POLYMER MODIFIED BITUMEN FOR AIRFIELDS – PRISTINA AIRPORT

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ABSTRACT

Airfield pavements are exposed to special conditions such as the effects of runway and aircraft de-icing chemicals, which may result in accelerated deterioration of the pavement. Aircraft safety may be jeopardised through stones loosening from the pavement, causing damage to aircraft engines. Accelerated deterioration of the pavement also shortens pavement life, resulting in increased capital costs. Special requirements therefore are needed for airfield pavements and binders used in such pavements. In Sweden, polymer modified bitumen frequently is used for asphalt concrete pavements on civil airfields. Special requirements specifications based on climatic conditions have been developed for such binders to ensure good performance as well as good resistance to de-icing chemicals.

Within a project run by Swedavia, renovation is carried out since spring 2004 at Pristina airport in Kosovo. The selection of bitumen is based on climatic conditions in the Kosovo area and Swedish experience of polymer modified binders for airfields since 1998. For the wearing course, the selected binder will be polymer modified bitumen fulfilling the requirements of PG (Performance Grade) 76-22 according to SHRP (Strategic Highway Research Program) with certain additional tests and requirements.

In this paper, Swedish experience of polymer modified binders for airfields is summarized and the binder design for Pristina airport discussed.

1. INTRODUCTION

Airfield pavements are exposed to special conditions such as the effects of runway/ aircraft de-icing agents or fuel spillage, which may result in accelerated deterioration of the pavement. Aircraft safety may be jeopardised through stones loosening from the pavement, causing damage to aircraft engines. Accelerated deterioration of the pavement also shortens pavement life, resulting in increased capital costs. Special requirements may therefore be necessary for airfield pavements and the binders used in such pavements. Modified binders often are needed and even specially suited binder specifications and requirements have to be used.

From Nordic experience and laboratory studies, it is an obvious fact that some runway de-icing chemicals have a degrading effect on asphalt concrete surfaces [1]. In the 1990's, asphalt durability problems due to the use of new de-icing chemicals were observed at some Nordic airports. For this reason, a joint research project between the Norwegian and Swedish CAAs (Civil Aviation Administration) started in 1998 as part of a larger development program about de-icing of runways and aircraft. A laboratory test method for determining the change in surface tensile strength of asphalt concrete after storage i de-icing agent was developed within this project.

In August 1998, some test sections of polymer modified asphalt concrete pavements were constructed at Arlanda airport for evaluation within a research project [2]. The purpose of the project was to compare and evaluate a number of polymer modified bitumens in order to create basis for a future Swedish requirements specification for pavements on civil airfields. This is also the work on which the binder specification for the new Arlanda Runway 3 is based. Construction works at Arlanda Runway 3 were performed during the period of 1999-2002, including also follow-up testing and control of the binder. Since 1998, polymer modified binders successfully have been used for airfields in Sweden.

Since 2004, major investment projects are going on at Pristina International airport in Kosovo. These projects have been initiated to correct nonconformities according the requirements of ICAO (International Civil Aviation Organization) ANNEX 14. Investment projects are contracted to mainly international contractors and are supervised by Swedavia, Swedish Aviation Development AB. One of the contractors, Granit Construction Stock Co, is responsible for the asphalt pavement works at the airport including the production of asphalt concrete according to certain technical specifications provided by Swedavia. The construction started in mid August 2006.

Swedish experience of polymer modified binders for airfields is summarized in this paper and the binder design for Pristina airport is presented and discussed.

2. POLYMER MODIFIED BITUMENS FOR AIRFIELDS

Depending on range of application and technique used, there are several reasons for using modified bitumens rather than conventional bitumens. The purpose of using modified bitumen in an asphalt pavement is to achieve better performance, in one way or another. In the case of airfields, the use of de-icing chemicals is one reason for choosing modified binders. Other reasons may be linked to climatic conditions and/or high tyre pressures. In improving bitumen properties, several types of modification have been used, including polymer modification, chemical reaction modification and modification using additives. Out of elastomer materials, SBS copolymers have attracted most attention for bitumen modification.

2.1 Binder specifications

There are mainly two alternatives for specifying polymer modified binders. Either it could be specified according to European standard EN 14023:2005 [3], or it could be specified according to SHRP binder specifications used in the US and Canada.

