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Road and Rail Infrastructure III

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CONSIDERATION REGARDING ASPHALT MIXTURES IN ROAD PAVEMENT AND AIRPORT PAVEMENT

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Abstract

Asphalt mixtures for airport present certain features comparatively to those for highways, main roads or streets of different technical categories, from composition point of view. Also, laboratory studies include additional specific tests according to European norms in the case of asphalt mixtures for airport. Beside this, the design of an airport pavement is different from those of a road pavement. This paper aims to draw up comparison between the requirements of airport asphalt mixture and road asphalt mixture from laboratory point of view and airport pavement and road pavement from design point of view. It presents laboratory studies and comparative case study.

Keywords: airport, road, design, asphalt concrete

1 Introduction

The airport pavement and road pavement belong to the same structural family. Both are required to build a platform to resist to a given level of traffic and traffic must be done in a safe and comfortable conditions. Due to the specific of airport surfaces, traffic loads are varied, [1-3]. Essential characteristics that differ between road surfaces and airport surfaces are due to applied loads. In the roads case, applied loads shows a slight lateral dispersion (if lane is less than 3.5 m, in alignment) which generate the rutting phenomenon; for airports, the traffic is dispersed (especially on runway) because of diversity of landing train configurations, [2, 3]. Frequency loads is different in case of airport surfaces comparing to road surfaces: thousands (tens of thousands)/day for high-traffic roads and only a few hundred/day for high-traffic airports. Aircraft traffic is significantly different of the road traffic. In the road field, axle load varies from country to country, is around 100 kN, with the pneumatic pressure around 0.8 MPa. In aeronautics, an airplane can transmit more than 900 kN, with a standard air pressure of 1.25 MPa, which can reach to 1.5 – 1.7 MPa.

On the roads, speed is variable depending on the technical class of the road (less than 100 km/h), but on airport surfaces speed is independent of airport/country (continuously variable for runway: more than 300 km/h and constant for taxiways). Peculiarities of those two types of surfaces are given by uniformity (flatness), roughness (adhesion), environmental conditions and deviation, interruption of traffic. In the road field, uniformity (flatness) represents the comfort and safety of passengers, while in aeronautical field the uniformity (flatness) has influence on render safety and the landing – takeoff maneuvers. Flatness has a great influence to the aircrafts damage. Roughness is important both for roads, where the polisaj phenomenon may occur, and for airport runways where tire wear is high and rubber deposits are important. Deviation or interruption of the traffic in case of road interventions is not a huge problem, due to the bypasses, while in the case of airport surfaces is an important issue, [2, 3].

2 Objectives

The objectives of this research are to present similarities and differences between a flexible road pavement and an airport asphalt mixtures, from the recipe, testing laboratory and pavement design point of view. Laboratory studies were done in the Roads Laboratory of the Research Center “Roads and Airports” from Faculty of Railways, Roads and Bridges, Technical University of Civil Engineering Bucharest.

3 Laboratory studies

3.1 Asphalt mixtures recipe

Among the materials component of a flexible pavement the asphalt mixture is considered to be the most important material to be characterized accurately. As is well known asphalt mixture should be as flexible at low temperatures to prevent cracking, and rigid enough at high temperatures to prevent rutting. A good behavior of asphalt mixture in exploitation requires a well designed asphalt mixture recipe and a proper compaction in situ.

Normative in force in our country regarding grading curve for asphalt mixtures for roads is AND 605/2013, [4]. Since Romanian rules do not provide requirements for the design of airport asphalt mixture recipe, to establish aggregate mixture has proposed a grading curve that followed French Design Manual LCPC 2007, [5]. We considered the comparison of two types of asphalt mixtures: BA 16 (asphalt concrete used in wearing course of an road pavement, with 16 mm nominal maximum size) and BBA 16 (asphalt concrete used in wearing course of an airport pavement, with 16 mm nominal maximum size), for highlight the characteristics of the two types of asphalt mixtures (Fig.1) in accordance to EN 13108-1 norm as asphalt concrete used in wearing course, [6].

