New Road Pavement Technologies – Examples of Applications in Poland

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The paper presents the applications of new road pavement technologies in Poland.
The dynamic growth of car traffic in Poland has been observed. The average daily traffic on international roads has doubled over the last decade. It is estimated that it went from 6 to 12 thousand of vehicles per day. There are also road sections where the traffic flow significantly exceeds the level of 20 thousand vehicles daily. General traffic measurements which are systematically carried out by the road administration confirm this phenomenon. With this increase in traffic, the roads in Poland have been devastated. A fairly common phenomenon is rutting which is the result of driving overloaded trucks, especially in summer.
The choice of the type of road pavement poses the problem for both investors and administrators. Without a doubt, factors to be taken into consideration include:

1. Technical conditions
2. Economic aspects
3. Availability of technologies and materials

Regardless of technical and economic conditions, one cannot eliminate any road paving technology, but seriously consider the alternatives: bitumen (asphalt) or concrete pavement.

Keywords: road pavement technology, durable asphalt pavements, durable concrete pavements.

1. INTRODUCTION

Travelling has become an indispensable part of our lives. We commute to work, we travel to school, and we go shopping. Striving of each traffic participant to minimize commuting times necessitates continuous development of transportation, which would enable getting around quickly, and, first of all, safely. Current means of transport compete to attract the largest number of travellers to use a given mode of transport. However, the main criteria based on which the travellers decide upon a specific means of transport are: speed, safety and comfort.

For many years we have observed the dynamic growth of car traffic in Poland, as well as worldwide. The average daily traffic on international roads increased 2-fold over the last decade. It is estimated that it went from 6 to 12 thousand of vehicles per day. There are also road sections where traffic flow significantly exceeds the level of 20 thousand vehicles daily. General traffic measurements which are systematically carried out by the road administration confirm this phenomenon. With this increase in traffic, the roads in Poland have been devastated. A fairly common phenomenon is rutting which is the result of driving overloaded trucks, especially in summer [3].

There is an ongoing argument between road contractors about the advantages and disadvantages of bituminous and concrete pavements.

All roads administered by the Region are paved with bitumen. The costs of repairs and ongoing maintenance of roads are much higher than the financial resources that Region has at its disposal annually.

Recently, there has been a significant technological development in the construction and design of concrete pavements in Poland. Investments are carried out for roads of both higher and lower classes.

GDDKiA has introduced a Regulation of General Director for National Roads and Motorways of June 16, 2014 including the annex, which contains a new version of the list of typical rigid pavement construction.

In Germany, the ratio of concrete to asphalt pavements changes continuously in favour of concrete (over 60%). Similarly, about 65% of new highways in the Czech Republic already have concrete pavements. Further examples of European countries, where the share of concrete roads is steadily increasing, are: Austria and the United Kingdom (50%). In Belgium, concrete highways account for 40%, while the share of local roads built in concrete technology is approx. 60%.

The choice of the type of road pavement poses the problem for both investors and administrators. Without a doubt, factors to be taken into consideration include technical conditions, economic aspects and availability of technologies and materials. Regardless of technical and economic conditions, one cannot eliminate any road paving technology, but seriously consider the alternatives: bitumen (asphalt) or concrete pavement.

2. EXAMPLES OF THE USE OF THE NEW PAVING TECHNOLOGIES

2.1. DURABLE ASPHALT PAVEMENTS

The main idea of highly-modified asphalt is to prevent pavement cracking and permanent deformation (rutting), and to increase the fatigue strength of asphalt layers. High polymer content of more than 7% m/m is used for this purpose, which causes phase inversion in the asphalt-polymer mix.

Durable pavements based on asphalt with high stiffness modulus (EME)

The main advantages of using EME mix in terms of structural work as well as social and economic benefits include:

- Increased durability
- High resistance to rutting
- The possibility of reducing the thickness of asphalt layers
- The possibility of development of the concept of durable pavements

Additional advantages of using high stiffness modulus mixes are also related to the incorporation of EME, because they thicken well due to the large amount of asphalt and low vacuum.