In the European standard specification, polymer modified binders are specified by penetration and softening point only. For the rest of the binder characteristics, classes are to be chosen within a given frame work. Although the majority of the tests and techniques normally used to investigate standard paving grade bitumens also can be used for polymer modified binders, empirical tests related to the in-service properties of bituminous mixtures often become less relevant. For instance, softening point is not a suitable measure for assessing the high temperature performance of polymer modified mixtures. However, a second generation of performance-related binder specification for paving grade bitumens is under development within CEN TC 336 WG1, and expected to be published around

2010 at the earliest [4]. Several of the test methods that will be part of this future European specification already are EN standards and very similar to those used in the SHRP binder specification.

The SHRP binder specification is a performance or functional related specification, and the different types of binder (Performance Grades) are adjusted according to climatic conditions. The same requirements go for all binders but at different temperatures. The specification is based mainly on pavement temperatures, and requirement limits depend on where (in what climatic zone) the binder is to be used. However, the SHRP binder specification does not always capture the performance of modified bitumens adequately either. Especially the low temperature performance may be underpredicted.

2.2 Swedish experience of polymer modified bitumens for airfields

Traditionally, standard bitumens 160/220 and 70/100 were used in Sweden for airfields before 1998. Since then, the use of polymer modified bitumen has increased a lot and is today preferred for all civil airfields. One main reason for using polymer modified binders instead of conventional binders is the possible resistance to de-icing chemicals. The following section deals with this complex of problems.

2.2.1 Degrading effect from de-icing chemicals

In Sweden, problems started in the winter season of 1992/1993, when the Swedish CAA changed run-way de-icing chemical from urea to acetates. After that, a new type of durability problems appeared at a number of airfields. In trying to solve the problems, a Swedish/ Norwegian joint project was initiated [5]. The project was divided into two parts; laboratory studies and experiments using a weather simulator. One of the methods developed within this project deals with the influence of de-icing chemicals on the surface tensile strength of an asphalt concrete. During the first part of 2002, the method was slightly modified to improve the storage procedure and increase precision. In 2005, the method was adopted as a European standard [6]. As part of the further development of the method, it was evaluated in a so-called round-robin test in order to determine precision statistics [7].

The degrading effect caused by de-icing chemicals may partly be explained by the time-dependant thermo-reversible softening/swelling phenomenon sometimes occurring in the binder due to several reasons. One reason may be the difference in density between binder and de-icing liquid. The pH-value, hygroscopic capacity and surface tension properties of the de-icing chemical solution are other parameters found to be of decisive importance. Emulsification, phase separation and chemical reaction may to some extent also be reasons behind the problems described. Other factors of importance for the asphalt concrete resistance are voids content, type of aggregate and adhesion properties. Management related factors such as de-icing chemical quantities and frequencies used for the airfield and the mechanical effect from snow clearance and steel brushing also have to be considered.

Concerning the environment, carboxyl acid salts such as acetates and formates are soluble in water and form basic solutions (high pH value). In nature, they are broken down to metal ions, carbon dioxide and water. However, breakdown proceeds slowly, especially at low temperatures.

Going from urea to nitrogen free de-icing chemicals in order to avoid over-fertilisation and negative effects on the environment, there are not so many further chemicals to select from than acetates and formats. This has to do with melting capacity, which is linked to average molecular weight or ionic weight which must be low.

The degrading effect due to de-icing is likely to appear at normal and higher temperatures, under mechanical influence from snow clearance and steel brushing, at high concentrations and much de-icing used. Soft binders are most sensitive. Other negative effects may appear as well, such as dirt spray on runway markings, lighting and equipment leading to traffic disturbance.

2.2.2 Binder specifications for Swedish airfields

Based on experience described in the previous section and results from research on polymer modified pavements [2], new requirements specifications for pavements on civil airfields in Sweden were suggested, including binder specifications.

For the polymer modified binder intended for Arlanda Runway 3 in 1998, a requirements specification according to SHRP was used, with a number of additional requirements, for instance concerning storage stability and resistance to de-icing chemicals. This specification also became part of the Swedish CAA technical description for airfield pavements.

