

Universidade do Minho

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Pais, J.C., Pereira, P.A.A., Minhoto, M.J.C., Baptista, A.

"Asphalt pavements recycling with asphalt rubber"

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PAPER	TITLE	SPEAKER
1000	LIFETIME ENGINEERING IN ROAD ASSET MANAGEMENT	Gaspar, Laszlo
1002	HIGH PRODUCTIVITY VEHICLES AND PAVEMENT ECONOMIC IMPACTS	Martin, Tim
<u>1003</u>	FAMLIT- A NEW PAVEMENT ASSESSMENT TOOL	Martin, Tim
<u>1006</u>	CHARACTERIZATION OF ROAD BASES AND SUBBASES MADE OF RECLAIMED ASPHALT PAVEMENT AND RECYCLED CONCRETE AGGREGATE	Taha, Ramzi
1008	BRIDGE MANAGEMENT PLAN AND STRATEGY	Jurić, Smiljan
1009	IMPLEMENTATION OF A COMMUNAL PMS IN GERMANY - STATE-OF-THE-ART -	Grossmann, Andreas
<u>1013</u>	MULTIDIMENSIONAL APPROACH TO DESCRIBE BRIDGE DETERIORIATION	Petschacher, Markus
1014	TRANSPORTATION ASSET MANAGEMENT IN THE UNITED STATES	Wlaschin, Julius B.
<u>1015</u>	A NEW DETERMINISTIC OPTIMIZATION MODEL PROPOSED TO BE USED IN THE PMS OF A PORTUGUESE MUNICIPALITY	Meneses, Susana
<u>1017</u>	THE NEW AUSTRIAN METHOD FOR THE STRUCTURAL ASSESSMENT OF PAVEMENT CONSTRUCTIONS FOR PMS PURPOSES	Simanek, Petra
<u>1018</u>	SECTION BASED PROBABILISTIC PERFORMANCE PREDICTION FICTION OR FUTURE?	Weninger-Vycudil, Alfred
<u>1019</u>	ROAD ASSET MANAGEMENT –MAIN MAINTENANCE MEASURES: BACKLOG AND EFFECTIVENESS	Potucek, Jaro
<u>1021</u>	SUSTAINING INFRASTRUCTURE SERVICES BY APPLICATION OF ASSET MANAGEMENT	Mante, Bart R.
<u>1024</u>	PAVEMENT MANAGEMENT SYSTEM ON THE STRATEGIC AND OPERATIVE LEVEL	Heller, Slawomir
<u>1026</u>	MAINTENANCE MANAGEMENT FOR THE CLASSIFIED ROAD NETWORK	Krmek, Mario
<u>1027</u>	A ROAD USER COSTS MODEL FOR PORTUGUESE TRUNK ROADS	Santos, Bertha
1028	COST 354 - PERFORMANCE INDICATORS FOR ROAD PAVEMENTS	Litzka, Johann
<u>1029</u>	ROAD ASSET MANAGEMENT AND TRANSPORTATION OF HAZARDOUS MATERIALS	Praticò, Filippo
<u>1030</u>	NEW AND OLD TECHNOLOGIES FOR THE DETERMINATION OF DENSITY OF HMAS	Moro, Antonino
1031	IMPLEMENTATION OF A STOCHASTIC PMS MODEL	Socina, Mihai
<u>1033</u>	ANALYSIS OF URBAN PAVEMENT SURFACE PROFILES ORIENTED TO ENVIRONMENTAL PERFORMANCE INDICATORS.	Nicolosi, Vittorio
<u>1035</u>	EXPERIMENTAL ANALYSIS OF INNOVATIVE JOINTS IN REHABILITATION OF AIRPORT PAVEMENTS	Mauro, Pozzi
1041	BASIC PARAMETERS OF OPTIMUM, COST-EFFECTIVE BRIDGE MAINTENANCE AND REHABILITATION	Lublóy, László
<u>1045</u>	PRIVATE PARTICIPATION IN MANAGING ROAD ASSETS	Gutiérrez-Bolívar, Oscar
<u>1048</u>	ENGINEERING STRUCTURES MANAGEMENT SYSTEM:EXAMPLE ON A FRENCH HIGHWAY NETWORK	Simon, Isabelle
<u>1053</u>	BREAKING THE SILOS IN ASSET MANAGEMENT: COMPREHENSIVE OPTIMIZATION IN LONG-TERM PLANNING OVER MULTIPLE ASSET TYPES	Mrawira, Donath
1054	INTEGRATION OF PAVEMENT MANAGEMENT SYSTEMS AND BRIDGE MANAGEMENT SYSTEMS	Neves, Luis
