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GENERAL ASPECTS CONCERNING THE NEED FOR RESEARCH, ASSIMILATION AND IMPLEMENTATION OF LONG LASTING FLEXIBLE ROAD PAVEMENTS IN ROMANIA

BY

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Abstract. The actual flexible pavements designed according to the existing norms are leading usually to overdesigned structures because of the lower values for the elastic modulus of the asphalt materials, specified in the existing norms. After a short introduction, presenting the general principles of flexible pavements design, the concepts of long lasting flexible pavements is considered in detail. Then a new research program, involving Accelerating Loading Test (ALT), undertaken in parallel with the experiments development on the road network, is proposed to the attention of the road policy decisions factors in this country. This research project, supported by specific design assumptions and calculations, takes into considerations the specific soil, climatic and traffic conditions of the road network in Romania. Finally the main conclusions and recommendations for assimilation and implementation of the long lasting flexible pavements in Romania are presented.

Key words: Long Lasting Flexible Pavements (LLFP); Accelerating Loading Test (ALT); structural design; design methods; design traffic.

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1. Introduction

As a new member of European Community, Romania is making significant efforts to integrate his transport infrastructure in the huge European road network. These efforts are focusing on rehabilitation and modernization of the existing road network and its development by using new modern and efficient methods for structural design in parallel with the implementation of new construction technologies. Our research is dedicated mainly to the assimilation and the development, in the specific traffic and climatic conditions of Romania, characterized by very severe winters and very hot summers, of the new concept of long lasting pavements, especially for the construction of the new roads and motorways. The actual flexible pavements designed according the existing norms (Roman. Doc. PD 177-200, 2001) are usually leading to overdesigned structures because of the lower values for the elastic module of the asphalt materials specified in the existing norms. The total thickness of classical pavement structures, currently used for important motorway projects in Romania, is currently reaching significant values ranging from 75 to 95 cm. In comparison with these traditional practices, the Long Lasting Flexible Pavements (LLFP), conceived on new principles and involving the use of high quality materials such as Stone Matrix Asphalt (SMA) (Andrei, 2002) are leading to thinner and in the same time more durable pavements. Here follows some typical example of long lasting flexible pavement structures envisaged to be studied on the Accelerating Testing Facility ALT-LIRA (Andrei, 2009) existing in the frame of "Gh. Asachi" Technical University of Iaşi (Fig. 1).

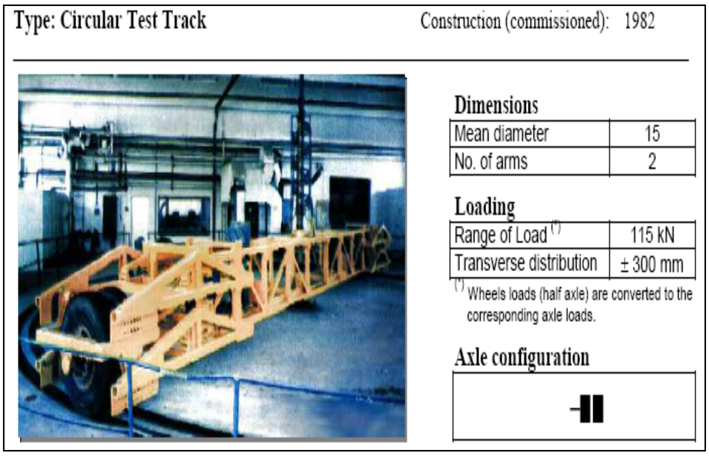

Fig. 1 – The accelerating testing circular track facility ALT-LIRA of "Gh. Asachi" Technical University of Iaşi (Andrei, 2009).

In order to evaluate the performance of these new LLFP's, in comparison with the classical ones, the following experiment (Fig. 2) involving the accelerating testing of a set of six distinct pavement sectors, including three witness classical ones (sector No. 1, No. 3 and No. 5) and other three LLFP sectors (No. 2, No. 4 and No. 6), constructed in accordance with the new LLFP concept, is envisaged to be realized in the near future on this performed facility. Traffic of 10, 30 and 60 million standard axle loads (m.s.a.) of 115 kN have been considered in the design of the new LLFP and also of the witness sectors, with the difference that the life of the LLFP structures was of 30 years instead of 15 years, used for the traditional structures.