According to this specification, mainly three polymer modified performance grade bitumens can be used in Sweden for airfields. These are PG 64-34, PG 64-28 and PG 64-22 (all with additional requirements).

3. PRISTINA AIRPORT

Within a project run by Swedavia, renovation is carried out since spring 2004 at Pristina airport in Kosovo. Asphalt concrete construction works started in mid August 2006.
For base and binder course layers, standard bitumen 70/100 according to EN 12591 is used, and for wearing courses polymer modified bitumen according to technical specification provided by Swedavia. Asphalt construction work using polymer modified bitumen is planned to start in 2007.

3.1 Selection of bitumen

The selection of bitumen mainly is based on climatic conditions in the Kosovo area, and Swedish experience of polymer modified binders for airfields since 1998. For the wearing course on runways and taxiways, the selected binder will be polymer modified bitumen fulfilling the requirements of PG 76-22 according to SHRP, with certain additional tests and requirements.

The choice of bitumen for Pristina airport is based on some local technical report [8] on climatic conditions in this area (between year 1933 and 1991) together with calculations according to SHRP and a Norwegian evaluation report for conditions in Norway [9]. Last but not least, the choice is based on Swedish experience of polymer modified binders for airfields (cf. section 2.1).

Concerning the local report on climatic conditions, no information about pavement temperatures was presented. The lowest registered air temperature was stated as -25°C (extreme case -27°C). Quite low temperatures seemed to occur during January and February. Furthermore, the lowest registered mean temperature over the coldest month was stated as -5°C (January 1963). The lowest registered temperature over one day and night is lacking in the report. The highest registered temperature was stated as +39°C (in July). Normally, maximum temperatures exceeding 30°C were registered from May to September, and the highest registered mean temperature over the warmest month was stated as +23°C (July 1988). Moreover, no extreme rainfall seems to occur (582 mm per year), the most of it falling in May (72 mm).

The SHRP binder specification is based on registered pavement temperatures. The maximum critical pavement design temperature (Tmax) for a binder grade is the highest registered 7-day temperature 20 mm down in the pavement. The corresponding minimum limiting temperature (Tmin) is the lowest registered temperature in the upper surface of the pavement. In the process of selecting polymer bitumen for Swedish airfields (and due to the lack of registered pavement temperatures), measured daily mean low temperature values have been used as a kind of minimum limiting design temperature. For low temperature safety reasons, -22, -28 and -34°C were chosen for airfields in the south, middle and north parts of Sweden, respectively. Regarding low temperatures, Pristina seems to be more like the south or middle part of Sweden. Putting the extreme lowest registered air temperature of -27°C (according to the Pristina report) into the SHRP calculation formula:

$$T_{upper\ surface} = 0,859 \times T_{air} + 1,7$$

a critical minimum temperature of -21°C is given for Pristina.

For Swedish climatic conditions, a maximum critical pavement design temperature of +64°C has been chosen for three so-called Swedish binder Performance Grades for airfields. The reason for this is that the pavement temperature at any Swedish airfield during summertime in extreme cases may reach approximately +60°C. Moreover, slowly moving heavy traffic occurs and maximum safety is prioritized. Regarding high temperatures, Pristina seems to have a considerably warmer climate during the main part of the year, compared to Sweden. Consequently, the upper limiting pavement design temperature should be higher than in Sweden (> +64°C). Putting the highest registered air temperature of +39°C (according to the Pristina report) and latitude (φ) of 42° into the modified SHRP calculation formula:

$$T_{20} = (T_{air} - 0,0055 \times \varphi^2 + 0,15 \times \varphi + 36) \times 0,9545 - 0,8$$

a critical maximum temperature of +68°C is given for Pristina. Considering also the slow moving heavy traffic, another +6 °C should be added. (The modification used for the SHRP formula was suggested in a Norwegian research report, giving higher and more realistic temperatures (at least for Norwegian conditions)).

Based on information and data listed above, one polymer modified bitumen, conforming to PG 76-22 according to SHRP binder specifications, is suggested for Pristina airport. Additionally, the binder must show good storage stability and good adhesion performance in combination with the aggregate to be used for Pristina airport. The specification for polymer modified bitumen intended mainly for the surface course of runways and taxiways on Pristina airport is given in the following section.