The first major road investment where the pavement structure has been made of blends of high stiffness modulus mix was related to the construction of the A2 motorway section from Łódź voivodship border to Stryków junction. This started a large-scale incorporation of EME mixes. Then-innovative technology of layering has been employed during the construction of this A2 motorway section. This technology is called compact asphalt. It involves laying two asphalt layers simultaneously. Hermann Kirchner, now Strabag Sp. z o.o., specialized in this technology. It allows for the incorporation of two different layers simultaneously, i.e., hot on hot. This allows for quick execution of works and considerable financial benefits, because:

- There is no need for sprinkling with asphalt emulsion
- Thickening process involves two layers simultaneously
- It helps to achieve a very good interlayer bonding, which extends the durability of the road
- It allows for thinning of the layers

Figure 1 below shows a set for stacking layers in the compact asphalt technology.

Fig. 1. Laying mineral asphalt mix in compact asphalt technology [7].

The experimental plot Opacz – Paszków (special asphalt) Model S 8, durability 50 years, contractor warranty 18 years.

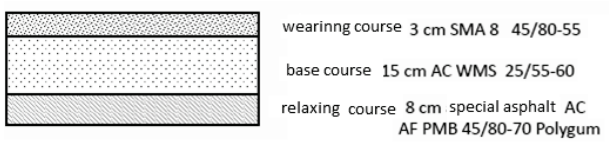

Fig. 2. Durable asphalt pavement cross-section at model Opacz- Paszków [4].

Durable pavements based on highly-modified asphalt (rubber + polymer modifier)

The experimental plot DK 92 Kłodawa – asphalt 45/80-55CR.

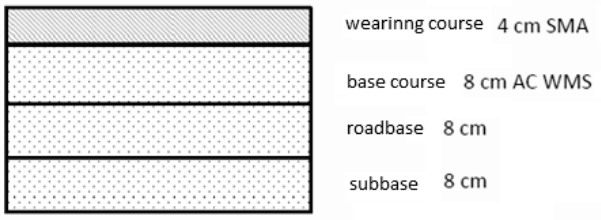

Fig. 3. Durable asphalt pavement cross-section at national road 92 Kłodawa [4].

Durable HiMA (highly-modified asphalt) pavements

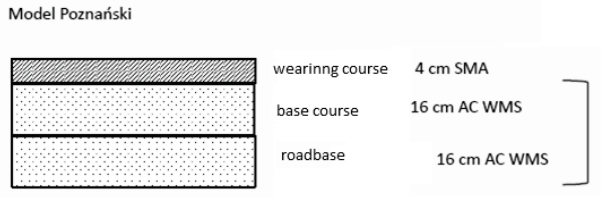

Fig. 4. Durable asphalt pavement cross-section Poznański model [6].

The binding layer has the characteristics of the carrier layer.

2.2. DURABLE CONCRETE PAVEMENTS

Currently two sections of concrete pavement with continuous reinforcement have been made in Poland. The results show that the fatigue life of these pavements is much larger than that of traditional concrete pavements.

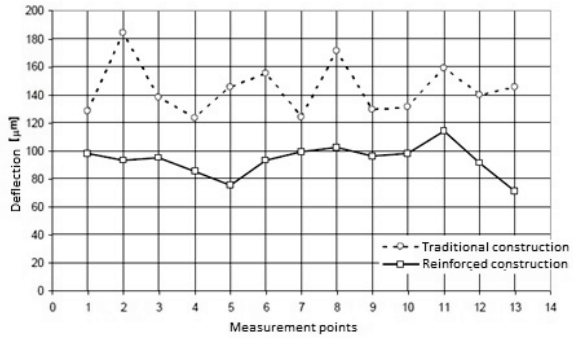

Fig. 6. Maximum deflections at the load of approx. 120 KN [5].

Experience from abroad shows that concrete pavements with continuous reinforcement do not require large expenditures for maintenance and curing of the top layer of pavement using MAM (Mineral-Asphalt Mix) should provide good results. Fatigue life is about 150,000,000 axles of 115 kN. Their advantage is the lack of transverse slots, full cooperation at micro-cracking and the planned durability of approx. 50 years.

2.3. PALE ASPHALT PAVEMENTS

Pale and brightened asphalt pavements are already widely used in France. French road contractors have developed various technologies for their production obtaining the effect of a pale road. This type of road pavement is also

