DURABILITY PROBLEMS ON NORDIC AIRFIELDS- THE INFLUENCE OF DEICING AGENTS ON ASPHALT CONCRETE

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ABSTRACT

In the 1990´s, asphalt durability problems due to the use of new deicing chemicals were observed at some Nordic airports. Degradation and disintegration of asphalt pavements occurred and there were also softening and stripping effects on bitumen and asphalt concrete together with loose stones on the runways.

The problems occurred when many airports in Norway and Sweden changed from urea to potassium acetate and potassium formate. Requirements from environmental authorities come because of nitrogen problems and over-fertilisation of soil and watercourses around airports caused by urea.

For this reason, a joint research project started in 1998 to solve the problems. The project carried out by Norwegian and Swedish Civil Aviation Administrations. Co-operation started with research institutes and deicing agent manufacturers. Later on has also Finnish Civil Aviation Administration joined the project.

The deicing development program contents full-scale experiments at three airports, laboratory investigation of binders and asphalt concretes, weather simulator test and evaluation of the results. Out of this process a method for determining adhesion of asphalt concrete after storage in deicing agent were developed. This method is named LFV Method 2-98.

The development program results lead to increased requirements in the requirement specifications used in the purchasing of runway and aircraft deicing agents in Norway and Sweden. Requirements of deicing agent influence on asphalt concrete and bitumen were introduced together with melting capacity requirements to get an effective deicing agent as possible.

Standardization works started in the SAE G-12 Fluids Subcommittee to get international accept for the problems with asphalt and bitumen. In the process of trying to get LFV Method 2-98 accepted as an international standard, a round robin test project will be carried through 2002-2003. The repeatability (within a laboratory) and the reproducibility (between participating laboratories) of the method will be defined.

KEYWORD:

PAVEMENT

PROBLÈMES DE DURABILITÉ SUR LES TERRAINS D'AVIATION NORDIQUES – L'INFLUENCE DES AGENTS DE DÉGIVRAGE SUR LE BÉTON D'ASPHALT

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RESUME ANALYTIQUE

Au cours des années 90, des problèmes de durabilité de l'asphalte en raison de l'utilisation de nouveaux produits chimiques de dégivrage ont été observés sur certains aéroports. Il y a eu dégradation et désintégration des revêtements bitumineux et on a également remarqué des effets d'assouplissement et de désenrobage sur le bitume et le béton d'asphalte ainsi que des départs de matériaux sur les pistes. Les problèmes sont survenus lorsque plusieurs aéroports de Norvège et de Suède ont remplacé l'urée par de l'acétate de potassium et du formate de potassium. Les autorités environnementales ont établi des exigences en raison des problèmes d'azote et de la surfertilisation du sol et des cours d'eau autour des aéroports causés par l'urée.

C'est pour cette raison qu'un projet de recherche conjoint a débuté en 1998 dans le but de résoudre ces problèmes. Le projet a été mené par les Autorités de l'aviation civile norvégienne et suédoise. Cette coopération s'est forgée avec les instituts de recherche et les fabricants d'agents de dégivrage. Ultérieurement, l'Autorité de l'aviation civile finnoise s'est également jointe au projet. Le programme de développement du dégivrage comporte des expériences à grande échelle sur trois aéroports, des enquêtes laboratoires des bétons d'asphalte et agglomérants, un test de simulateur météorologique et une évaluation des résultats. De ce processus, une méthode de détermination de l'adhérence du béton d'asphalte après stockage dans l'agent de dégivrage a été élaborée. Cette méthode s'appelle la méthode LFV 2-98.

Les résultats du programme de développement ont mené à des exigences plus strictes au niveau des spécifications utilisées dans l'achat d'agent de dégivrage pour les pistes et les avions en Norvège et en Suède. Les exigences quant à l'influence de l'agent de dégivrage sur le béton d'asphalte et le bitume ont été introduites ensemble en tenant compte de la capacité de fusion pour obtenir un agent de dégivrage le plus efficace possible.

Le sous-comité des fluides SAE G-12 a entamé les travaux de normalisation, afin d'obtenir une acceptation à l'échelle internationale pour les problèmes d'asphalte et de bitume. Dans un effort pour obtenir l'acceptation de la méthode LFV 2-98 comme norme internationale, un projet d'essais comparatifs interlaboratoires sera effectué en 2002 et 2003. La répétabilité (au sein d'un laboratoire) et la reproductibilité (entre les laboratoires participants) de la méthode seront définies.

