

3rd EUROPEAN PAVEMENT AND ASSET MANAGEMENT CONFERENCE - PAPERS by Paper Reference Number

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1021	SUSTAINING INFRASTRUCTURE SERVICES BY APPLICATION OF ASSET MANAGEMENT	Mante, Bart R.
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1029	ROAD ASSET MANAGEMENT AND TRANSPORTATION OF HAZARDOUS MATERIALS	Praticò, Filippo
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1091	EVALUATION OF SOIL-CEMENT STRENGTHS IN REGIONAL ROADS OF CASTILLA Y LEÓN	Gonzalo Orden, Hernán
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1093	THE USE OF DATA MINING TECHNIQUES FOR ROAD MAINTENANCE PLANNING	Giuliana, Giovanni
1095	MECHANICAL BEHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE UGL	Luzia, Rosa
1096	TRAFFIC SIMULATION TOOLS APPLIED TO PAVEMENT DESIGN	Vasconcelos, António
1099	HARMONIZATION OF PROJECT AND STRATEGIC LEVEL PAVEMENT MANAGEMENT	Mladenovic, Goran
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1113	PAVEMENT MANEGEMENT SYSTEM OF EP - ESTRADAS DE PORTUGAL, S.A. STRUCTURE AND THE FUNCTIONALITIES	Costa-Pereira, Francisco
1114	ROAD NETWORK:RESOURCE MANAGEMENT FOR ITS MAINTENANCE	Varela, Fernando
1116	FACTORS INFLUENCING THE RELIABILITY OF PAVEMENT PERFORMANCE MODELS	Gaspar, Laszlo
1117	DEVELOPMENT OF THE HUNGARIAN HIGHWAY ASSET MANAGEMENT	Gaspar, Laszlo
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1119	ROAD SAFETY MANAGEMENT IN LISBON: DEVELOPMENT OF EFFICIENT CORRECTIVE SAFETY MEASURES.	Carvalho, Carmen
1120	ACCIDENT PREDICTION MODELS FOR URBAN AREAS A STATE-OF-THE-ART	Gomes, Sandra Vieira
1129	MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT	Flintsch, Gerardo
1130	TRAFFIC DEPENDENT MARKOV TYPE MULTIPERIOD PMS MODEL	Bako, Andras
1132	PAVEMENT IMPACTS ON HIGHWAY RUNOFF QUALITY– ARE COASTAL AREAS SPECIAL CASES?	Antunes, Pedro
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1137	A MIXTURE MODEL FOR PREDICTING PATTERNS OF SPATIAL REPEATABILITY IN HEAVY VEHICLE FLEETS	O'Brien, Eugene
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1091	EVALUATION OF SOIL-CEMENT STRENGTHS IN REGIONAL ROADS OF CASTILLA Y LEÓN	Gonzalo Orden, Hernán
1092	ASPHALT RUBBER MIXTURES IN PORTUGAL: FATIGUE RESISTANCE	Miranda, Henrique
1093	THE USE OF DATA MINING TECHNIQUES FOR ROAD MAINTENANCE PLANNING	Giuliana, Giovanni
1095	MECHANICAL BEHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE UGL	Luzia, Rosa
1096	TRAFFIC SIMULATION TOOLS APPLIED TO PAVEMENT DESIGN	Vasconcelos, António
1099	HARMONIZATION OF PROJECT AND STRATEGIC LEVEL PAVEMENT MANAGEMENT	Mladenovic, Goran
1104	MODELING ROAD-TYRE NOISE	Martins, Mário
1106	RUTTING COMPARISON OF LABORATORY AND FIELD SAMPLES WITH VERIFIED REPEATED CREEP TESTS IN ASPHALT MIXTURES	Aksoy, Atakan
1112	A MAINTENANCE MANAGEMENT SYSTEM FOR THE STATE OF RIO GRANDE DO SUL PAVED ROADS	Pinto, Paulo
1113	PAVEMENT MANEGEMENT SYSTEM OF EP - ESTRADAS DE PORTUGAL, S.A. STRUCTURE AND THE FUNCTIONALITIES	Costa-Pereira, Francisco
1114	ROAD NETWORK:RESOURCE MANAGEMENT FOR ITS MAINTENANCE	Varela, Fernando
1116	FACTORS INFLUENCING THE RELIABILITY OF PAVEMENT PERFORMANCE MODELS	Gaspar, Laszlo
1117	DEVELOPMENT OF THE HUNGARIAN HIGHWAY ASSET MANAGEMENT	Gaspar, Laszlo
1118	CONTRIBUTION OF THE STATE ROAD REHABILITATION TO TRAFFIC SAFETY	Vajdić, Marko
1119	ROAD SAFETY MANAGEMENT IN LISBON: DEVELOPMENT OF EFFICIENT CORRECTIVE SAFETY MEASURES.	Carvalho, Carmen
1120	ACCIDENT PREDICTION MODELS FOR URBAN AREAS A STATE-OF-THE-ART	Gomes, Sandra Vieira
1129	MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT	Flintsch, Gerardo
1130	TRAFFIC DEPENDENT MARKOV TYPE MULTIPERIOD PMS MODEL	Bako, Andras
1132	PAVEMENT IMPACTS ON HIGHWAY RUNOFF QUALITY– ARE COASTAL AREAS SPECIAL CASES?	Antunes, Pedro
1133	MANAGEMENT OF SURFACE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES	Barranco, Jose Marcobal
1135	THE TRAFFIC AND TEMPERATURE EFFECT ON THE REFLECTIVE CRACKING	Minhoto, Manuel
1136	ANALYSIS OF PAVEMENT PERFORMANCE MODELS FOR USE IN PAVEMENT MANAGEMENT SYSTEMS	Ferreira, Adelino
1137	A MIXTURE MODEL FOR PREDICTING PATTERNS OF SPATIAL REPEATABILITY IN HEAVY VEHICLE FLEETS	O'Brien, Eugene
1138	CONTRIBUTIONS TO THE DEVELOPMENT OF THE PORTUGUESE ROAD ADMINISTRATION'S PAVEMENT MANAGEMENT SYSTEM	Ferreira, Adelino
1139	CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODEL	Santos, Bruno
1140	STUDY OF THE CAUSES AND REMEDIES OF PREMATURE SURFACE CRACKING OF ASPHALT PAVEMENTS	Pais, Jorge
1141	PAVEMENT MANAGEMENT SYSTEM ON A FRENCH HIGHWAY NETWORK	Giacobi, Cécile
1142	TOWARDS NOISE CLASSIFICATION OF ROAD PAVEMENTS	Freitas, Elisabete
1143	PRELIMINARY RESULTS OF A 2 GHZ HORN ANTENNA GPR ON A PAVEMENT SECTION IN PORTUGAL	Costa, Andre
1144	CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLCYLED CRUMBLED RUBBER	Dias, José
1145	TECHNOLOGIES FOR THIN-LAYER MAINTENANCE	Marquardt, Andreas
keynote	MECHANISTIC-EMPIRICAL PAVEMENT DESIGN AND PERFORMANCE PREDICTION, OPPORTUNITIES AND CHALLENGES FOR PMS	Flintsch, Gerardo



