) pavements as thin layers in the various pavement systems. In a broad context, a multitude of benefits of using AR as part of a pavement preservation strategy were listed, including less reflective cracking in combination with SAMI, reduced maintenance, excellent durability, less ravelling, good rut resistance, good skid resistance and smooth ride, better drainage facilities, reduced tyre/road noise, cost effectiveness, beneficial engineering use for old tyres, and higher energy efficiency. One version of AR is applied as a very thin layer. However, it must be noted that these are the merits of AR typical for some deteriorated pavement conditions in the USA. In Europe, so far, there has been a limited production so far with thin AR.

Three years operation of asphalt rubber pavements on Swedish motorways, highways and some urban arterials have indicated from satisfactory/similar to very good performance, in comparison to conventional pavements (which are usually SMA). Please refer to results and presentations at www.gummiasfalt.se. With regard to noise properties, distinction shall be made between gap-graded and open-graded versions. Only the open-graded version offers any advantage to the reference SMA pavements; an advantage that may be marginally better than that of conventional porous asphalt concrete pavement. Three years is a short service time even in Sweden, so further monitoring, research and practical applications, including further research on the cost effectiveness of AR and its alternatives, will determine whether the AR concept will be a success in Sweden.

7. WINTER CLIMATE CONCERNS

The Nordic countries are highly interested in the effect on TAL of the exposure to traffic with vehicles using studded tyres. The present review concludes that aggregate quality and the proportion of large aggregate are the main parameters determining wear resistance of dense- and gap-graded asphalt concrete wearing courses.

TAL as defined in this project with layer thickness 10 – 30 mm have approximately 11 mm nominal maximum aggregate size (NMAS) or smaller. When winter conditions call for extensive use of studded tyres and snow chains, TAL may not be an optimum surface layer: “The larger the aggregate the better" is an appropriate advice from a pavement durability point of view.

8. PRODUCT STANDARDS, CLASSIFICATION AND APPROVAL

TAL must be CE-marked in order to be marketed as complying with an EN 13108 series product standard. These standards specify asphalt mixes; rather than their final application on the road. The ETAG 16 guideline on ultra thin layers intends to deal with the entire process, including paving operations and final application. Products complying with this guideline will probably pave an additional route for future CE marking. The impact of CE marking on the market still has to be seen in the daily practise of procuring asphalt materials, because CE marking has not yet been fully implemented.

At present, classification of pavement acoustic characteristics is limited to declaring product properties in Denmark, the Netherlands and the UK. CEN work on this is at an initial stage. No system exists for checking pavement product conformity of production concerning its noise characteristics.

9. MAIN ADVANTAGES AND DISADVANTAGES OF TAL

The most important advantages of TAL compared with standard dense asphalt concrete 0/11 or SMA 0/16 were found to be:

- Potential for noise reduction
- Lower cost
- Less required working space (height under bridges and need for curb adjustments).

Other advantages include, for example, higher skid resistance at low and medium speeds, improved sustainability in most respects, better rut resistance, and faster laying.

The most important disadvantages were found to be:

- Weather conditions while laying TAL are more critical
- Dismantling by milling implies downgrading the material
- Susceptible to cracking related to substrate deficiencies.

Other disadvantages include, for example, susceptibility to ravelling, delamination and frost damage; manual laying is not possible; shorter lifetime, and rather low skid resistance in wet weather for some TAL variants. A couple of major problems that may occur are illustrated in Figure 4. These may occur also for thicker pavements, although the relative frequency may be higher for TAL.

Figure 4. Two of the most common problems with TAL: ravelling (left) and delamination (right). Photo courtesy of Ian Walsh, Jacobs Engineering (UK) Ltd.

10. MAIN CONCLUSIONS FROM THE STATE-OF-THE-ART REPORT

The SoA report indicates that actual achievement of both excellent functional properties and good durability (lifetime) is nothing which comes easily. In practice, it is often difficult to realise both requirements simultaneously, since they are frequently in conflict with each other. The information made available through the SoA report should, therefore, serve as a basic guideline for achieving the best compromise between the goals. Learning from laboratory performance tests together with experience in the field will provide useful input. These practical tasks are addressed in the subsequent final project report.

Application of TAL is certainly worthwhile on many major types of roads and streets, in particular as a renewable “skin” on a stable road construction having sufficient bearing capacity. The skin satisfies both the road users’ need for sufficient skid resistance and energy efficiency, and the roadside residents’ needs for a quiet and clean environment; as well as most other important functions expected from a high quality road surfacing.

REFERENCES

1. Sandberg U, Kragh J, Goubert L, Bendtsen H, Bergiers A, Biligiri A P, Karlsson R, Nielsen E, Olesen E, Vansteenkiste S (2010). Optimization of Thin Asphalt Layers – State-of-the-Art Review. Check "Publications" at http://www.vti.se/default 2782.aspx for downloading this document or http://www.vejdirektoratet.dk/dokument.asp?page=document&objno=59234