<u>1056</u>	VARIATION OF THE INTERNATIONAL ROUGHNESS INDEX VALUES IN FUNCTION OF THE HEAVY TRAFFIC	Laszlo, Petho
<u>1059</u>	MIX DESIGN FOR COLD-IN-PLACE PAVEMENT RECYCLING; DOES IT GUARANTEE PERFORMANCE?	Sufian, Zulakmal
1060	DEVELOPMENT OF A TECHNICO-ECONOMIC OPTIMIZATION MODEL FOR PAVEMENT MAINTENANCE WORKS	Lepert, Philipe
1061	IDENTIFYING STRUCTURAL CHANGES IN PAVEMENT PROFILES FROM TRAFFIC SPEED DEFLECTOGRAPH DATA USING MML INFERENCE	Byrne, Matt
1064	THEORETICAL BASIS FOR THE TREATMENT OF LONG DRAINAGE PATHS ON MOTORWAYS	Griffiths, Geoffrey
1065	EFFECT OF ASPHALT LAYER THICKNESS VARIABILITY ON PREDICTED FLEXIBLE PAVEMENT LIFE	Valle, Paola Dalla
1066	THE EFFECT OF DRAINAGE CONDITION ON THE LIFETIME OF PAVED ROADS IN NORTHERN EUROPE	Saarenketo, Timo
1067	DEM SIMULATION OF FIELD ASPHALT COMPACTION	Micaelo, Rui
1068	RECYCLING OF ASPHALT PAVEMENTS WITH ASPHALT RUBBER	Minhoto, Manuel
1070	EVALUATING EFFECT OF FILM THICKNESS ON AGING OF ASPHALT THROUGH THIN FILM OVEN TEST	Chanda, Satish
1071	LABORATORY OPTIMIZATION OF CONTINUOUS BLEND ASPHALT RUBBER	Pereira, Paulo
1072	SKID RESISTANCE AND TEXTURE OF COMPACTED ASPHALT MIXES EVALUATED BY THE IFI IN LABORATORY	Pereira, Paulo
1075	INFLUENCE OF TEMPERATURE ON THE FATIGUE LIFE OF FLEXIBLE PAVEMENTS	Silva, Hugo
1077	STUDY ON THE CONSEQUENCES OF AFFIXING THE CE MARKING TO BITUMINOUS MIXTURES	Palha, Carlos

AN ALTERNATIVE OFFICETION ANALYSIS ORE THE EVALUATION OF THE PARMENT CONDITION ANDER - A ROADS TECHNICAL COLLABORATION ACROSS THE EUROPEAN NORTHERN PERIPHERY MUTOR, ROAD CONDITION ASSESSMENT ON CYCLE PATHS WITH A NEWLY DEVICEOPED MEASURING TECHNICOGY Anger, Randoff SPEED MANAGEMENT IN RECIDINAL AND NATIONAL SINGLE CARRIAGEWAY THROUGH ROADS: AN INTEGRATED APPROACH SIVA, ANA MARIA SPEED MANAGEMENT IN RECIDINAL AND NATIONAL SINGLE CARRIAGEWAY THROUGH ROADS: AN INTEGRATED APPROACH SIVA, ANA MARIA SPEED MANAGEMENT IN RECIDINAL AND NATIONAL SINGLE CARRIAGEWAY THROUGH ROADS: AN INTEGRATED APPROACH SIVA, ANA MARIA SPEED MANAGEMENT IN RECIDINAL ROAD NATIONAL SINGLE CARRIAGEWAY THROUGH ROADS: AN INTEGRATED APPROACH SIVA, AND MARIA SPEED MANAGEMENT IN RECIDINAL ROAD NATIONAL SINGLE CARRIAGEWAY THROUGH ROADS: AN INTEGRATED APPROACH SPEED MANAGEMENT IN RECIDINAL ROAD NATIONAL SINGLE CARRIAGEMENT SYSTEM PERSONANDE CARRIAGEMENT OF STATEMENT OF THE ANALYSE OF THE ANAL			
IBADEX - A ROADS TICKINCIAL COLLABORATION ACROSS THE EUROPEAN HORTHERN PERIPHERY		RELATION BETWEEN ZERO SHEAR VISCOSITY AND ZERO FREQUENCY COMPLEX VISCOSITY AT DIFFERENT TEMPERATURES	Nguyen, Viet Hung