3rd European Conference on Pavement and Asset Management

General Program

Day 0		Sunday, 6 July 2008	
15:00 - 19:00	Registration (DEC main hall, level 2)		
Day 1		Monday, 7 July 2008	
08:00 - 17:00	Registration (DEC main hall, level 2)		
09:00 - 10:00	Opening Session (Room: Auditorio Laginha Serafim, level 3)		
10:00 - 11:00	Invited Lecturer (Room: Auditorio Laginha Serafim, level 3)		
11:00 - 11:30	Exhibition Inauguration and Coffee break (level 4)		
	Room: Auditorio Laginha Serafim (level 3)	Room: AFD 3.1 (level 3)	Room: SE 4.2 (level 4)
11:30 - 13:00	Session A1 Modelling Asset Performance - part 1	Session B1 Asset Condition Evaluation - part 1	
13:00 - 14:20	Lunch (tent with exit from Exhibition level, level 4)		
14:20 - 16:05	Session A2 Modelling Asset Performance - part 2	Session B2 Asset Condition Evaluation - part 2	
16:05 - 16:25	Coffee break (level 4)		
16:25 - 18:10	Session A3 Implementation of Management Systems - part1	Session B3 Asset Management - part 1	
18:15 - 20:00			COST 354
20:30 - 23:30	Reception at Sé Velha (Old Cathedral near the old campus of the University of Coimbra)		
Day 2		Tuesday, 8 July 2008	
08:00 - 17:00	Registration (DEC main hall, level 2)		
09:00 - 10:00	Invited Lecturer (Room: Auditorio Laginha Serafim, level 3)		
10:00 - 10:20	Coffee break (level 4)		
	Room: Auditorio Laginha Serafim (level 3)	Room: AFD 3.1 (level 3)	Room: SE 4.2 (level 4)
10:20 - 11:30	Session A4 Implementation of Management Systems - part2	Session B4 Asset Management - part 2	
11:30 - 13:10	Session A5 Pavement Technologies - part1	Session B5 Asset Manag. and Implem. of Manag. Sys - part 3	
13:10 - 14:20	Lunch (tent with exit from Exhibition level, level 4)		
14:20 - 16:05	Session A6 Pavement Technologies - part2	Session B6 Pavement Technologies - part3	DAWG
16:05 - 17:00	Session A7 Pavement Technologies - part4	Session B7 Pavement Technologies - part5	DAWG
17:00 - 17:30	Coffee break (level 4)		
17:30 - 18:15	Closing Session (Room: Auditorio Laginha Serafim, level 3)		
19:30 - 00:30	Banquet at Convento de Sandelgas (Sandelgas is about 20 km from Coimbra using EN 111 national highway)		
Day 3		Wednesday, 9 July 2008	
08:00 - 20:30	Technical Visit to Operations Centre of BRISA (main Portuguese motorways concessionaire) and visit to Sintra and the sea side at S. Martinho do Porto and Nazaré		



3rd European Conference on Pavement and Asset Management

Sessions Program

Day 0		Sunday, 6 July 2008	
15:00 - 19:00	Registration (DEC main hall, level 2)		
Day 1		Monday, 7 July 2008	
08:00 - 17:00	Registration (DEC main hall, level 2)		
09:00 - 10:00	Opening Session (Room: Auditorio Laginha Serafim, level 3)		
10:00 - 11:00	"ASSET MANAGEMENT IN PRACTICE" by Hamid Zarghampour (Room: Auditorio Laginha Serafim, level 3)		
11:00 - 11:30	Exhibition Inauguration and Coffee break (level 4)		
	Room: Auditorio Laginha Serafim (level 3)	Room: AFD 3.1 (level 3)	Room: SE 4.2 (level 4)
	Session A1	Session B1	
11:30 - 13:00	Modelling Asset Performance - part 1	Asset Condition Evaluation - part 1	
	A1.1 - FACTORS INFLUENCING THE RELIABILITY OF PAVEMENT PERFORMANCE MODELS	B1.1 - COST 354 - PERFORMANCE INDICATORS FOR ROAD PAVEMENTS	
11:30 - 11:42	L. Gáspár (ref. 1116)	J. Litzka, B. Leben, F. La Torre, A. Weninger-Vycudil, M. L. Antunes (ref. 1028)	
	A1.2 - DEVELOPMENT OF A TECHNICO-ECONOMIC OPTIMIZATION MODEL FOR PAVEMENT MAINTENANCE WORKS	B1.2 - THE NEW AUSTRIAN METHOD FOR THE STRUCTURAL ASSESSMENT OF PAVEMENT CONSTRUCTIONS FOR PMS PURPOSES	
11:42 - 11:54	P. Lepert, F. Brillet (ref. 1060)	A. Weninger-Vycudil; P. Simanek (ref. 1017)	
	A1.3 - BREAKING THE SILOS IN ASSET MANAGEMENT. COMPREHENSIVE OPTIMIZATION IN LONG-TERM PLANNING OVER MULTIPLE ASSET TYPES	B1.3 - FAMLIT - A NEW PAVEMENT ASSESSMENT TOOL	
11:54 - 12:06	D. Mrawira, L. Amador (ref. 1053)	N. Michel, R. Hassan, J. Roberts (ref. 1003) - Tim Martin	
	A1.4 - SECTION BASED PROBABILISTIC PERFORMANCE PREDICTION FICTION OR FUTURE?	B1.4 - BASIC PARAMETERS OF OPTIMUM, COST-EFFECTIVE BRIDGE MAINTENANCE AND REHABILITATION	
12:06 - 12:18	A. Weninger-Vycudil, G. Samek, T. Rohringer (ref. 1018)	L. Lubl6y (ref. 1041)	
	A1.5 - MULTIDIMENSIONAL APPROACH TO DESCRIBE BRIDGE DETERIORATION	B1.5 - SKID RESISTANCE AND TEXTURE OF COMPACTED ASPHALT MIXES EVALUATED BY THE IFI IN LABORATORY	
12:18 - 12:30	M. Petschacher, K. Gragger (ref. 1013)	G. Trich6s, L. Fontes, J. Pais, A. Ferreira, P. Pereira (ref. 1056)	
	A1.6 - A ROAD USER COSTS MODEL FOR PORTUGUESE TRUNK ROADS	B1.6 - VARIATION OF THE INTERNATIONAL ROUGHNESS INDEX VALUES IN FUNCTION OF THE HEAVY TRAFFIC	
12:30 - 12:42	B. Santos, L. Picado-Santos, V. Cavaleiro (ref. 1027)	L. Petho, C. Toth (ref. 1072)	
12:42 - 13:00	DISCUSSION	DISCUSSION	
13:00 - 14:20	Lunch (tent with exit from Exhibition level, level 4)		