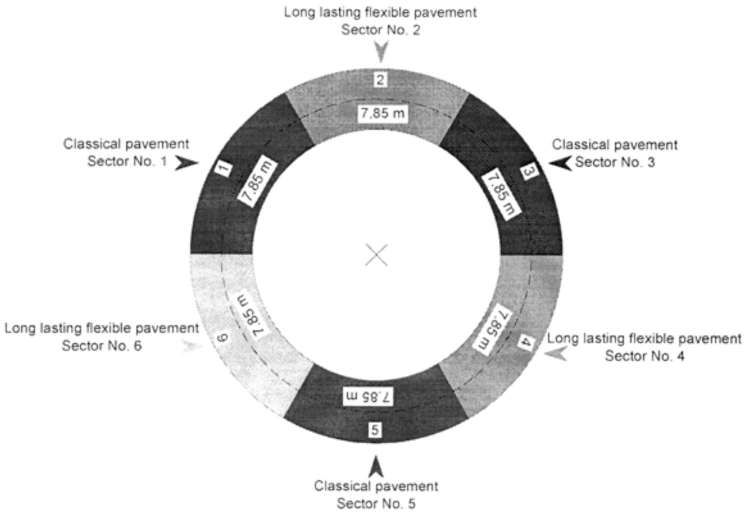

Fig. 2 – Experimental sectors envisaged to be tested on the circular track of the ALT-LIRA facility.

With the view that long lasting pavements be viable, they must perform from the perspectives of both engineering and economic considerations. Designing against structural defects, proper materials selection, good construction practices, and scheduling resurfacing activities to maintain the functionality of the pavement are the primary engineering concerns for performance (Asphalt Pavement Alliance, 2011). It is expected that efficient design, low maintenance rehabilitation costs, and long pavement life will ensure the economy of the pavement. In accordance with long lasting pavement concept it is necessary to periodically monitor the pavement condition, to identify surface distresses and to ensure they do not further progress into the structure than the top few cm of the pavement. Thus, distresses such as top-down fatigue cracking, thermal cracking, rutting and surface wear can be confined only to the wearing course by resurfacing. There are a number of case histories (Asphalt Pavement Alliance, 2011) that support the idea that thick, well-constructed asphalt pavements have distresses extending no deeper than their surfaces.

The future work involves the construction of the envisaged experimental sectors on the circular track facility of "Gh. Asachi" Technical

University of Iaşi, parallel with the construction of similar experimental sectors on a real motorway, selected on the existing public road network, followed by monitoring their performances in time and the drafting of specific technical recommendations for the design and construction of LLFP's.

2. Structural Design of Flexible Pavements

In this study two types of pavement structure have been considered, a classical one and an LLFP conceived according the principals mentioned above. This design study has been conducted conformably to Romanian norm PD *177*/2001 which is based on simultaneously observation of the following criteria:

a) the admissible tensile strain at the bottom of the bituminous layers;

b) the admissible compression strain at the subgrade level;

c) the admissible tensile strain at the bottom of the layer of natural aggregates stabilized with hydraulic or pozzolan binders.

This analytical design method involves the establishing of a specific road pavement structure and verification of the loading conditions of pavement, under the design traffic and also frost verifications.

The following input data are necessary for the design:

a) structure and intensity of traffic and their evolution;

b) the geotechnical characteristics of the subgrade;

c) the hydrological regime of the road pavement (type of cross section, the way of rainfall waters drainage, possibilities of drainage, level of ground water).

2.1. Conception and Design of Classical and Witness ALT Sectors

The experimental road sector envisaged for study was considered to be located in a climatic region type I, having cross sections in embankment with a

Table 1
The Classical Pavement Structures Selected for the Design

Layer Name	No. 1 / m.s.a.=10	No. 3 / m.s.a.=30	No. 5 / m.s.a.=60	E, [Mpa]	μ
	h, [cm]	h, [cm]	h, [cm]		
Wearing course (MASF 16/SMA)	4	5	5	4,000	0.35
Binder course (B.A.D. 25)	6	10	10	3,500	0.35
Bituminous base – AB2	15	15	15	5,000	0.35
Ballast stabilized with cement	20	20	30	1,000	0.25
Ballast foundation	25	35	35	156…223*	0.27
Subgrade/soil type – P5	∞	∞	∞	80	0.42

N o t e: *Function of the subgrade elasticity modulus according Roman. Dec. PD 177-200, 2001.

maximum height of 1.00 m, the subgrade soil being a P5 type according to Romanian Doc. PD *177-200*, 2001. In this hypothesis, and considering three categories of design traffic expressed in million standard axles (m.s.a.), namely: 10, 30 and respectively 60 m.s.a., the following pavement structures, as shown in Tables 1 and 2, have been studied.