DODE ONDITION ASSESSMENT ON CYCLE PATHS WITH A NEWLY DEVELOPED MEASURING TECHNOLOGY Anger, Randorf Siza, And Maria Siza And Maria SPEED MANAGEMENT IN RESIONAL AND NATIONAL SINGLE CARRAGEWAY THROUGH ROADS. AN INTEGRATED APPROACH Siza, And Maria Siza PRECIMENANCE HARAGEMENT IN RESIONAL PROPERTY OF THE DESIGN OF PORTUGUESE BITUMINOUS MINTURES Gardete, Dinis SPEED MANAGEMENT OR STREAM THE DESIGN OF PORTUGUESE BITUMINOUS MINTURES GARDEN, DINIS SPEED MANAGEMENT OR STREAM THE DESIGN OF PORTUGUESE BITUMINOUS MINTURES GARDEN, DINIS ACOMPANISON BETWEEN THE LIEE OF A RECYCLED ASPHALT PAWKINN'S AND AN ENVOINE AND	<u>1080</u>	AN ALTERNATIVE DEFLECTION ANALYSIS FOR THE EVALUATION OF THE PAVEMENT CONDITION	Oliveira, Joel
DEED MAINAGEMENT IN REGIONAL AND NATIONAL SINGLE CARRIAGEWAY THROUGH ROADS: AN INTEGRATED APPROACH SING, ARIA MARIA 1007. THE USE OF THE GRATORY COMPACTION IN THE DESIGN OF PORTUGUESE BITUMINOUS MICHIDIRS SPERIORMANCE-BASED BIND BOSEN MEMBRIOD FOR BITUMINOUS IN INFORMATION. CAPITAG, SIMINO 1008. PREVENCE BOSEN MEMBRIOD FOR BITUMINOUS OF MICHIDIRS PREVENCE BOSEN MEMBRION DESIGN MEMBRIOD FOR BITUMINOUS HOT MAIR REVCUENT IN PLANT CAPITAG. ACCOMPANISON BETWEEN THE LIFE OF A RECYCLED ASPHALP PAYEMENT HAD A NEW ONE ROAD SPANISH NATIONAL ROAD BY TWORK PAYEMENT MANAGEMENT SYSTEM ASPHALT RUBBER MINTURES IN PORTUGAL: PATIGUE RESISTANCE CONTROL OF THE MEMBRION OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL MICHIANICAL BEHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL MICHIANICAL BHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL MACHIANICAL BHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL MARINICAL BHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL MARINICAL BHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL MARINICAL BHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL MARINICAL BHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL MARINICAL BHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL MARINICAL BHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL MARINICAL BHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL MARINICAL BHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL MARINICAL BHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL MARINICAL BHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL MARINICAL BHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL MARINICAL BHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL MARINICAL BHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL MARINICAL BHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL MARINICAL BHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL MARINICAL BHAVE AND THE PORTUGUESE USLAND AS SET MANAGEMENT OF THE APPLICATION OF MICROGRINDING AN	<u>1081</u>	ROADEX – A ROADS TECHNICAL COLLABORATION ACROSS THE EUROPEAN NORTHERN PERIPHERY	Munro, Ron