MOT-CLE :

PAVEMENT

Background

In the 1990s, asphalt durability problems due to the use of new deicing chemicals were observed at some Nordic airports. Degradation and disintegration of asphalt pavements occurred at Gothenburg-Landvetter, Sundsvall and Oslo-Fornebu airports. There were also softening and stripping effects on bitumen and asphalt concrete together with loose stones on the runways.

The problems occurred when many airports in Norway and Sweden changed from urea to potassium acetate and potassium formate. Requirements from environmental authorities come because of nitrogen problems and over-fertilisation of soil and watercourses around airports caused by urea.

Deicing development program

For this reason, a joint research project started in 1998 as part of a larger development program “Deicing of runways and aircraft” to solve the problems. The project carried out by Norwegian and Swedish Civil Aviation Administrations. Co-operation started with Swedish National Road and Transport Research Institute, Royal Institute of Technology (Sweden), Sintef (Norway), Byggforsk (Norway) and deicing agent manufacturers.

The deicing development program contents

- full-scale experiments at Gothenburg-Landvetter, Oslo-Gardermoen and Angelholm airports
- laboratory investigation of binders and asphalt concretes
- weather simulator test, “The Trondheim experiment” and
- evaluation of the results.

Laboratory investigation

In the laboratory investigation bitumen 160/220 (B180) was stored in potassium acetate and potassium formate. The bitumen was stored in 20 °C, 40 °C and 60 °C with the storage times 24 hours and one week. The softening point was then determined.

The result of this storage showed that the bitumen had been significantly influenced, booth softened and dissolved. That happens already in the storage at 20 °C. The consistency of the bitumen was also changed.

The test therefore increased with bitumen B40, B 50/70 (B60) and B 70/100 (B85). The result shows that all bitumen sorts were influenced there bitumen 160/220 was affected most because of the more soft consistence.

The laboratory investigation then goes further with tests of asphalt concrete. A surface tensile strength test, adhesion test were performed on asphalt specimens (Marshall specimen). It was done before and after the specimens were stored in deicing agent. The surface tensile strength required for failure to occur in the upper surface was measured.

Out of this process a method for determining adhesion of asphalt concrete after storage in deicing agent were developed. This method was named LFV Method 2-98 (see enclosure). The storage time in the first version of the method was 14 days in the temperature of 40 °C. Comparison with adhesion value of specimen not stored in deicing agent is done.

Weather simulator test

The weather simulator test "The Trondheim experiment" has been conducted with a number of deicing agent manufacturers. Test slabs of asphalt pavements from the runways at Gothenburg-Landvetter, Oslo-Gardermoen (two different types) and Angelholm airports were used. These four types of pavements had not been exposed to deicing agents.

The total time in the weather simulator test contents 13 weeks. This is intended to simulate about two years exposure on Nordic airfields with runway deicing 50 days each year. After 13 weeks the evaluating of the results started. It showed that failure occurred in every case and the bitumen was softened. Brushes were used on the test slabs and they become black because of the softened bitumen.

Deicing development program results

The development program results lead to increased requirements in the requirement specifications used in the purchasing of runway and aircraft deicing in Norway and Sweden. Requirements of deicing agent influence on asphalt concrete and bitumen were introduced together with melting capacity requirements to get an effective deicing agent as possible.

Standardization works started in SAE G-12 Fluids Subcommittee to get international accept for the problems with asphalt and bitumen. The AMS specifications that regulate international requirements on deicing agents content no requirements regarding the influence of deicing agents on asphalt concrete. Requirements are necessary to guarantee high flight safety and improve regularity and economy for airfield operators. However there are requirements in the AMS specifications regulating the affect of deicing agent on concrete.

The aim is to introduce requirements of the runway deicing agent influence on asphalt and bitumen in SAE AMS specifications 1431B and 1435A. In the long run it is also planned to introduce the same requirements for aircraft deicing agents in SAE AMS 1424 and 1428.

Finnish Civil Aviation Administration has also joined the project “Deicing of runways and aircraft” and introduced corresponding requirements as Norway and Sweden have in their requirement specifications.

Round robin test of LFV Method 2-98

During 2002 and the beginning of 2003, the LFV Method 2-98 was slightly modified to improve the storage procedure and increase precision. The main difference between the modified LFV Method 2-98 and the original one is that the storage time has increased to 10 weeks.