3rd European Conference on Pavement and Asset Management

Sessions Program

Day 1		Monday, 7 July 2008	
08:00 - 17:00	Registration (DEC main hall, level 2)		
13:00 - 14:20	Lunch (tent with exit from Exhibition level, level 4)		
	Room: Auditorio Laginha Serafim (level 3)	Room: AFD 3.1 (level 3)	Room: SE 4.2 (level 4)
	Session A2	Session B2	
14:20 - 16:05	Modelling Asset Performance - part 2	Asset Condition Evaluation - part 2	
14:20 - 14:32	A2.1 - MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT	B2.1 - AN ALTERNATIVE DEFLECTION ANALYSIS FOR THE EVALUATION OF THE PAVEMENT CONDITION	
	Z. Wu, G. Flintsch, A. Ferreira, L. Picado-Santos (ref. 1129)	J. Oliveira, H. Silva, P. Pereira, A. Almeida (ref. 1080)	
14:32 - 14:44	A2.2 - A MIXTURE MODEL FOR PREDICTING PATTERNS OF SPATIAL REPEATABILITY IN HEAVY VEHICLE FLEETS	B2.2 - EFFECT OF ASPHALT LAYER THICKNESS VARIABILITY ON PREDICTED FLEXIBLE PAVEMENT LIFE	
	N. Harris, E. Obrien, S. Wilson (ref. 1137)	P. Valle, A. Collop, N. Thom (ref. 1065)	
14:44 - 14:56	A2.3 - ANALYSIS OF PAVEMENT PERFORMANCE MODELS FOR USE IN PAVEMENT MANAGEMENT SYSTEMS	B2.3 - IDENTIFYING STRUCTURAL CHANGES IN PAVEMENT PROFILES FROM TRAFFIC SPEED DEFLECTOGRAPH DATA	
	A. Ferreira, L. Picado-Santos, Z. Wu, G. Flintsch (ref. 1136)	M. Byrne (ref. 1061)	
14:56 - 15:08	A2.4 - TRAFFIC DEPENDENT MARKOV TYPE MULTIPERIOD PMS MODEL	B2.4 - ANALYSIS OF URBAN PAVEMENT SURFACE PROFILES ORIENTED TO ENVIRONMENTAL PERFORMANCE	
	A. Bakó, K. Ambrus-Somogyi, T. Hartványi, I. Szüts (ref. 1130)	V. Nicolosi, M. D'Apuzzo, B. Festa, L. Mancini (ref. 1033)	
15:08 - 15:20	A2.5 - ACCIDENT PREDICTION MODELS FOR URBAN AREAS A STATE-OF-THE-ART	B2.5 - PRELIMINARY RESULTS OF A 2 GHZ HORN ANTENNA GPR ON A PAVEMENT SECTION IN PORTUGAL	
	S. Gomes, J. Cardoso, C. Carvalheira, L. Picado-Santos (ref. 1120)	A. Costa, A. Correia (ref.1143)	
15:20 - 15:32	A2.6 - MODELING ROAD-TYRE NOISE	B2.6 - TOWARDS NOISE CLASSIFICATION OF ROAD PAVEMENTS	
	M. Martins, L. Picado-Santos, E. Freitas (ref. 1104)	E. Freitas, J. Paulo, J. Coelho, P. Pereira (ref. 1142)	
15:32 - 15:44	A2.7 - TRAFFIC SIMULATION TOOLS APPLIED TO PAVEMENT DESIGN	B2.7 - CONDITION ASSESSMENT ON CYCLE PATHS WITH A NEWLY DEVELOPED MEASURING TECHNOLOGY	
	A. Vasconcelos, A. Silva, A. Seco, J. Silva (ref. 1096)	R. Anger, A. Schniering (ref. 1082)	
15:44 - 16:05	DISCUSSION	DISCUSSION	
16:05 - 16:25	Coffee break (level 4)		



3rd European Conference on Pavement and Asset Management

Sessions Program

Day 1		Monday, 7 July 2008	
08:00 - 17:00	Registration (DEC main hall, level 2)		
16:05 - 16:25	Coffee break (level 4)		
	Room: Auditorio Laginha Serafim (level 3)	Room: AFD 3.1 (level 3)	Room: SE 4.2 (level 4)
	Session A3	Session B3	
16:25- 18:10	Implementation of Management Systems - part1	Asset Management - part 1	
16:25 - 16:37	A3.1 - MAINTENANCE MANAGEMENT FOR THE CLASSIFIED ROAD NETWORK	B3.1 - LIFETIME ENGINEERING IN ROAD ASSET MANAGEMENT	
	A. Künkel-Henker, Mario Krmek (ref. 1026)	L. Gáspár (ref. 1000)	
16:37 - 16:49	A3.2 -IMPLEMENTATION OF A COMMUNAL PMS IN GERMANY - STATE-OF-THE-ART	B3.2 - TRANSPORTATION ASSET MANAGEMENT IN THE UNITED STATES	
	R. Roos, M. Stöckner, A. Grossmann (ref. 1009)	J. Wlaschin (ref. 1014)	
16:49 - 17:01	A3.3 - A MAINTENANCE MANAGEMENT SYSTEM FOR THE STATE OF RIO GRANDE DO SUL PAVED ROADS	B3.3 - ROAD ASSET MANAGEMENT –MAIN MAINTENANCE MEASURES: BACKLOG AND EFFECTIVENESS	
	R. Rodrigues, F. Gonçalves, P. Pinto, E. Taffe Jr. (ref. 1112)	J. Potucek (ref. 1019)	
17:01 - 17:13	A3.4 - PAVEMENT MANEGEMENT SYSTEM OF EP - ESTRADAS DE PORTUGAL, S.A. STRUCTURE AND THE	B3.4 - HARMONIZATION OF PROJECT AND STRATEGIC LEVEL PAVEMENT MANAGEMENT	
	F. Pereira, E. Duarte, T. Moital (ref. 1113)	K. Tsunokawa, G. Mladenovic, A. Djurekovic, S. Marin (ref. 1099)	
17:13 - 17:25	A3.5 - CONTRIBUTIONS TO THE DEVELOPMENT OF THE PORTUGUESE ROAD ADMINISTRATION’S PAVEMENT	B3.5 - BRIDGE MANAGEMENT PLAN AND STRATEGY	
	L. Picado-Santos, A. Ferreira (ref. 1138)	B. Kuvačić, S. Jurić (ref. 1008)	
17:25 - 17:37	A3.6 - PAVEMENT MANAGEMENT SYSTEM ON A FRENCH HIGHWAY NETWORK	B3.6 - SUSTAINING INFRASTRUCTURE SERVICES BY APPLICATION OF ASSET MANAGEMENT	
	C. Giacobi, E. Layerle (ref. 1141)	H. Altena, R. Kuijper, B. Mante (ref. 1021)	
17:37 - 17:49	A3.7 - IMPLEMENTATION OF A STOCHASTIC PMS MODEL	B3.7 - PRIVATE PARTICIPATION IN MANAGING ROAD ASSETS	
	M. Socina (ref. 1031)	O. Gutiérrez-Bolivar, M. Torrens (ref. 1045)	
17:49 - 18:10	DISCUSSION	DISCUSSION	
18:15 - 20:00			COST 354
20:30 - 23:30	Reception at Sé Velha (Old Cathedral near the old campus of the University of Coimbra)		



3rd European Conference on Pavement and Asset Management

Sessions Program

Day 2 Tuesday, 8 July 2008

08:00 - 17:00 Registration (DEC main hall, level 2)

09:00 - 10:00 [MECHANISTIC-EMPIRICAL PAV. DSGN. AND PERF. PREDICTION, OPPORT. AND CHALL. FOR PMS by Gerardo Flintsch \(Room: Auditorio Laginha Serafim, level 3\)](#)

10:00 - 10:20 Coffee break (level 4)

Room: Auditorio Laginha Serafim (level 3)

Room: AFD 3.1 (level 3)

Room: SE 4.2 (level 4)

	Session A4	Session B4
10:20 - 11:30	Implementation of Management systems - part 2	Asset Management - part 2
10:20 - 10:32	A4.1 - DEVELOPMENT OF THE HUNGARIAN HIGHWAY ASSET MANAGEMENT	B4.1 - A NEW DETERMINISTIC OPTIMIZATION MODEL PROPOSED TO BE USED IN THE PMS OF A PORTUGUESE MUNICIPALITY
	L. Gáspár (ref. 1117)	S. Meneses, A. Ferreira, L. Picado-Santos, P. Pereira (ref. 1015)
10:32 - 10:44	A4.2 - ROAD NETWORK:RESOURCE MANAGEMENT FOR ITS MAINTENANCE	B4.2 -INTEGRATION OF PAVEMENT MANAGEMENT SYSTEMS AND BRIDGE MANAGEMENT SYSTEMS
	F. Soto, R. Loranca (ref. 1114)	L. Neves, A. Ferreira (ref. 1054)
10:44 - 10:56	A4.3 -PAVEMENT MANAGEMENT SYSTEM ON THE STRATEGIC AND OPERATIVE LEVEL	B4.3 -HIGH PRODUCTIVITY VEHICLES AND PAVEMENT ECONOMIC IMPACTS
	S. Heller (ref. 1024)	R. Hassan, T. Thoresen, T. Martin, R. Roper (ref. 1002)
10:56 - 11:18	A4.4 - ENGINEERING STRUCTURES MANAGEMENT SYSTEM:EXAMPLE ON A FRENCH HIGHWAY NETWORK	B4.4 -ROAD ASSET MANAGEMENT AND TRANSPORTATION OF HAZARDOUS MATERIALS
	I. Simon, M. Trains (ref. 1048)	F. Praticò, R. Ammendola, A. Moro (ref. 1029)
11:18-11:30	Discussion	Discussion
11:30 - 13:10	Session A5 Pavement Technologies - part1	Session B5 Asset Manag. and Implem. of Manag. Sys - part 3