THE USE OF THE GYRATORY COMPACTOR IN THE DESIGN OF PORTUGUISE BITUMINOUS MIXTURES SORGER, DINIS THE USE OF THE GYRATORY COMPACTOR IN THE DESIGN OF PORTUGUISE BITUMINOUS MIXTURES CAPITÃO, SININO PERFORMANCE BASED MIX DESIGN METHOD FOR BITUMINOUS HOT-MIX RECYCLING IN PLANT CAPITÂND PERFORMANCE BASED MIX DESIGN METHOD FOR BITUMINOUS HOT-MIX RECYCLING IN PLANT CAPITÂND PROMOBILE CONTROL OF SOLIC CAPITÂND PROMOBILE CAP	***************************************	CONDITION ASSESSSMENT ON CYCLE PATHS WITH A NEWLY DEVELOPED MEASURING TECHNOLOGY	Anger, Randolf
PERFORMANCE BASED MIX DESIGN METHOD FOR BITUMINOUS HOT-MIX RECYCLING IN PLANT COPIEDS, SINHING A COMPARISON BETWEEN THE LIFE OF A RECYCLED ASPHALT PAVEMENT AND A NEW ONE Martinez, Adrians ROBO, AVANO TRAVARED SPANISH NATIONAL ROBO NETWORK PRAVEMENT MANAGEMENT SYSTEM ROBO, AVANO TRAVARED LIVIAL ROBO SPANISH NATIONAL ROBO SET CASTILLA Y LEÓN GONZALO OFIGER. SPANISH TURBER MIXTURES IN PORTUGAL FARGUE RESISTANCE MIRANDA, HORALD SPANISH STANDAR LOGAL STANDAR ST	<u>1083</u>	SPEED MANAGEMENT IN REGIONAL AND NATIONAL SINGLE CARRIAGEWAY THROUGH ROADS: AN INTEGRATED APPROACH	Silva, Ana Maria
A COMPARISON BETWEEN THE LIFE OF A RECYCLED ASPHALT PAVEMENT AND A NEW ONE ACCOMPANISON BETWEEN THE LIFE OF A RECYCLED ASPHALT PAVEMENT AND A NEW ONE SPANISH NATIONAL ROAD NETWORK PAVEMENT MANAGEMENT SYSTEM ROBO, ÁNARD NEW STEM ASPHALT RUBBER MIXTURES IN PORTUGAL: SATIGUE RESISTANCE MIRADA, Henrique MIRADA, Hen	<u>1087</u>	THE USE OF THE GYRATORY COMPACTOR IN THE DESIGN OF PORTUGUESE BITUMINOUS MIXTURES	Gardete, Dinis
1003 SPANISH NATIONAL ROAD NETWORK PAVEMENT MANAGEMENT SYSTEM 1004 SPANISH NATIONAL ROAD NETWORK PAVEMENT MANAGEMENT SYSTEM 1005 EVALUATION OF SOLLCEMENT STEINGTHIS IN REGIONAL ROADS OF CASTILLA Y LEÓN 1005 MECHANICAI BEHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL 1005 MECHANICAI BEHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL 1006 MECHANICAI BEHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL 1007 MECHANICAI BEHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE USL 1008 TRAFFICE SIMULATION TO ROUS APPLIED TO PAVEMENT DESIGN 1009 HARMONIZATION OF PROJECT AND STRATEGIC LEVEL PAVEMENT BEING 1009 HARMONIZATION OF PROJECT AND STRATEGIC LEVEL PAVEMENT MANAGEMENT 1010 MODELING ROAD-TIRR NOISE 1010 MODELING ROAD-TIRR NOISE 1011 AND ADDRIVE MATERIALS OF A STRATE OF RIG GRANDE DO SUL PAVED ROADS 1012 PAVEMENT MANAGEMENT SYSTEM FOR THE STATE OF RIG GRANDE DO SUL PAVED ROADS 1013 PAVEMENT MANAGEMENT SYSTEM FOR THE STATE OF RIG GRANDE DO SUL PAVED ROADS 1014 ROAD NETWORK-RESOURCE MANAGEMENT FOR ITS MANINERANCE 1015 PAVEMENT MANAGEMENT FOR ITS MANINERANCE 1016 PAVEMENT MANAGEMENT FOR ITS MANINERANCE 1017 PAVEMENT MANAGEMENT FOR ITS MANINERANCE 1018 PAVEMENT MANAGEMENT FOR ITS MANINERANCE 1019 PAVEMENT OF THE HURIDARIAN HIGHWAY ASSET MANAGEMENT 1019 DEVELOPMENT OF THE HURIDARIAN HIGHWAY ASSET MANAGEMENT 1019 DEVELOPMENT OF THE HURIDARIAN HIGHWAY ASSET MANAGEMENT 1019 PROJECTION MODELS FOR URBAN AREAS A STATE-OF-THE-ART 1019 MULTI-CRITERIA OPTINIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT 1019 PAVEMENT OF SURFACE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES 1018 BATANCO, JOSE MATCODAIL 1019 MULTI-CRITERIA OPTINIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT 1019 PAVEMENT OF SURFACE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES 1019 BATANCO, JOSE MATCODAIL 1019 MULTI-CRITERIA OPTINIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT SYSTEMS 1019 PAVEMENT MANAGEMENT OF SURFACE CHAR	<u>1088</u>	PERFORMANCE-BASED MIX DESIGN METHOD FOR BITUMINOUS HOT-MIX RECYCLING IN PLANT	Capitão, Silvino
ASPHALT RUBBER MIXTURES IN PORTUGAL: PATIGUE RESISTANCE Miranda, Henrique	<u>1089</u>	A COMPARISON BETWEEN THE LIFE OF A RECYCLED ASPHALT PAVEMENT AND A NEW ONE	Martínez, Adriana
1092 ASPHALT RUBBER MIXTURES IN PORTUGAL: FATIGUE RESISTANCE 1093 THE USE OF DATA MINING TECHNIQUES FOR ROAD MAINTENANCE PLANNING 1094 MECHANICA, BEHAVIOUR OF TWO CRISHED MATERIALS USED IN PORTUGUESE U.G. 1095 TRAFFIC SIMULATION TOOLS APPUED TO PAVEMENT DESIGN 1096 TRAFFIC SIMULATION TOOLS APPUED TO PAVEMENT DESIGN 1097 HARMONIZATION OF PROJECT AND STRATEGIC LEVEL PAVEMENT MANAGEMENT 1098 MECHANICA BEHAVIOUR OF TWO CRISHED MATERIALS USED IN PORTUGUESE U.G. 1099 HARMONIZATION OF PROJECT AND STRATEGIC LEVEL PAVEMENT MANAGEMENT 1099 HARMONIZATION OF PROJECT AND STRATEGIC LEVEL PAVEMENT MANAGEMENT 1090 HARMONIZATION OF PROJECT AND STRATEGIC LEVEL PAVEMENT MANAGEMENT 1090 HARMONIZATION OF PROJECT AND STRATEGIC LEVEL PAVEMENT MANAGEMENT 1090 HARMONIZATION OF PROJECT AND STRATEGIC LEVEL PAVEMENT MANAGEMENT 1091 MODELING ROAD-TYPE NOISE 1092 HARMONIZATION OF PROJECT AND STRATEGIC LEVEL PAVEMENT MANAGEMENT 1093 HARMONIZATION OF RADIAL STATEGIC LEVEL PAVEMENT MANAGEMENT SYSTEM OF PE-STRATEGIC SEPTOR FOR PAVEMENT OF REPORT AND STRATEGIC LEVEL PAVEMENT MANAGEMENT SYSTEM OF PE-STRATEGIC SEPTOR FOR STRATEGIC LEVEL PAVEMENT MANAGEMENT SYSTEM OF PE-STRATEGIC SEPTOR FOR STRATEGIC LEVEL PAVEMENT MANAGEMENT SYSTEM OF PE-STRATEGIC SEPTOR FOR STRATEGIC LEVEL PAVEMENT SHAPPEN TO SEPTOR FOR STRAT	<u>1090</u>	SPANISH NATIONAL ROAD NETWORK PAVEMENT MANAGEMENT SYSTEM	Rojo, Álvaro Navareño
1093 THE USE OF DATA MINING TECHNIQUES FOR ROAD MAINTENANCE PLANNING MECHANICAL BEHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE UGL LUZIA, ROSA MECHANICAL BEHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE UGL LUZIA, ROSA 1093 HARMONIZATION OF PROJECT AND STRATEGIC LEVEL PAYEMENT DESIGN VASCONCEIOS, António Modeling ROAD-TYRE NOISE Martins, Mário MODELING ROAD-TYRE NOISE Martins, COMPARISON OF LABORATORY AND FIELD SAMPLES WITH VERIFIED REPEATED CREEP TESTS IN ASPHALT MIXTURES Alsoy, Atakan 1112 A MAINTENANCE MANAGEMENT SYSTEM FOR THE STATE OF RIO GRANDE DD SUL PAYED ROADS PINTO, Paulo 1113 PAVEMENT MANAGEMENT SYSTEM OF EP - ESTRADAS DE