Table 2
The Results of Classical Pavement Structures Selected for the Design

Pavement structure	N_c, m.s.a.	ε_r, micro - def	N_{adm}, m.s.a.	Design criteria					
				$\sigma_r \leq \sigma_{r\ adm}$		$\varepsilon_z \leq \varepsilon_{z\ adm}$		RDO ≤ RDO_{adm}	
				σ_r, MPa	$\sigma_{r\ adm}$, MPa	ε_z, micro - def	$\varepsilon_{z\ adm}$, micro - def	RDO	RDO_{adm}
Sector No. 1	10	69	21.39	0.107	0.218	177	177	0.48	0.80
Sector No. 3	30	55.2	51.87	0.080	0.207	124	131	0.58	0.80
Sector No. 5	60	49.8	78.06	0.060	0.200	102	109	0.77	0.80

As all design criteria are satisfied, as shown synthetically in Table 2, the classical pavement structures represented in Fig. 3 have been proposed to be tested in the frame of this research.

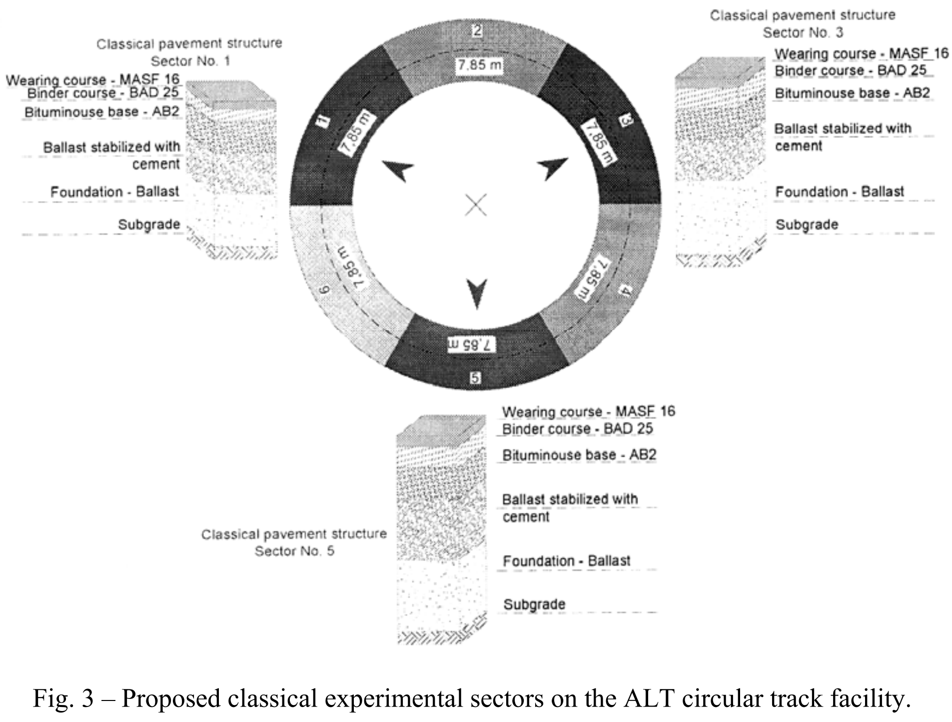

Fig. 3 – Proposed classical experimental sectors on the ALT circular track facility.

2.2. Conception and Design of Long Lasting Flexible Pavement – LLFP ALT Sectors

Adopting the same hypothesis concerning the experimental road sector, but considering higher categories of design traffic, namely: 20, 60 and 120 m.s.a., the following LLFP pavement sectors, as shown in Table 3, have been conceived and verified according PD *177*-2001 procedures.

Table 3
The LLFP Structures Selected for the Design

Layer Name	No. 2 / m.s.a.=20	No. 4 / m.s.a.=60	No. 6 / m.s.a.=120	E, [Mpa]	μ
	h, [cm]	h, [cm]	h, [cm]		
Upper (Wearing) course (MASF 16/SMA)	5	5	5	7,000	0.35
Medium compres-sion resistance course (Asphaltic Macadam)	25	30	30	6,000	0.35
Lower tensile resistance course (MASF 8/SMA)	5	5	5	7,000	0.35
Ballast Subbbase	25	30	45	192…250*	0.27
Subgrade/soil type – P5	∞	∞	∞	80	0.42

N o t e: *Function of the subgrade elasticity modulus according (Roman. Dec. PD 177-200, 2001).