3rd European Conference on Pavement and Asset Management

Sessions Program

Day 2		Tuesday, 8 July 2008	
08:00 - 17:00	Registration (DEC main hall, level 2)		
	Room: Auditorio Laginha Serafim (level 3)	Room: AFD 3.1 (level 3)	Room: SE 4.2 (level 4)
10:20 - 11:30	Session A4 Implementation of Management systems - part 2	Session B4 Asset Management - part 2	
11:30 - 13:10	Session A5 Pavement Technologies - part 1	Session B5 Asset Manag. and Implem. of Manag. Sys - part 3	
11:30 - 11:42	A5.1 - TECHNOLOGIES FOR THIN-LAYER MAINTENANCE A. Marquardt	B5.1 - SPEED MANAGEMENT IN REGIONAL AND NATIONAL SINGLE CARRIAGEWAY THROUGH ROADS: AN INTEGRATED APPROACH A. Seco, A. Silva, C. Galvão (ref. 1083)	
11:42 - 11:54	A5.2 - A. Marquardt (ref. 1145)	B5.2 - CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODEL B. Santos, A. Antunes (ref. 1139)	
11:54 - 12:06	A5.3 - MIX DESIGN FOR COLD-IN-PLACE PAVEMENT RECYCLING; DOES IT GUARANTEE PERFORMANCE? Z. Sufian, N. Aziz, M. Motori, M. Hussain (ref.1059)	B5.3 - ROADEX – A ROADS TECHNICAL COLLABORATION ACROSS THE EUROPEAN NORTHERN PERIPHERY R. Munro, T. Saarenketo, K. Palo (ref. 1081)	
12:06 - 12:18	A5.4 (ex- A6.2) - LABORATORY OPTIMIZATION OF CONTINUOUS BLEND ASPHALT RUBBER L. Fontes, P. Pereira, G. Trichês, J. Pais, R. Luzia (ref. 1071)	B5.4 - THE USE OF DATA MINING TECHNIQUES FOR ROAD MAINTENANCE PLANNING B. Festa, L. Sparavigna, G. Giuliana (ref. 1093)	
12:18 - 12:30	A5.5 - PERFORMANCE-BASED MIX DESIGN METHOD FOR BITUMINOUS HOT-MIX RECYCLING IN PLANT A. Baptista, L. Picado-Santos, S. Capitão, J. Oliveira (ref. 1088)	B5.5 - CONTRIBUTION OF THE STATE ROAD REHABILITATION TO TRAFFIC SAFETY M. Sršen, N. Sukalić, M. Vajdić (ref. 1118)	
12:30 - 12:42	A5.6 - CHARACTERIZATION OF ROAD BASES AND SUBBASES MADE OF RECLAIMED ASPHALT PAVEMENT AND RECYCLED CONCRETE AGGREGATE R. Taha, K. Alshamsi (ref. 1006)	B5.6 - SPANISH NATIONAL ROAD NETWORK PAVEMENT MANAGEMENT SYSTEM A. Navareño, V. Gómez (ref. 1090)	
12:42 - 12:54	DISCUSSION	B5.7 - ROAD SAFETY MANAGEMENT IN LISBON. DEVELOPMENT OF EFFICIENT CORRECTIVE SAFETY MEASURES C. Carvalho, L. P.-Santos, S. Gomes, J. Cardoso (ref. 1119)	
12:54 - 13:10	DISCUSSION	DISCUSSION	
13:10 - 14:20	Lunch (tent with exit from Exhibition level, level 4)		

3rd European Conference on Pavement and Asset Management

Sessions Program

Day 2		Tuesday, 8 July 2008		
08:00 - 17:00	Registration (DEC main hall, level 2)			
13:10 - 14:20	Lunch (tent with exit from Exhibition level, level 4)			
	Room: Auditorio Laginha Serafim (level 3)	Room: AFD 3.1 (level 3)	Room: SE 4.2 (level 4)	
14:20 - 16:05	Session A6 Pavement technologies - part 2	Session B6 Pavement technologies - part 3	DAWG	
14:20 - 14:32	A6.1 - THE USE OF THE GYRATORY COMPACTOR IN THE DESIGN OF PORTUGUESE BITUMINOUS MIXTURES D. Gardete, L. Picado-Santos, S. Capitão, H. Silva (ref. 1087)	B6.1 - EVALUATION OF SOIL-CEMENT STRENGTHS IN REGIONAL ROADS OF CASTILLA Y LEÓN J. Berzosa, H. Orden (ref. 1091)		
14:32 - 14:44	A6.2 (ex- A5.4) - RECYCLING OF ASPHALT PAVEMENTS WITH ASPHALT RUBBER J. Pais, P. Pereira, M. Minhoto, A. Baptista (ref. 1068)	B6.2 - MECHANICAL BEHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE UGL R. Luzia, L. Picado-Santos, P. Pereira (ref. 1095)		
14:44 - 14:56	A6.3 - A COMPARISON BETWEEN THE LIFE OF A RECYCLED ASPHALT PAVEMENT AND A NEW ONE M. Centeno, H. Orden, A. Martínez (ref. 1089)	B6.3 - NEW AND OLD TECHNOLOGIES FOR THE DETERMINATION OF DENSITY OF HMAs F. Praticò, A. Moro, R. Ammendola (ref. 1030)		
14:56 - 15:08	A6.4 - ASPHALT RUBBER MIXTURES IN PORTUGAL: FATIGUE RESISTANCE H. Miranda, F. Batista, J. Neves, M. Antunes, P. Fonseca (ref. 1092)	B6.4 - DEM SIMULATION OF FIELD ASPHALT COMPACTION R. Micaelo, M. Azevedo, J. Ribeiro, N. Azevedo (ref. 1067)		
15:08 - 15:20	A6.5 - INFLUENCE OF TEMPERATURE ON THE FATIGUE LIFE OF FLEXIBLE PAVEMENTS H. Silva, J. Oliveira, L. Picado-Santos (ref. 1075)	B6.5 - STUDY ON THE CONSEQUENCES OF AFFIXING THE CE MARKING TO BITUMINOUS MIXTURES H. Silva, C. Palha, D. Gardete, S. Capitão (ref. 1077)		
15:20 - 15:32	A6.6 - RUTTING COMPARISON OF LABORATORY AND FIELD SAMPLES WITH VERIFIED REPEATED CREEP TESTS IN A. Aksoy, E. Iskender, H. Ozen (ref. 1106)	B6.6 - MANAGEMENT OF SURFACE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF J. Marcobal (ref. 1133)		
15:32 - 15:44	A6.7 - THE TRAFFIC AND TEMPERATURE EFFECT ON THE REFLECTIVE CRACKING M. Minhoto, J. Pais, P. Pereira (ref. 1135)	B6.7 - EXPERIMENTAL ANALYSIS OF INNOVATIVE JOINTS IN REHABILITATION OF AIRPORT PAVEMENTS G. Rios, F. Fiori, M. Pozzi (ref. 1035)		
15:44 - 16:05	DISCUSSION	DISCUSSION		
16:05 - 17:00	Session A7 Pavement Technologies - part4	Session B7 Pavement Technologies - part5	DAWG	