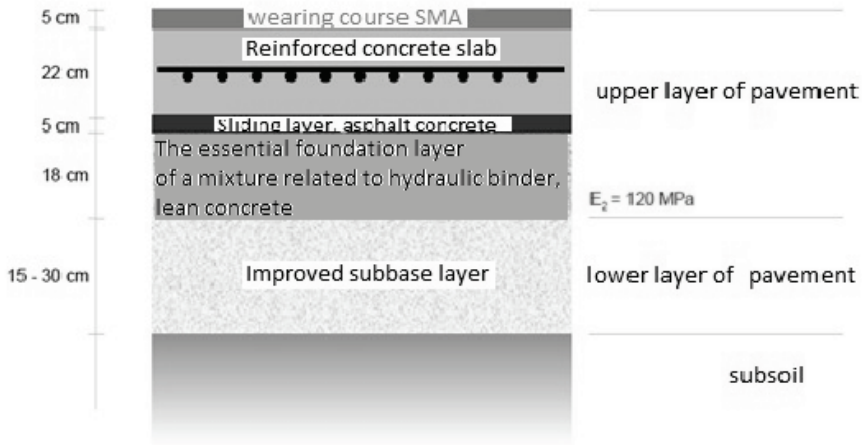

Fig. 5. Layering of a durable pavement with continuous reinforcement [5].

appreciated in Germany, though the access to light aggregates which are essential in their production of clear is limited there.

In Poland, such pavements have been used for example on the Siekierkowska Bridge and Route in Warsaw or on Bełk – Świerklany and Gdańsk – Nowe Marzy sections of A1 motorway. However, despite the possession of light aggregate resources, they are still exceptions in Poland.

Fig. 7. Brightened asphalt pavement in Poland, A1 Bełk – Świerklany [6].

Fig. 8. Brightened asphalt pavement in Germany [6].

One of the advantages of these pavements is limited rutting, and this may be one of the arguments for their broader use in Poland. The temperature of the wearable layer of pale surfaces can be less than the temperature of dark surfaces by up to 10 degrees Celsius, and this results in lowering the temperature of the bonding layer and the foundation. The decrease of the temperature of asphalt layers in summer enables to use somewhat softer binder. In this case, an additional effect is obtained, that is, improved resistance to cracking in winter. Thus, the technologies of "pale" asphalt provide greater durability by simultaneously increasing the resistance to rutting and cracking.

Ways to obtain a pale surface effect:

- The use of light aggregates:
- Artificial aggregates, such as sintered flint:
  – Advantages:
    - Very light colour, almost white. A high rate of retroreflection > 0.40 [(cd/m2)/lx],
    - Little decrease in retroreflection when wet (20%),
    - High PSV value (57)
  – Disadvantages:
    - High price: €57 to €80/t (about PLN 330/t),
    - Much less available on the Polish market
- Natural aggregates:
  – Advantages:
    - Widespread availability on the Polish market
    - Price comparable to the prices of other aggregates
    - Darker than white, but sufficiently light 15 - 35[(cd/m2)/lx]
  – Disadvantages:
    - Larger decrease in retroreflection when wet
    - Not all aggregates meet the requirements in terms of abrasion, polishing, and adhesion
- Use of artificial asphalts (colourless or coloured with light pigments)
- The use of light aggregates to roughen the surface.
- Sanding the pavement in order to obtain an immediate brightening effect.

German experience

Studies have shown the reduction in surface temperature by 8 – 10°C (SMA 0/8) on average when using:

– Aggregate > 2mm – 68%
– Polymer-modified asphalt 25/50-55
– Brightening aggregate: artificial 25%.

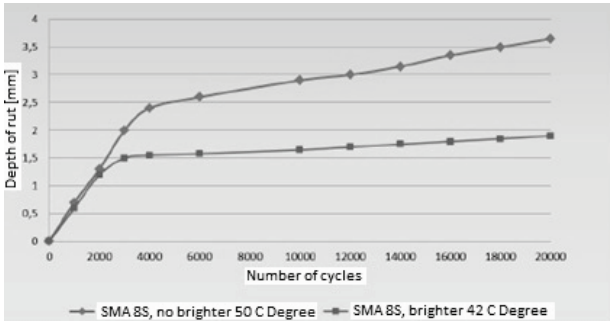

Fig. 9. Rut depth depending on the number of cycles – German studies [5].

"Using B 65 asphalt with the brightened surface in the context of high temperatures corresponds to B 45 asphalt in a non-brightened surface in terms of stiffness" [1].

"In summer, it is possible to achieve the same effect of resistance to deformation of B 80 asphalt as in non-brightened surfaces for B 65 asphalt" [2].