Restrictions imposed by French Design Manuel LCPC regarding the grading curve are [5]: aggregates below 16 mm size should be set between 90 and 100%; aggregates below 6.3 mm size must be between 65 and 80%; grading curve can be both continuous and discontinuous; less than 2 mm aggregate size should be between 35 and 45%;

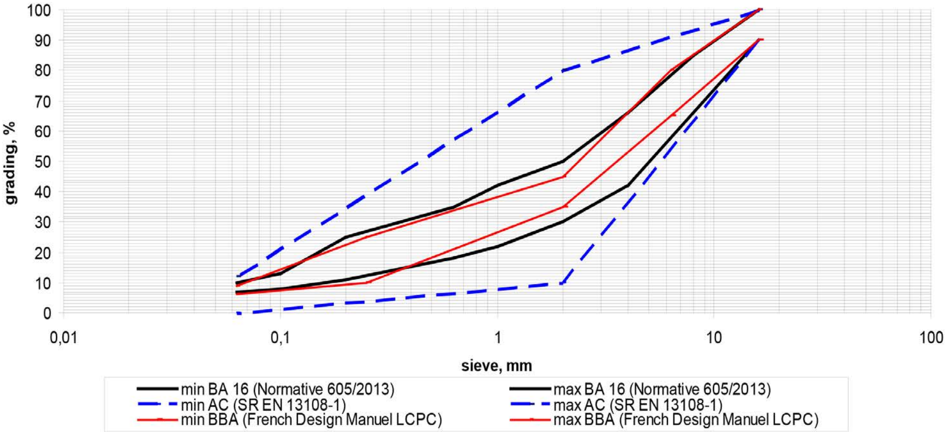

Figure 1 Comparison grading curves

Percent of bitumen was determined based of the method proposed by Duriez (1950):

$$TL = K \cdot \alpha \cdot \sqrt[5]{\Sigma} \tag{1}$$

where:

K	richness modulus (3.75 – 4 for road and 4 – 4.25 for airport);
α	correction coefficient relative to the density of aggregates;
Σ	specific surface area, expressed in square meters per kilogram, [5].

Restrictions imposed by French Design Manuel LCPC for BBA16 are: the used bitumen can be unmodified or modified; the percentage of bitumen must be above 5.2% ($TL_{min5.2}$ – according to SR EN 13108-1) and restrictions imposed by Normative 605/2013, for BA 16 are: the used bitumen can be unmodified or modified; the percentage of bitumen must be between 5.7 % – 6.5 % ($TL_{min5.6}$ – $TL_{min6.4}$ – according to SR EN 13108-1), [4, 5, 6].
The recipe is designed for an asphalt mixture used in wearing course of an airport pavement; the mixture has 16 mm nominal maximum size.
Knowing this, we further proposed to use two asphalt mixture recipes, one for road, BA 16 (designed according to Romanian standards) and one for airport, BBA 16 (designed according to French Design Manuel), in order to compare their performances taking into account general and fundamental characteristics.
The used materials and recipe of asphalt mixture BBA16 are: aggregates 29% sort 8/16, 23% sort 4/8, 37% sort 0/4; limestone filer 11%; bitumen 5.3% type 45/80 Fr.
The used materials and recipe of asphalt mixture BA16 are: aggregates 25% sort 8/16, 22% sort 4/8, 45% sort 0/4; limestone filer 8%; bitumen 6.1% type 50/70.

3.2 Type of tests

The type testing procedure applied on roads and airports is defined by standards; it has been characterized by an approach based to the greatest extent possible on asphalt mix performance. For structural type materials, it may be classified within the "fundamental" approach. For other material types, the approach is qualified as empirical, as intended in the European standardization, even though it involves "performance related" testing, [3, 5, 6].
Type testing imposes specifications on the components, and especially on the aggregates. It relies upon tests on the gyratory shear press, water resistance, rutting resistance, stiffness modulus and fatigue resistance.
The specific tests have been chosen depending on the type testing level (from 1 to 4, the level 0 doesn't include tests). This type testing level typically depends upon: the type of mixture, the position of the bituminous mixture layer in the pavement, its thickness, projected traffic levels, any special loadings, [5].