3rd European Conference on Pavement and Asset Management

Sessions Program

Day 2		Tuesday, 8 July 2008	
14:20 - 16:05	Session A6 Pavement technologies - part 2	Session B6 Pavement technologies - part 3	DAWG
16:05 - 17:00	Session A7 Pavement technologies - part 4	Session B7 Pavement technologies - part 5	DAWG
16:05 - 16:17	A7.1 -CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBER J. Dias, L. Picado-Santos (ref. 1144)	B7.1 - PAVEMENT IMPACTS ON HIGHWAY RUNOFF QUALITY- ARE COASTAL AREAS SPECIAL CASES? P. Antunes, A. Barbosa (ref. 1132)	
16:17 - 16:29	A7.2 -EVALUATING EFFECT OF FILM THICKNESS ON AGING OF ASPHALT THROUGH THIN FILM OVEN TEST R. Choundhary, S. Chandra (ref. 1070)	B7.2 - THEORETICAL BASIS FOR THE TREATMENT OF LONG DRAINAGE PATHS ON MOTORWAYS G. Griffiths, P. Valle (ref. 1064)	
16:29 - 16:41	A7.3 - RELATION BETWEEN ZERO SHEAR VISCOSITY AND ZERO FREQUENCY COMPLEX VISCOSITY AT DIFFERENT TEMPERATURES V. Nguyen, G. Airey, M. Liao (ref. 1078)	B7.3 - THE EFFECT OF DRAINAGE CONDITION ON THE LIFETIME OF PAVED ROADS IN NORTHERN EUROPE T. Saarenketo (ref. 1066)	
16:41 - 17:00	DISCUSSION	DISCUSSION	
17:00 - 17:30	Coffee break (level 4)		
17:30 -18:15	Closing Session (Room:Auditório Laginha Serafim,Level 3)		
19:30 - 00:30	Banquet at Convento de Sandelgas (Sandelgas is about 20 km from Coimbra using EN 111 national highway)		
Day 3		Wednesday, 9 July 2008	
08:00 - 20:30	Technical Visit to Operations Centre of BRISA (main Portuguese motorways concessionaire) and visit to Sintra and the sea side at S. Martinho do Porto and Nazaré		

THE TRAFFIC AND TEMPERATURE EFFECT ON THE REFLECTIVE CRACKING

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Abstract

This paper presents a study on the influence of the effects of temperature variations, in comparison to the traffic effects, on the reflective cracking behavior. It intends to contribute to the improvement of the pavement overlay design methods which consider reflective cracking as one among distress criteria. The development of this study was based on the numerical simulation of the overlay behavior, through the implementation of numerical thermal and mechanical models based on the finite element, considering the simultaneous action of traffic and temperature variations and their influence on reflective cracking. For overlay design purposes, it is important to consider temperature variations in the evaluation of the overlay behavior produced by the reflective cracking. The expected performance of an asphalt rubber hot mix, produced by the wet process with 20% crumb rubber was compared to a conventional asphalt taking into account the performance of these mixes.

INTRODUCTION

Bituminous overlays have been the most used method to rehabilitate cracked pavements and their service life depends on their performance in different distress modes. When an overlay is placed on a cracked pavement, cracks will develop and propagate to the pavement surface, directly above the cracks of the existing pavement, due to static and repetitive loading, in a few years of service. This phenomenon of distress is traditionally referred as "reflective cracking" and it is a major problem to highway agencies throughout the world (De Bondt, 2000).

Daily and seasonal temperature variations, and associated thermal stresses, maybe a cause for premature overlay cracking, affecting the overlay life of asphalt pavements (Epps, 1997). The binder properties (stiffness, ageing, penetration, among others) are sensitive to temperature variations and the combination of the two most important effects - wheel loads passing above (or near) the crack and the tension increase in the material above the crack (in the overlay) due to a rapid decrease of temperature - have been identified as the most likely causes of high states of stress and strain above the crack and responsible for the reflective cracking phenomena (Sousa et al., 2002).

Thus, due to daily temperature variations, which show an influence in the pavement thermal state a few centimetres below the surface, stresses are induced in the overlay in two different ways: through restrained shrinkage of the overlay and through the movements of the existing blocks resulting of thermal shrinkage (Halim, 1989).

An analytical study about reflective cracking which considered temperature variations was performed throughout a year to evaluate the temperature influence on overlay reflective cracking behaviour. To perform this study, it was necessary to consider temperature variations in all bound layers and the overlay restrained shrinkage phenomenon. For that, a numerical analysis based on 3-D Finite Element methodology was adopted for the numerical simulation of that phenomenon (Minhoto, 2007).

The theoretical modelling of that mechanical mechanism needs the evaluation of material properties, in terms of stiffness modulus, thermal contraction coefficient and viscoelastic response, expressed by relaxation modulus. For the overlay behavior evaluation through a numerical simulation, two hot-mix types were considered: a conventional hot-mix asphalt overlay and an asphalt-rubber hot mix, produced with 20% crumb rubber by the wet process.

STUDY BACKGROUND

This study involves the calculation of the hourly stresses and strains generated by traffic and thermal loading, characterized through the temperature variation in the full-depth of the pavement. The temperature distribution throughout the pavement structure was obtained using field measurements recorded with a datalogger associated with thermocouples, made in a pavement section located at IP4 main road, near Bragança, in the north of Portugal, throughout a year. Traffic data were obtained from field measurements near the temperature measurements location.

Stresses and strains calculations were performed using a 3D Finite Element analysis (FE) for each loading case. For thermal loading, the behavior of bituminous material was considered as viscoelastic, characterized by relaxation modulus, once the overall state of tension in the overlay caused by the temperature variation is time-dependent. For traffic loading, the bituminous material behavior was considered as elastic, characterized by the stiffness modulus. The maximum stresses and strains are concentrated above the existing cracks, creating an active zone of pavement failure or crack propagation. The calculated traffic and thermal stresses and strains were used to verify the influence of the thermal loading in the overlay behavior, through the evaluation of the damage associated to each type of loading.

The overlay damage, during the year, was hourly obtained by comparing the traffic effectively observed with the hourly predicted overlay life that results from each loading case. The evaluation of overlay life for each loading case was made with basis on the mechanistic-empirical methodology proposed by Sousa et al. (2002), which is capable of assembling simultaneously Modes I and II crack opening. In that methodology the influence of pavement characteristics on state of stress and strain was considered by using the Von Mises strain deviator, as expressed in Equation 1:

$$\varepsilon_{VM} = \frac{1}{1+\nu} \sqrt{\frac{1}{2} \left((\varepsilon_1 - \varepsilon_2)^2 + (\varepsilon_1 - \varepsilon_3)^2 + (\varepsilon_2 - \varepsilon_3)^2 \right)} \quad (1)$$

where ε_{VM} is the Von Mises strain, ν is the Poisson's coefficient and $\varepsilon_1, \varepsilon_2, \varepsilon_3$, are the principal strains. This methodology uses the deviator strain, ε_{VM} , as a "controller", to compare with the results of flexural fatigue tests, in controlled strain, to obtain the predicted overlay life.

SIMULATION PROCEDURES

The simulation procedures involve a multiple 3-D finite-element calculations and each solution was obtained hourly, for each loading case (traffic, temperature variation and both superimposed) and for each axle load type. First, the thermal model, using the steady-state thermal analysis, computes temperatures hourly in all nodes of the mechanical models. These temperatures are needed to set the elements stiffness in traffic models and to calculate the temperature variation, ΔT , in each node, in the thermal model. This temperature variation, ΔT , allows the thermal strain calculation, $\Delta \varepsilon$, given by $\Delta \varepsilon = \alpha * \Delta T$. The thermal strain, when restrained, allows thermal stress calculation as a result of temperature decrease.