In the process of trying to get LFV Method 2-98 accepted as an international standard, a round robin test project will be carried through 2003. The purpose of the project is to have a reliable and well defined test method with precision data according to ISO 5725. The repeatability (within a laboratory) and the reproducibility (between participating laboratories) of the method will be defined.

The round robin test contents tests with asphalt specimens stored in runway deicing liquid (potassium acetate and potassium formate), aircraft deicing liquid (glycol), water (de-ionized), deicing liquid with high pH value and air as a reference.

Eight European laboratories from Sweden, Norway, Finland, Germany, Belgium and Switzerland are taking part in the round robin project that is planned to finish in the autumn 2003.

ENCLOSURE

LFV METHOD 2-98 (rev 2003-02)

Effect of de-icing fluid on the surface tensile strength of asphalt concrete for airfields - Adhesion Test

1 INTRODUCTION

The purpose of the test is to determine the effect of storage in de-icing fluid on the surface tensile strength of asphalt concrete. The surface strength is the force in N/mm² required for failure to occur in the upper surface of the asphalt concrete under perpendicular ”pull off” tension with an increase in tensile force of 200 N/s.
The test is performed largely in the same way as the method used for testing the adhesion of road markings to a road pavement and/or the adhesion of bridge deck waterproofing to an underlying concrete or steel surface.

2 TEST METHODS

2.1 Principle

Testing shall be performed on a sawn cylindrical test specimen on which a well-defined test surface has been carefully drilled out in the asphalt concrete to a depth of about 5 mm. A steel plate shall be bonded to the test surface. The specimen with test plate shall then be stored in de-icing fluid. During testing, the plate is pulled off with an increase in tensile force of 200 N/s, the force being applied perpendicularly to the test surface. The surface strength upon failure and the type of failure shall be recorded.
The results are compared with those for specimens which have not been stored in de-icing fluid.

2.2 Apparatus and materials

a) Vessel for storing specimens in de-icing fluid.

b) Vacuum exsiccator.

c) Vacuum pump for evacuation of the exsiccator. The pump shall be capable of achieving a pressure of 6.7 kPa within 10 min and maintaining this pressure (within ± 0,3 kPa) throughout the vacuum treatment.

d) Manometer for measuring absolute pressure in the exsiccator.

e) Approved equipment for laboratory mixing of bituminous asphalt mixture.

f) Approved equipment for compaction of Marshall specimens or other approved laboratory compaction equipment such as gyratory compaction machine, roller or vibrating hammer.

g) Circular steel plates with a diameter of 50 mm and a tolerance of 0,5 mm. The steel plate shall be attached by suitable means (e. g. screwed) to the tensile test machine. Minimum thickness of steel plate shall be 10 mm from bottom of steel plate to bottom of screw hole.

h) Suitable adhesive (e.g. two part epoxy resin) for bonding the steel plates to the test specimen.

i) Base and holder for fixing the specimen prior to testing (see Fig. 1).

j) Tensile test machine, with force increasing rate control and automatic load recording, fitted with suitable clampings and base to ensure that the tensile force can be applied without momentum perpendicular to the test specimen.

k) Equipment for drilling out a test surface.

l) Conditioning device giving a temperature of (23 ± 1) °C.

m) Circular saw capable of cutting asphalt with finish that has no imperfections discernible by touch.

n) Heating cabinet giving a temperature of (40 ± 2) °C for heated storage of specimens.

o) Exsiccator grease.

2.3 Preparation of test specimens

Produce a number of specimens by compaction according to Marshall or other laboratory compaction method. The specimens should have a diameter of (100 ± 5) mm and a height of (60 ± 10) mm.
The asphalt mix may be produced in an asphalt mixing plant or in the laboratory.

2.4 Determination of dry weight and bulk volume

Allow the specimens to reach room temperature. Mark them with a waterproof marking.
Store the specimens overnight in room temperature on a flat surface.
The next day, determine the bulk density for each specimen according to EN 12697-6.
Divide the specimens into two equal groups (a wet and a dry group) with regard to bulk density. The mean bulk density must not differ by more than 30 kg/m^3 between the groups.

2.5 Preparation of test surface

Saw the specimens in half and carefully drill a test surface with a diameter of 50 mm and a depth of about 5 mm approximately in the centre of the sawn surface of the specimen.
Allow the specimens to dry on a flat surface at room temperature for at least three days.
Bond the test plate to the test surface by carefully applying a thin layer of epoxy adhesive. Allow the specimen to cure at room temperature until the following day. Prepare the test surfaces of specimens from both groups.