Table 4
The results of LLFP Structures Selected for the Design

Pavement structure	N_c, m.s.a.	ε_r, micro - - def	N_{adm}, m.s.a.	Design criteria			
				$\varepsilon_z \leq \varepsilon_{z\text{ adm}}$		RDO ≤ RDO_{adm}	
				ε_z, micro - - def	$\varepsilon_{z\text{ adm}}$, micro - - def	RDO	RDO_{adm}
Sector No. 1	20	56.3	47.96	136	147	0.42	0.80
Sector No. 3	60	44.1	126.48	104	109	0.47	0.80
Sector No. 5	120	41.7	157.94	87.9	90	0.76	0.80

As all design criteria are satisfied, as shown synthetically in Table 4, the LLFP structure represented in Fig. 4 have been selected for study.

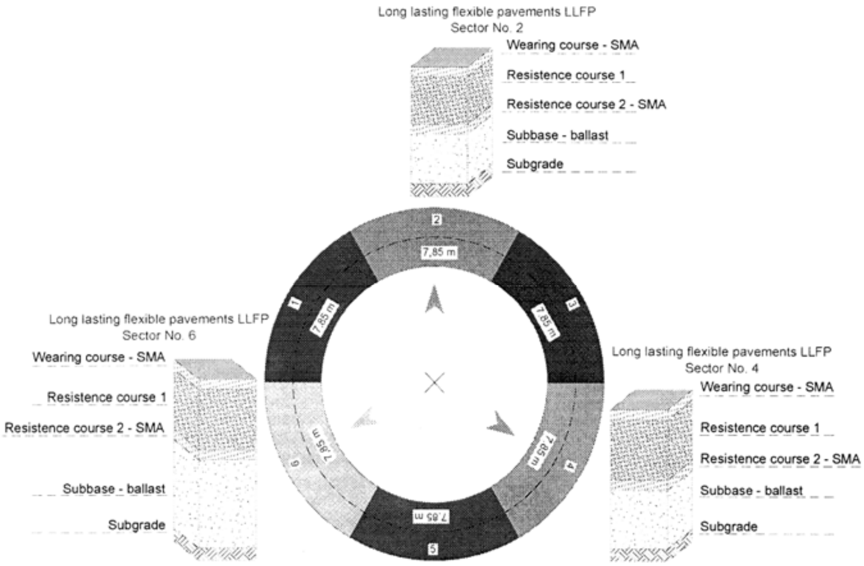

Fig. 4 – Proposed LLFP experimental sectors on the ALT circular track facility.

3. Checking Frost Resistance for Classical Pavements and LLFP

Frost resistance of both classical pavements and LLFP have been verified, according Romanian standards (STAS *1709*/*1*-90, *1709*/*2*-90, *1709*/*3*-90), taking into considerations the following particular conditions of the road project, envisaged for testing these pavements under real traffic loading:

a) Subgrade soil type: P5.
b) Climatic type: I.
c) Hydrological regime: 1.
d) Level of underground water: N_{af} = 300 cm.
e) Depth of freezing: 70 cm.

Table 5
Results of Frost Checking for Classical Pavements

Crt. No.	Frost checking characteristics of pavement structures	Sector/structure		
		No. 1	No. 3	No. 5
1	Total thickness, [cm]	70	85	95
2	$Z_{cr.}$, [cm]	96	101	105
3	ΔZ, [cm]	26	31	35
4	$H_{S.R.}$, [cm]	70	85	95
5	$H_{ech.}$, [cm]	44	54	60
6	$K_{ef.}$	0.46	0.53	0.57
7	$K_{adm.}$	0.40	0.40	0.40
$K_{ef.} \geq K_{adm.}$		0.46 > 0.40	0.53 > 0.40	0.57 > 0.40

The results of frost checking for classical pavements and LLFP are presented synthetically in Table 5 and, respectively, in Table 6. According to these results one may conclude that the essential condition established for the frost coefficient ($K_{ef.} \geq K_{adm.}$) is satisfied for both types of pavements.