The strain and stress states obtained for traffic loading and temperature variations were superimposed (added), to obtain the stress and strain states for superimposed loading. After that operation, the average Von Mises strains in the nodes above the crack zone were computed for each loading case. The Von Mises Strains were used to estimate the overlay life for each studied case.

Equation 1 was used to relate the average Von Mises strain with a fatigue strain concept used on flexural fatigue laws, normally used to evaluate the prediction of pavement life. In this way, the Von Mises strain was related with fatigue laws used in pavement analysis, obtained from four-points flexural fatigue tests, to estimate of the overlay fatigue life. For each hour, the overlay life is obtained for nodal temperature occurred in the zone above the crack.

After overlay life computation, the hourly damage was evaluated. It was obtained as the ratio between observed traffic and overlay life, expressed in number of axles, following the equation:

$$D_{h,e} = \frac{N_{h,e}}{N_{adm,h,e}} \quad (2)$$

where: $D_{h,e}$ = Hourly damage of axle "e", at hour "h";
 $N_{h,e}$ = Number of axles "e" observed at hour "h";
 $N_{adm,h,e}$ = Number of predicted axles, for axle "e", at hour "h".

LOADS

In order to calculate pavement thermal effects and the thermal response of mixes, the temperature distribution in bituminous layers evaluation was made during periods of twenty-four hours along the year of 2004. These temperature distributions allow calculating thermal effects in the zone above the crack. Pavement thermal state variations depend on the climatic conditions, by the thermal diffusivity of used materials (thermal conductivity, specific heat and density) and the depth below the surface (Minhoto et al., 2005).

The temperature distribution throughout the pavement structure, at every hour of the day and night, during a year, was obtained by field measurements, using a temperature-recording

equipment (Datalogger with thermocouples). During twelve months (January 2004 to December 2004) pavement temperatures were measured on a new pavement section, located at IP4 main road, near Bragança, in the north of Portugal. At that location, seven thermocouples were installed in the pavement, at seven different depths: at surface, 27.5 mm, 55 mm, 125 mm, 165 mm, 220 mm and 340 mm, in a pavement with a 0.125 m overlay layer and a 0.215 m cracked layer. The top one was installed on the pavement surface. The depths for the other six were chosen to provide a good representation of the whole asphalt concrete layers. Figure 1 shows the observed surface temperature where it can be observed the typical temperature variations at summer and at winter periods.

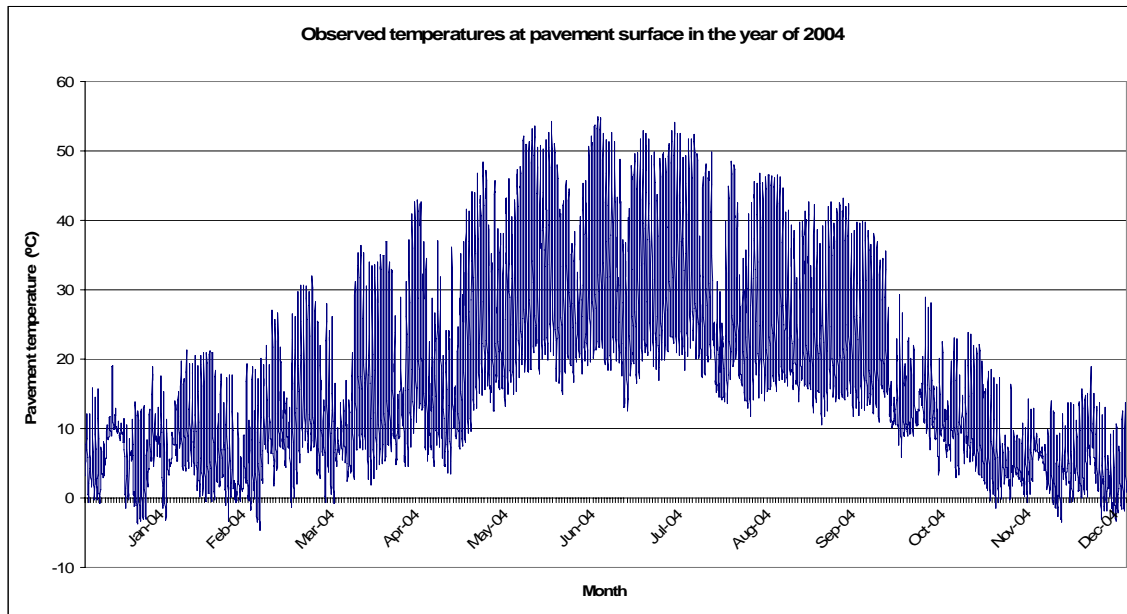


Figure 1 – Observed temperatures at pavement surface

The traffic data were obtained in terms of number of axles, type of axles and wheel load. The number of axles is useful to calculate the damage associated to the traffic. The wheel load configuration, considered in the numerical simulation, is defined as a surface load (pressure) near the vertical location of the crack, simulating the 130 kN standard axle load.

PAVEMENT MODELLING

The pavement structure was idealized as a set of horizontal layers, with constant thickness, resting on the subgrade. For crack reflection analysis, the top layer represents the bituminous overlay and the subjacent layer represents the existing cracked bituminous layer, where a crack is modelled by elements without stiffness. The structural model configuration of the analysed pavement is presented in Figure 2.

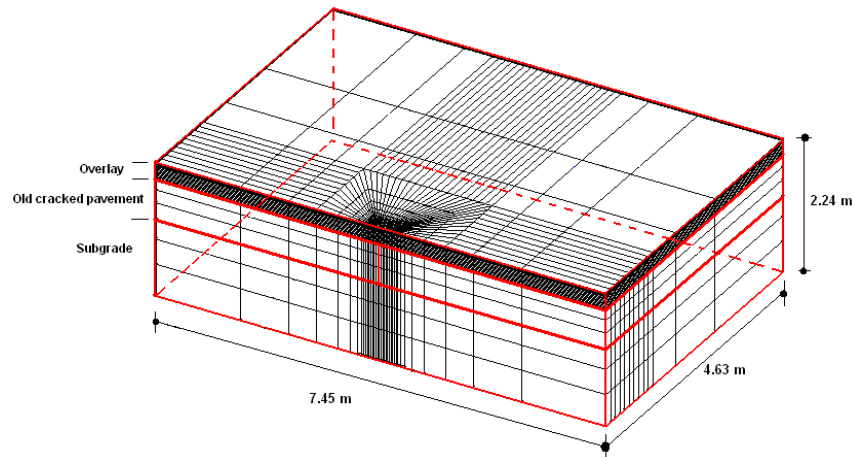


Figure 2 – FE structural model configuration for numerical simulation

The FE model used in numerical analysis was developed by using a ANSYS 7.0 source code and the mechanical model was designed with a three-dimensional finite element mesh, based on a 3-D eight-node structural solid element, that assumes linear approximation of the displacements field and has three degrees of freedom per node.

The analyzed body had a length of 4.63 m, 7.45 m wide and 2.24 m thickness. The total thickness of the model is the result of all pavement layers thicknesses: 0.125 m overlay, 0.215 m cracked layer, 0.30 m aggregate base layer and 1.6 m subgrade. The crack was modelled on the layer just below the overlay, with 10 mm width and longitudinal cracks were simulated.

The processing type of the model depends on the loading case considered in the evaluation of stress and strain states. For thermal loading effects on the overlay, through the evaluation of the mechanical effect of temperature variations, the processing was made as a numerical transient analysis (time-rate dependent), as it is a long term load type, and the material properties must be defined as time-rate dependent, by defining the mechanical behavior through the relaxation modulus. For traffic load the linear elastic analysis was used.