3.2 Requirements specification for polymer modified bitumen

This section is an extract from the current technical specification concerning runway and taxiway resurfacing on Pristina airport. According to this specification, the binder shall be an elastomer-modified bitumen using styrene-butadiene-copolymer (such as SBS). The modified binder shall meet the requirements according to the SHRP Superpave specification of a PG 76-22 as listed in Table 1 below.

Table 1 - PG 76-22

Test	***Test method***	***SUPERPAVE Specification***
Original bitumen		
Viscosity at 135°C	*ASTM D4402*	*Max 3 Pas*
DSR 10 s^{-1} 2) $G^*/\sin\delta$ at 76°C	*AASHTO TP5*	*Min 1.0 kPa*
After RTFOT (AASHTO T240)		
Mass loss		*Max 1.0 %*
DSR 10 s^{-1} $G^*/\sin\delta$ at 76°C	*AASHTO TP5*	*Min 2.2 kPa*
After PAV at 100°C (after RTFOT) (AASHTO PP1)		
DSR 10 s^{-1} $G^*\cdot\sin\delta$ at 31°C	*AASHTO TP5*	*Max 5000 kPa*
BBR at –12°C 1)	*AASHTO TP1*	
Stiffness S		*Max 300 MPa*
m-value		*Min 0.3000*

1) Physical hardening after conditioning time 24 hours ±10 minutes at the test temperature shall be reported. S and m-value are given.
2) A temperature sweep from –30°C to +80°C at 10 rad s^{-1} shall be given (complex modulus G* and phase angle) for information only.

The following shall be given as well by the bitumen supplier:

- Density at 25°C (EN-ISO 3838)
- Softening point (R & B) (EN 1427)
- Penetration at 25°C (EN 1426)
- Chemical characterization by GPC (Gel Permeation Chromatography).

In addition to the requirements of PG 76-22 as shown above, also the following requirements shall be fulfilled:

- *Elastic recovery* at 10°C 70-90 (% abs.)
  Testing is performed according to EN 13398 ”Determination of elastic recovery of modified bitumen”.

- *Storage stability* after 72 hours at 180°C
  Δ softening point max 5°C

∆ elastic recovery max 5 % (abs.)
Testing is performed according to EN 13399 ”Determination of storage stability of modified bitumen”.

- *Resistance to de-icing agent*

  Asphalt concrete

  Potassium acetate KAc and formate 50%,
  The retained strength after storage in potassium acetate or formate (50%) shall be at least 85%. Storage testing shall be performed according to EN 12697-41. Asphalt concrete specimens shall be prepared with the specific aggregate (maximum size 16 mm) and polymer modified bitumen intended for the surface course of the airport.

Polymer type and content
are given by the polymer bitumen supplier together with a suitable method for determining the polymer content of the product using for instance IR spectroscopy.

For quality control of binder content and particle size distribution
of the asphalt mix, as well as for possible recovering of the binder for comparison with the corresponding original binder, also the following information is required from the bitumen supplier:

- Suitable extraction method for determining binder content and particle size distribution. What solvent(s) can be used?
- Suitable method for binder recovery. What solvent(s) can be used?
- Suitable procedure at GPC-analysis of the binder. What solvent(s) can be used?

Finally, the following shall be given by the supplier:

- Suitable storage and pumping temperatures
- Maximum heating temperature and time for the bitumen
- Suitable laying temperature for the asphalt mix with this particular bitumen
- Quality control documentation for the bitumen production

4. CONCLUSIONS

Airfield pavements are exposed to different conditions compared to road pavements. Special requirements specifications therefore are needed for airfield pavements and binders used in such pavements.

One conclusion to be drawn from the limited experience presented in this paper is that polymer modified bitumens for airfields should not be specified according to European standard EN 14023, or according to SHRP binder specifications alone. Additional requirements such as resistance to de-icing chemical are needed as well.

The binder specification suggested for the polymer modified bitumen intended for Pristina airport is based on climatic conditions registered in the Kosovo area and Swedish experience of polymer modified binders for airfields since 1998. For the wearing course, the selected binder will be polymer modified bitumen PG 76-22 according to SHRP, with certain additional tests and requirements. Fulfilling the requirements, this binder should perform well on Pristina airport.

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