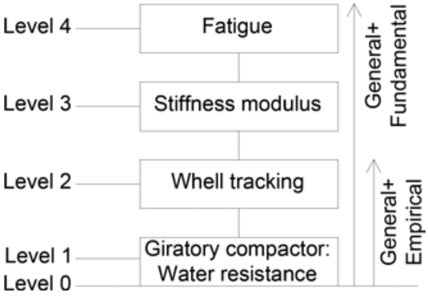

Figure 2 The general, empirical and fundamental approach for asphalt mixtures

According the definitions of EN 13108-1, level 0, level 1 and level 2 are relevant of the general + empirical approach and level 3 and level 4 of the general + fundamental one (Fig.2), [5, 6].

The asphalt mixtures used in the airport area, especially the area of taxiway and the apron must satisfy besides usually requirements for roads, some requirements related to resistance to fuel and de-icing agents according to European norms.

Determination of the water resistance sensitivity according to method A involves dividing a set of cylindrical specimen in two equivalent lots. Determination of the ratio betwen indirect tensile strength for the conditioned lot in water and for the dry lot, expressed as a percentage.

The wheel tracking test involves determining susceptibility of asphalt mixtures subject to deformations, susceptibility evaluated by measuring the rut depth formed by repeated passes of a loaded wheel at a fixed temperature.

Asphalt mixture stiffness is determined by either a complex modulus test (sinusoidal loading on a trapezoidal or parallelepiped specimen) or uniaxial tensile test (on a cylindrical or parallelepiped specimen). The load is applied over a domain of small deformations, through controlling time or frequency, temperature, and the loading law, [5].

Fatigue testing involves determining fatigue life of asphalt mixtures by alternative tests and includes bending tests and direct and indirect tensile tests, under a sinusoidal load or other loads controlled, by using different types of samples and support.

Further are presented the limitations of two types of asphalt mixture considering the presented above tests according to Design Manuel LCPC and AND 605/2013 Norm (Table 1). Test conditions are according to SR EN 13108-20 and the categories of values are according to EN 13108-1, [4-7].

Table 1 Type testing and test conditions for asphalt mixtures BBA 16 and BA 16

Mixture	Type testing and test conditions according to SR EN 13108-20			
BBA16	Void content, 80 girations	Laboratory results	Values	5.05
			SR EN 13108-1	V_{min5}
		French Design Manuel LCPC, limits		V_{min3}, V_{max7}
BA16		Laboratory results	Values	3.7
			SR EN 13108-1	$V_{min3.5}$
		Normative 605/2013, limits, max.		V_{max5}
BBA16	Wheel tracking 60°C, small size device procedure B, conditioning in air	Laboratory results	Values	4.88
			SR EN 13108-1	PRD_{AIR5}
		French Design Manuel LCPC, large size device, limits		$P_{7.5}$
BA16		Laboratory results	Values	17.68
			SR EN 13108-1	$PRD_{AIR\ NR}$
		605/2013 Norm, limits, max.%		PRD_{AIR5}
BBA16	Stiffness, 2PB-TR, 15°C, 10Hz	Laboratory results	Values	9054
			SR EN 13108-1	$S_{min9000}$
		French Design Manuel LCPC, limits		$S_{min7000}$
BA16	Stiffness, IT-CY, 20°C, 124µs	Laboratory results	Values	10243
			SR EN 13108-1	$S_{min9000}$
		Normative 605/2013, limits, min.		4600
BBA16	Resistance to fatigue, 2PB-TR, 10°C, 25Hz	Laboratory results	Values	$\varepsilon_6 = 230$
			SR EN 13108-1	ε_{6-220}
		French Design Manuel LCPC, limits		$\varepsilon_6 = 130$

4 Design flexible structure

4.1 Road

Flexible pavement design for roads is carried out in our country according to PD 177 Norm and assume following steps, [8]:

- establishing the traffic corresponding to a perspective period, expressed in 115KN standard axles, equivalent to vehicles which will travel on the road;
- establishing the bearing capacity at the formation level, depending on the type of soil, the climatic type of the area in which the road is located and hydrological regime of pavement;
- choosing the layers for pavement, consideration the materials prevalent in the region, minimum thickness constructive, maximum thickness, etc.;
- the pavement analysis to the standard axle load, considering the thickness of each layer and deformation characteristics of materials and the foundation soil;
- establishing the pavement behavior under traffic involves comparing the calculated specific strain values with the admissible values. This means compliance with the criterion of specific tensile straine on the based of asphalt layers (ε_r), which involves determining the rate of degradation to fatigue (RDO) as the ratio between calculated traffic (N_c) and the admissible traffic (N_{adm}) and the criterion of specific admissible vertical straine at formation level (ε_z);

To illustrate which is presented above, we considered a road pavement by following: 4 cm asphalt concrete BA 16 used in the wearing course (dynamic modulus = 3600 MPa, Poisson coefficient = 0.35), 6 cm asphalt concrete AB 16 used in the base course (dynamic modulus = 5000 MPa, Poisson coefficient = 0.35), 15 cm crushed stone (a dynamic modulus = 400 MPa, Poisson ratio = 0.27), 15 cm ballast (dynamic modulus = 172 MPa, Poisson coefficient = 0.27) and a type of soil P2 (sand and gravel, a dynamic modulus = 90 MPa, Poisson coefficient = 0.30). The traffic volume to which is loaded the road pavement is Nc = 0.95 m.o.s. (heavy traffic). With ALIZE program (elastic multi-layers) it was determined the specific straine values which we have compared with the admissible values according with Table 2.

Table 2 Verification of the flexible structure for roads

ε_r, microdef	ε_z, microdef	RDO	$\varepsilon_{z,\ admisibil}$, microdef	$RDO_{admisibil}$	N_c (m.o.s)
214.5	708.4	0.70	608.7	0.90	0.95

4.2 Airport

In our country there are no norms for design flexible pavement for airports, but one of the methods which take into account is the French method, which involves the following steps, [2, 9]:

- traffic forecasting during exploitation;
- determination the characteristics of the foundation soil, characterized by CBR (Californian Bearing Ratio);
- reviewing climatic factors;
- calculation of equivalent thickness of road pavement depending on the CBR value of the earth foundation and the adopted calculation load.

Actual thickness of the road pavement is obtained taking into account the constructive thickness and the equivalence coefficients that for treated materials with binders are considering the influence of temperature. The minimum equivalent thicknesses of the binder bounded layers is determined depending on the equivalent thickness of road structures and CBR. In order to compare the method of design for an airport pavement to the method of road pavement design we considered that knowed the load which acts to runways, P’’ = 73.2 t, type

of aircraft (B747-200), type of landing gear (bogie), foundation soil characterized by CBR = 10 (soil type P2) and the traffic corresponds to a period of exploitation of 10 years, by a factor of 1/3.65 and 10 overlapping movements / day.
With abacus corresponding for airplane type and CBR's were determined equivalent thickness of the road structure He = 57.25 cm. Considering the relation for the equivalent thickness calculation:

$$H_e = \sum_{i=1}^{n} h_i \cdot c_i \tag{2}$$

and equivalence coefficients resulted the following airport pavement: 6 cm asphalt concrete BBA 16 used in the wearing course (c_i = 2), 10 cm asphalt concrete EME used in the base course (c_i = 1.9), 15 cm crushed stone (c_i = 1), 15 cm ballast (c_i = 0.75).

5 Conclusions

There are no complete similarity between pavement for roads and pavement for airports. Unification of international technical standards for roads is recommended, and in the case of airport surfaces is obligatory (done by norms / recommendations ICAO). Grading curve of asphalt mix designed by French Design Manuel LCPC fall within the limits of grading for asphalt concrete AC 16 and for asphalt concrete BA 16. Characteristics of the designed asphalt mixtures is falling in the limits of EN 13108-1. Limits of values for voids volume to 80 gyrations, wheel tracking and stiffness modulus are near, but the airport asphalt mixture, according with French Design Manuel LCPC must satisfy the conditions of sensitivity to water and fatigue conditions which the Romanian norm does not provide for road asphalt mixture.
It should be noted that both pavements for roads and for airports have the same advanced technique, contrary for the each specifications. It is the natural evolution of design methods, of the materials and methods of construction.

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