MECHANICAL PROPERTIES

The mechanical properties of the bituminous materials considered in the processing of models were obtained from a set of laboratory tests and are: stiffness modulus, viscoelastic properties (relaxation modulus) and thermal contraction coefficient. In order to estimate the reflective cracking overlay life, fatigue laws were obtained from four-point flexural fatigue tests, for several temperatures.

In this study two types of bituminous mixes were analysed: an asphalt rubber hot mix and a conventional hot mix asphalt. These mixes were extracted from the pavement located on a trial section on Km 197.700 of IP4. In both cases, slabs were obtained from “in situ” pavement, after “in place” operations. For the conventional dense asphalt mix (CM) the binder used was a PG 70-10 (50/70) and the binder content was 5.4 %. The aggregates used were derived from good quality Portuguese granite, extracted near the trial section.

Stiffness modulus

The stiffness modulus, which is temperature-dependent, was evaluated from flexural fatigue tests, conducted according to the AASHTO TP 8-94, performed for 4 different temperatures: -5°C; 5°C, 15 °C and 25°C. In that way, it was considered that the bituminous materials show a linear elastic behavior. The values obtained for the stiffness modulus are presented in Table 1, for both materials modelled, i.e. asphalt rubber hot mix and conventional asphalt mix.

Table 1 – Elastic properties of bituminous mixtures

Temperature (°C)	Stiffness (MPa)	
	Asphalt rubber hot mix	Conventional asphalt mix
-5	4434	16157
5	3221	13563
15	1948	9304
25	1107	4781

Fatigue

The four-point flexural fatigue tests were also performed for several temperatures to obtain the fatigue laws coefficients of temperature-dependent. The fatigue behavior considered for the studied mixtures was evaluated after the stiffness modulus tests for the same test temperatures. For each test temperature (-5°C; 5°C, 15 °C and 25°C) a fatigue life law was achieved and fitted in the following model:

$$N_f = \left(\frac{\varepsilon_t}{(aV_b + b)E^{-c}} \right)^{-d} \quad (3)$$

where N_f is the fatigue resistance, ε_t is the strain level, E is the stiffness modulus, V_b is the volume of the binder in the mixture and a , b , c and d are constants obtained for each material type, presented in the Table 2. The Equation 3 may be expressed through the following equation, as function of ε_t :

$$\varepsilon_t = ((a \times n) + b) \times E^c \times N^d \quad (4)$$

Table 2 – Fatigue parameters for asphalt rubber hot mix and for conventional mix

Material type	a	b	c	d
Conventional asphalt mix	1.009	0.928	-0.337	-0.252
Asphalt rubber hot mix	1.957	0.926	-0.434	-0.144

Relaxation Modulus

The viscoelastic material properties are time-and-temperature dependent. A bituminous material behaves as a viscous fluid for high temperatures and as a solid at low temperatures. The temperature influence in the mix behavior may be considered through the adoption of thermal-rheological simplicity principle (WLF function), which considers that the relaxation curve for high temperatures is identical to the low temperature relaxation curve, if loading time is scaled.

Relaxation tests were performed at -5 °C, 5 °C, 15 °C and 25 °C, using bituminous samples representing an asphalt rubber hot mix and a conventional asphalt mix. Each sample is subjected to a constant vertical axial strain, ϵ_0 , applied during loading time, through an induced constant displacement, applied to each sample, with an adopted time loading of 7200 seconds (Figure 3). During each test with controlled constant temperature, in periods of time previously defined, the evolution of the load applied to the sample necessary to keep the sample with a constant length (constant strain) during the loading time, was measured.

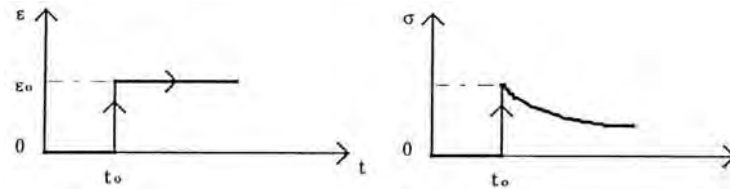


Figure 3 – Relaxation Stresses - strains relationship

With the accomplishment of each test, the values of three controlled parameters are periodically obtained: temperature, sample deformations (displacements) and load. The load is the used parameter for the characterization of the relaxation behaviour of the mixtures. The temperature and the sample deformation are parameters that must be kept constant throughout the test. In Figure 4 a representative graph of the curves obtained for each test (or for each sample) is presented, involving the asphalt rubber hot mix.

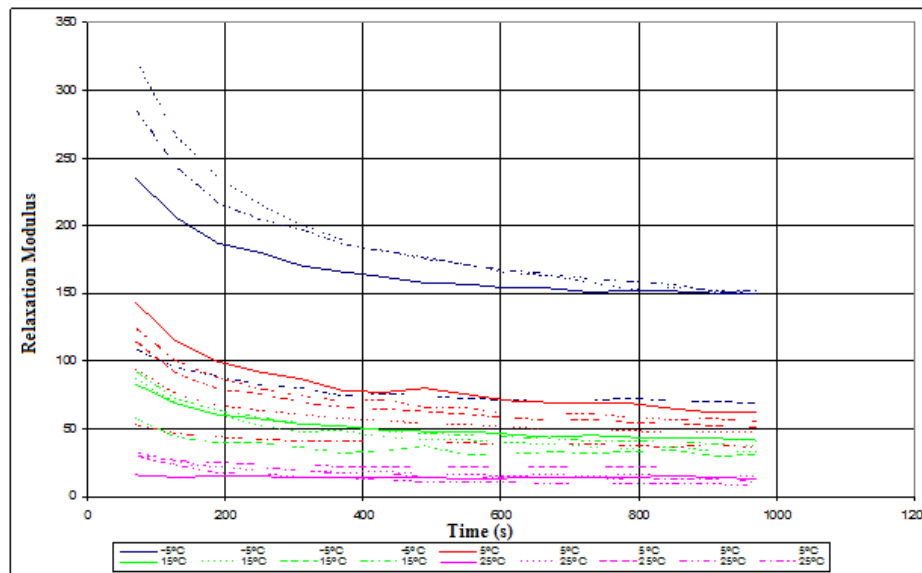


Figure 4 – Relaxation bulk modulus for AR-HMA mix

The characterization of the relaxation behavior of mixtures is made through the determination of the bulk relaxation modulus and the shear relaxation modulus. Representative curves of each type of the observed modulus were obtained and were used as a basis for the adjustment to the functions kernel, in the form of a Prony series. The Prony series must be representative of the viscoelastic behavior of the studied mixtures and include the consideration of thermal-rheological simplicity principle, through the following equations:

$$G = G_{\infty} + \sum_{i=1}^{n_G} G_i \exp\left(-\frac{t}{\tau_i^G}\right) \quad (5)$$

$$K = K_{\infty} + \sum_{i=1}^{n_K} K_i \exp\left(-\frac{t}{\tau_i^K}\right) \quad (6)$$

$$\log_{10}(A(T(\tau))) = \frac{C_1(T - T_r)}{C_2 + T - T_r} \quad (7)$$

The parameters obtained from this process are presented in Table 3, namely the elastic shear modulus, G_i , elastic volumetric modulus, K_i , relaxation times, τ_i^G , τ_i^K , reference temperature, T_r and C_1 and C_2 for WLF function.