PORTUGAL, S.A. STRUCTURE AND THE FUNCTIONALITIES COSTA-PEREIR, Francisco 1114 ROAD NETWORK: RESOURCE MANAGEMENT FOR ITS MAINTENANCE VAREIR, Francisco 1115 FACTORS INFLUENCING THE RELIABILITY OF PAYEMENT PERFORMANCE MODELS 1116 FACTORS INFLUENCING THE RELIABILITY OF PAYEMENT PERFORMANCE MODELS 1117 DEVELOPMENT OF THE HUNGARIAN HICHWAY ASSET MANAGEMENT 1118 OND SAFETY MANAGEMENT IN LISBON. DEVELOPMENT OF EFFICIENT CORRECTIVE SAFETY MEASURES. 1119 CONTRIBUTION OF THE STATE ROAD REHABILITATION TO TRAFFIC SAFETY 1120 ACCIDENT PREDICTION MODELS FOR URBAN AREAS A STATE-OF-THE-ART 1121 MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT 1122 MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT 1123 PAVEMENT IMPACTS ON HIGHWAY RUNOFF QUALITY—ARE COASTAL AREAS SPECIAL CASES? 1124 MANAGEMENT OF SURFACE CHARACCTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES 1125 BARRACCE AND TEMPERATURE REFERED ON THE REFLICENCY CORRECTIVE SERVING MANAGEMENT SYSTEMS 1126 BARRACCE AND TEMPERATURE REFERED ON THE REPORTMENT SEY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES 1127 BARRACCE AND TEMPERATURE REFERED ON THE PROTUGANCE MODELS 1128 CONTRIBUTIONS TO THE DEVELOPMENT OF THE PORTUGANCE MODELS 1129 BARRACCE AND TEMPERATURE REFORMANCE MODELS FOR ASPHALT PAVEMENT MAN	<u>1091</u>	EVALUATION OF SOIL-CEMENT STRENGTHS IN REGIONAL ROADS OF CASTILLA Y LEÓN	Gonzalo Orden, Hernán
1095 MECHANICAL BEHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE UGL 1096 TRAFFIC SIMULATION TOOLS APPLIED TO PAVEMENT DESIGN 1099 HARMONIZATION OF PROJECT AND STRATEGIC LEVEL PAVEMENT MANAGEMENT 1104 MODELING ROAD-TYRE NOISE 1105 MODELING ROAD-TYRE NOISE 1106 RUTTING COMPARISON OF LABORATORY AND FIELD SAMPLES WITH VERIFIED REPEATED CREEP TESTS IN ASPHALT MIXTURES 1110 AND RUTTING COMPARISON OF LABORATORY AND FIELD SAMPLES WITH VERIFIED REPEATED CREEP TESTS IN ASPHALT MIXTURES 1111 ANAINTENANCE MANAGEMENT SYSTEM FOR THE STATE OF RIO GRANDE DO SUL PAVED ROADS 1111 PAVEMENT MANAGEMENT SYSTEM FOR THE STATE OF RIO GRANDE DO SUL PAVED ROADS 1111 PAVEMENT MANAGEMENT SYSTEM OF EP - ESTRADAS DE PORTUGAL, S.A. STRUCTURE AND THE FUNCTIONALITIES 1112 CONTRIBUTION OF THE STATE ROAD REMAINSTANCE 1114 ROAD NETWORK-RESQUECE MANAGEMENT FOR ITS MAINTENANCE 1115 FACTORS INFLUENCING THE RELIABILITY OF PAVEMENT PERFORMANCE MODELS 1116 FACTORS INFLUENCING THE RELIABILITY OF PAVEMENT PERFORMANCE MODELS 1117 DEVELOPMENT OF THE HUNGARIAN HIGHWAY ASSET MANAGEMENT 1118 GONTRIBUTION OF THE STATE ROAD REHABILITATION TO TRAFFIC SAFETY 1119 ROAD SAFETY MANAGEMENT IN USBON: DEVELOPMENT OF TERICIENT CORRECTIVE SAFETY MEASURES. 