Polish experience

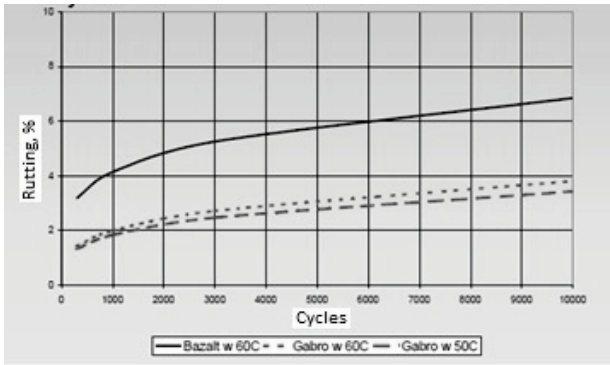

Fig. 10. Rut depth depending on the number of cycles – Polish studies [5].

Pale surfaces have a significant impact on increasing the resistance of asphalt pavement to rutting.

The ability to use higher penetration, so-called "soft" asphalt, which significantly reduces the number of low-temperature cracking and significantly increases the fatigue life.

3. CONCLUSION

Last year's amendment to the Public Procurement Law was aimed at, among others, a departure from common use of the lowest price as the main criterion. According to the new law, the client is required to introduce at least one other criterion. The purpose of the new regulations is to make clients evaluate the bids not only in terms of the price, but rather look at the total cost. This cost takes into account costs such as maintenance and all other services which fall outside the bid.

Such an approach in road investments is an opportunity for the more widespread use of concrete pavement than before.

The goal of each road operator is to deliver sustainable and quality roads, and to minimize the cost of construction and maintenance of roads. This can be achieved by selecting the type of pavement.

The advantage of asphalt technologies is much greater suitability for repair of roads enabling to restore traffic after just a few hours and taking up only one lane during works. In the case of concrete it lasts at least 28 days, during which concrete cures, acquires the designed strength and is subjected to special treatment. Asphalt technologies are much less prone to contractor errors. The effective control of the quality of work is vitally important from the point of view of the road operator. Asphalt technology enables full control of the quality of materials at the project preparation and post-execution stages. The other benefits include the ability to reuse materials from the demolition of asphalt pavement and good traction for vehicles.

The disadvantages of asphalt include: sensitivity to heat and cold, dark colour requiring the consumption of large amounts of energy for lighting, higher cost of construction and maintenance than for concrete pavements, the requirement for layering and frequent repairs.

The main advantages of concrete pavements include the durability of at least 30-40 years. Long intervals between major maintenance work as compared to repairs of bituminous pavement. Concrete roads are less prone to high and low temperatures and high load resistance. According to cited studies done at Białystok University of Technology, the difference between the loudest concrete pavement and quietest asphalt are on the verge of measurement error. Similar observations were made in Germany and the Czech Republic. The advantages also include the ability to make a complete pavement in a single paver pass, reuse materials from demolition of concrete pavement, high surface brightness, and thus lower lighting costs.

The disadvantages of concrete pavements include the sensitivity of concrete mix on low-quality components, the need for expansion joints, which increase the loudness of roads and the need for periodic replacement of expansion joint sealing.

The analysis of road construction solutions in terms of load capacity, durability and the costs of construction and operation with particular regard given to traffic data, ground conditions and the technology of construction and maintenance of pavements, results slightly in favour of concrete pavements.

Factors influencing the decision regarding the choice should also include the conditions of purchase of machinery, the supply of bituminous binders and cements, which are general economic factors, and operational reliability of the pavement, which are technical and economic factors.

Usability is an equally important aspect to consider when choosing a pavement type. Concrete pavement has the advantage in this area. This advantage already stands out in higher capacity compared to bituminous pavement. Although the major disadvantage of concrete pavements is cracking, they are more resistant to weathering compared to bituminous pavements and hence to the formation of defects in the structure depending on the season. The additional advantage of concrete pavements is resistance to rutting, which substantially impacts the safety of road users. Currently, safety aspects are very important in designing transport solutions, which is why it is a very valuable advantage.

To sum up the considerations, one should explicitly state that the objective of this study was achieved and its measurable result is a comprehensive comparative analysis of the costs of construction and maintenance of concrete and bituminous pavements and conclusions demonstrating the advantages of concrete over bituminous pavement.

The conclusions included in the paper are consistent with generally accepted trends in the construction, administration, and operation. One should agree with the view that both technologies, concrete and cement, should find their way to Polish roads. Most importantly, the reasons for which they will be used, are substantive rather than political. It is also important that research findings are properly documented, based on statistically significant samples (number of measurements) and available generally and in detail for all concerned.

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