Table 3 – Relaxation parameters for an asphalt rubber hot mix and for a conventional mix

	Parameters	AR - HMA	Conventional asphalt Mix		Parameters	AR - HMA	Conventional asphalt Mix
Shear Parameters	G_{∞}	5.11E+00	1.04E+01	Volumetric Parameters	K_{∞}	1.38E+01	2.81E+01
	G_1	2.09E+02	2.89E+02		K_1	5.62E+02	7.85E+02
	G_2	4.13E+01	9.45E+01		K_2	1.12E+02	2.60E+02
	G_3	8.85E+00	1.13E+01		K_3	2.39E+01	3.07E+01
	τ_1^G	6.03E-02	5.99E-01		τ_1^K	6.05E-02	5.85E-01
	τ_2^G	1.47E+01	9.49E+00		τ_2^K	1.47E+01	9.16E+00
	τ_3^G	9.86E+03	1.00E+04		τ_3^K	9.86E+03	9.92E+03
WLF				T_r	1.38E+01	1.31E+01	
				C_1	2.23E+07	2.56E+07	
				C_2	1.44E+08	1.39E+08	

Thermal contraction

Thermal contraction tests were performed using samples of asphalt rubber and conventional mixes. The obtained coefficient of thermal contraction is constant and independent from the temperature. This study adopted the value of $4.3 \times 10^{-5} \text{ } ^\circ\text{C}^{-1}$ for the asphalt rubber hot mix and $3.5 \times 10^{-5} \text{ } ^\circ\text{C}^{-1}$ for the conventional asphalt mix.

DAMAGE EVALUATION

In one-year time-period the main results obtained from this simulation were: i) the Von Mises strains; ii) predicted overlay life; iii) overlay damage. These calculations were performed for traffic loading, temperature variations and the combination of both, traffic and temperature. The Von Mises strain for each loading case was used to predict the pavement life after overlying. Figure 5 shows the hourly predictive overlay life resulting from traffic and traffic+ ΔT loading cases for the conventional mix.

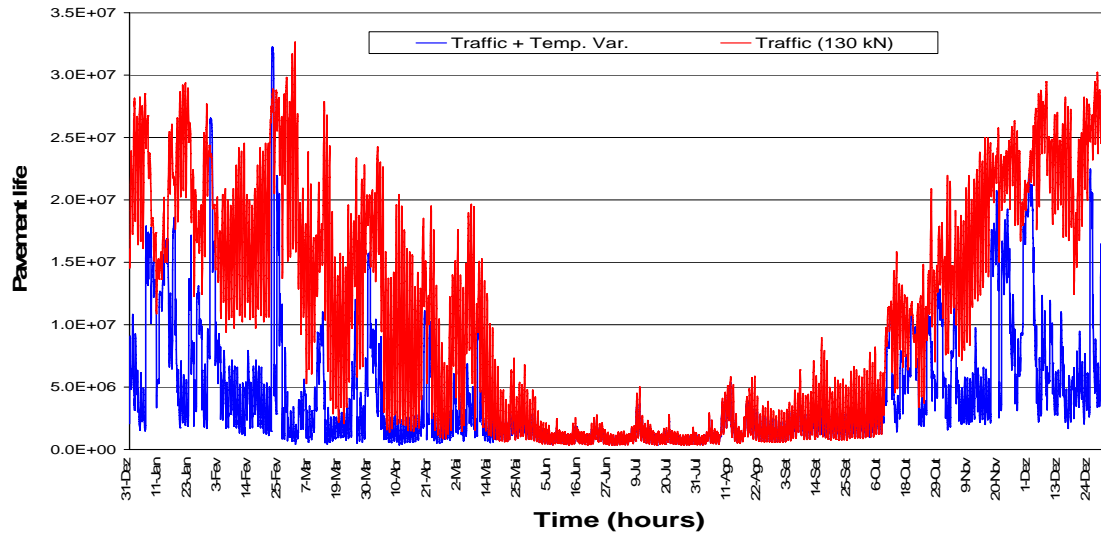


Figure 5 – Predicted overlay life for traffic and temperature variations for the conventional mix

The results show that the overlay life obtained from traffic loading is higher than the overlay life obtained from traffic+ ΔT loading, mainly in winter season, when low temperatures occur. In summer, the predicted overlay life is inferior to that of winter. Thus, the effect of traffic+ ΔT may have a significant influence on the overlay life, which will justify a special attention.

Knowing the predicted overlay life and the number of axles distribution during the year allows to perform an estimation of the annual damage evolution. The damage evaluation is made in terms of damage distribution and in terms of accumulated damage evolution, measured hourly and monthly. Figure 6 shows the accumulated monthly damage occurred in a conventional mix and in an asphalt-rubber mix overlay for traffic and traffic+ ΔT . In this figure the accumulated monthly damage occurred due to the traffic loading is lower than the damage observed for traffic+ ΔT . Thus, the traffic+ ΔT effect in the overlay damage may have a significant influence when compared with traffic effects that should be considered in a design process. The figure also shows that the asphalt-rubber mix presents a better performance than the conventional mix for traffic+ ΔT load case.

CONCLUSIONS

The finite-element analysis was used to simulate the reflective cracking performance of bituminous mixture overlays throughout a year, considering the temperature variations as the main cause for reflective cracking. A thermal response of the pavement structure, made by a thermal analysis, was performed before a mechanical analysis. In the mechanical analysis the transient effect of relaxation was considered, once the overall state of tension in the overlay caused by the temperature variation is also a function of the viscoelastic response of the bituminous materials.

Temperature variations in bituminous layers (overlay and cracked layers), which cause a state of tension in the overlay, are particularly important for estimating the overlay life. The effect of accumulated restrained thermal stresses, as a result of the effect of temperature variations

shrinkage, added to the traffic loading effect, will reduce the overlay life. Thus, the effect of temperature variations will support the need for a special attention towards overlay design procedures.

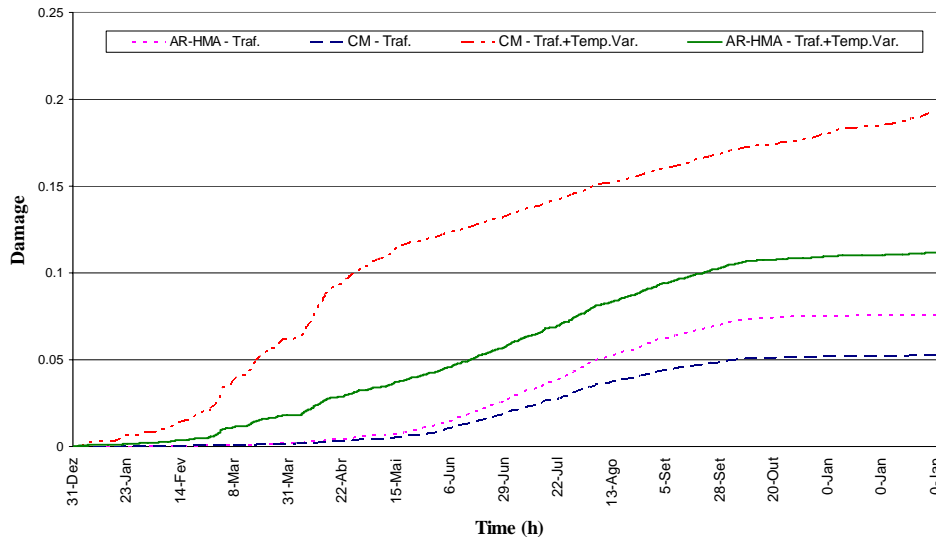


Figure 6 – Accumulated hourly damage

This study allowed concluding that, if the temperature variation is considered, the asphalt rubber mixes show a clear difference in terms of reflective cracking performance, when compared with conventional asphalt mixes. These differences are more expressive during cold seasons. In those seasons the asphalt rubber mixes overlays show a better performance than conventional asphalt mixes overlays.

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