2.6 Storage in de-icing fluid

Store the specimens with bonded test plate from the wet group in de-icing liquid at (40 ± 2) °C and perform the test at (23 ± 1) °C.
Store the specimens in de-icing fluid, first for 3 hours ± 5 min under vacuum and room temperature, and then for a further 70 days ± 1 hour at normal pressure and specified storage temperature. Four specimens are normally stored for testing.
Place the specimens with the test plate upwards in the exsiccator. Pour de-icing fluid at room temperature into the exsiccator to a level 2-3 cm above the top of the asphalt concrete surface.
Evacuate to an absolute pressure of 6,7 ± 0,3 kPa within 10 ± 1 min. Adjust the evacuation rate and pressure with a valve or rubber hose with clamp.
Keep the absolute pressure at (6,7 ± 0,3) kPa for 3 hours. Turn off the pump and carefully admit air into the exsiccator until atmospheric pressure is reached.
Continue storage in a vessel at (40 ± 2) °C for a further 70 days ± 1 hour. Here again, the specimens must be placed with the test plate upwards immersed in de-icing fluid to a level 2-3 cm above the top of the asphalt concrete specimen surface. At the same time, the group of dry specimens is stored on a flat surface at room temperature.
After storage, condition the specimens to test temperature in the de-icing fluid not longer than until the next day.

2.7 Procedure

Take the specimen out of the de-icing fluid. Directly fix the specimen in the tensile test machine and the test plate attached to the machine. Apply the tensile force perpendicularly to the test surface and perform the test with an increase in tensile force of 200 N/s until failure occurs.
Record the tensile force together with the mode of failure. The following general modes of failure may occur:

- in the asphalt concrete, 5mm or deeper;
- superficially in the asphalt concrete surface;
- adhesive failure.

The test is carried out at (23 ± 1) °C.
At least three valid tests shall be carried out. The mean surface strength shall be calculated from a minimum of three accepted test results.

Test results for specimens stored in de-icing fluid are compared to test results for not stored specimens.

2.8 Expression of results

2.8.1 Method of calculation

The surface strength shall be calculated, to the nearest 0,1 N/mm², as the stress at maximum force by the following equation:

$$\sigma_{max} = \frac{F_{max}}{A}$$

where:

σ_{max} surface strength at failure, in N/mm²

F_{max} recorded maximum force, in N

A test area, in mm²

The mean value of the three test results shall be calculated.

2.8.2 Precision of the test method

No round robin test has been performed.

2.9 Test report

The test report shall include at least the following information:

- all details necessary to identify the de-icing product tested (such as type, product name, density, pH value and concentration);
- a reference to this method and any deviation from it;
- information on preparation of test specimens in accordance with clause 2.3, type of asphalt, including aggregate and bitumen designation;
- bulk density of all specimens and mean and SD for each group according to clause 2.4;
- information on storage according to clause 2.6;
- the test results and failure mode according to clause 2.7 for each individual test, mean values;
- the dates of delivery and preparation of specimens;
- the date of tests.

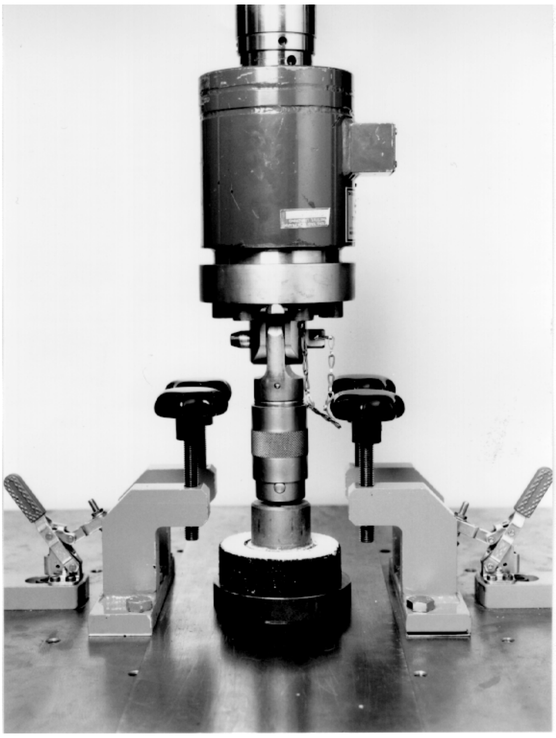

Figure 1 *Example of base, test specimen and equipment for adhesion testing (road markings).*