Table 6
Results of Frost Checking for LLFP Pavements

Crt. No.	Frost checking characteristics of pavement structures	Sector/structure		
		No. 2	No. 4	No. 6
1	Total thickness, [cm]	60	70	85
2	$Z_{cr.}$, [cm]	92	96	100
3	ΔZ, [cm]	22	26	30
4	$H_{S.R.}$, [cm]	60	70	85
5	$H_{ech.}$, [cm]	38	44	55
6	$K_{ef.}$	0.41	0.46	0.55
7	$K_{adm.}$	0.40	0.40	0.40
$K_{ef.} \geq K_{adm.}$		0.41 > 0.40	0.46 > 0.40	0.55 > 0.40

4. Conclusions

This research study has been conducted on both classical and LLFP pavement structures selected to be studied on the existing Accelerating Testing Facility ALT-LIRA, at "Gh. Asachi" Technical University of Iaşi. The final synthetic results of the comparative study of both classical and LLFP pavements are presented in Table 7.

In relation with the results presented in Table 7 the following conclusions could be considered:

1. By using asphalt materials with higher elasticity modulus value (*e.g.* E = 6,000…7,000 MPa), and disposing them according to the LLFP concept, it is possible to construct flexible pavement structures with total thicknesses lower than those of classical/witness ones, but capable to support considerable higher design traffics.

2. These new LLFP structures proved also to be frost resistant when checked according the Romanian standards (STAS *1709*/*1*-90, *1709*/*2*-90, *1709*/*3*-90).

3. This research exercise will be extended in the near future, by considering a parallel design approach using the actual Romanian norm and the new methods, specially developed in the frame of the Asphalt Pavement Alliance (Asphalt Pavement Alliance, 2011) and also some other modern structural design methods, like Mechanistic-Empiric Pavement Design Guide ME-PDG (National Highway Inst., 2002) or the actual UK Highway Agency method (Design Manual for Roads and Bridges, 2010).

Table 7
The Final Synthetic Results of the Comparative Study of both Classical and LLFP Pavements

Classical pavement structure					Long lasting pavement structure				
Layer	Elasticity moduli E, [MPa]	Design traffic 10 m.s.a	Design traffic 30 m.s.a	Design traffic 60 m.s.a	Layer	Elasticity moduli E, [MPa]	Design traffic 20 m.s.a	Design traffic 60 m.s.a	Design traffic 120 m.s.a
Wearing course (MASF16/ SMA)	4,000	4	5	5	Upper (Wearing) course (MASF 16/SMA)	7,000	5	5	5
Binder course (B.A.D. 25)	3,500	6	10	10	Medium compression resistance course (Asphaltic Macadam)	6,000	25	30	30
Bituminous base (AB2)	5,000	15	15	15	Lower tensile resistance course (MASF 8/SMA)	7,000	5	5	5
Ballast stabilized with cement	1,000	20	20	30	Ballast subbase	192…250	25	30	45
Foundation (Ballast)	156…223	25	35	35	Subgrade/soil type P5	80	∞	∞	∞
Subgrade/ soil type P5	80	∞	∞	∞					
Total thickness, [cm]		70	75	95	Total thickness, [cm]		60	70	85

5. Future Work

Based on existing knowledge and latest developments in this field (Andrei, 2010; Kaur, 2011), the future work intends the construction of the envisaged experimental sectors on the circular track of the ALT facility of Technical University of Iaşi, parallel with the construction of similar experimental sectors, selected on the existing public road network, followed by monitoring their performances in time and the drafting of specific Technical Recommendations for the Design and Constructions of LLFP.

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ASPECTE GENERALE PRIVIND NECESITATEA CERCETĂRII, ASIMILĂRII ŞI IMPLEMENTĂRII STRUCTURILOR RUTIERE FLEXIBILE DURABILE ÎN ROMÂNIA

(Rezumat)

Structurile rutiere flexibile, dimensionate conform normelor româneşti existente, sunt de obicei supradimensionate datorită faptului că mixturile asfaltice specificate în standardele româneşti au un modul de elasticitate redus. În introducere sunt prezentate principiile generale ale proiectării îmbrăcăminţilor flexibile şi apoi sunt detaliate câteva aspecte privind proiectarea îmbrăcăminţilor flexibile durabile. În continuare, se propune, în atenţia factorilor de decizie, un nou program de cercetare, care implică încercări accelerate – ALT, în paralel cu realizarea unor sectoare experimentale pe reţeaua de drumuri existente din România. La baza acestui program de cercetare au stat ipotezele şi calculele de dimensionare a structurilor rutiere care iau în considerare tipurile de pământuri, zonele climatice şi condiţiile de trafic specifice reţelei de drumuri din România. In final sunt prezentate concluziile şi recomandările ce se impun pentru asimilarea şi implementarea structurilor rutiere flexibile durabile in România.