1120 ACCIDENT PREDICTION MODELS FOR URBAN AREAS A STATE-OF-THE-ART 1121 MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT 1122 MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT 1123 TRAFFIC CAPITAL DETIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT 1124 MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT 1125 MANAGEMENT OF SUBRACE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES 1126 BARO, AND SAFELY CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES 1127 MANAGEMENT OF SUBRACE CHARACTERISTICS OF ASPHALT PROVINCENT BY AVEMENT SAY SHEMENT SYSTEMS 1128 PAVEMENT IMPACTS ON HIGHWAY BUNDOFF QUALITY—ARE COASTAL AREAS SPECIAL CASES? 1129 MULTI-CRITERIA OPT	<u>1092</u>	ASPHALT RUBBER MIXTURES IN PORTUGAL: FATIGUE RESISTANCE	Miranda, Henrique
1096 TRAFFIC SIMULATION TOOLS APPLIED TO PAVEMENT DESIGN VASCONCEIOS, ANTONIO 1099 HARMONIZATION OF PROJECT AND STRATEGIC LEVEL PAVEMENT MANAGEMENT MIDDELING ROAD-TYRE NOISE MATTINS, MÁRIO 11104 MODELING ROAD-TYRE NOISE MATTINS, MÁRIO 11105 RUTTING COMPARISON OF LABORATORY AND FIELD SAMPLES WITH VERIFIED REPEATED CREEP TESTS IN ASPHALT MIXTURES A KAOY, ATAKAN 11112 A MAINTENANCE MANAGEMENT SYSTEM FOR THE STATE OF RIG GRANDE OD SUL PAVED ROADS PINTO, PAUID 1113 PAVEMENT MANEGEMENT SYSTEM OF EP - ESTRADAS DE PORTUGAL, S.A. STRUCTURE AND THE FUNCTIONALITIES COSTA-PEREIR, FRANCES 1114 ROAD NETWORK/RESCOURCE MANAGEMENT FOR ITS MAINTENANCE 1115 FACTORS INFLUENCING THE RELIABILITY OF PAVEMENT PERFORMANCE MODELS GASPAR, LASZÍO 1111 DEVELOPMENT OF THE HUNGARIAN HIGHWAY ASSET MANAGEMENT 1112 OEVELOPMENT OF THE HUNGARIAN HIGHWAY ASSET MANAGEMENT 1113 ROAD SAFETY MANAGEMENT IN LISBON: DEVELOPMENT OF EFFICIENT CORRECTIVE SAFETY MEASURES. CAPVAÍNEIR, GARRÍA 1112 ROAD SAFETY MANAGEMENT IN LISBON: DEVELOPMENT OF EFFICIENT CORRECTIVE SAFETY MEASURES. CAPVAÍNEIR, GARRÍA DETINATION OF THE MUNDARY ASSET MANAGEMENT 1112 MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT 1112 MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT 1113 TRAFFIC DEPENDENT MARKOY TYPE MULTIPERIOD PMS MODEL 1114 MANAGEMENT OF SURRACE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES BARY, Addrás 1113 MANAGEMENT OF SURRACE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES BARTAGO, JOSE MARCOBAIL 1113 MANAGEMENT OF SURRACE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES BARTAGO, JOSE MARCOBAIL 1113 MANAGEMENT OF SURRACE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES BARTAGO, JOSE MARCOBAIL 1113 MANAGEMENT OF SURRACE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLIC	<u>1093</u>	THE USE OF DATA MINING TECHNIQUES FOR ROAD MAINTENANCE PLANNING	Giuliana, Giovanni
HARMONIZATION OF PROJECT AND STRATEGIC LEVEL PAVEMENT MANAGEMENT MODELING ROAD-TYRE NOISE MOTING COMPARISON OF LABORATORY AND FIELD SAMPLES WITH VERIFIED REPEATED CREEP TESTS IN ASPHALT MIXTURES Aksoy, Atakan PINTID, Paulo 1112 A MAINTENANCE MANAGEMENT SYSTEM FOR THE STATE OF RIO GRANDE DO SUL PAVED ROADS PINTID, Paulo 1113 PAVEMENT MANAGEMENT SYSTEM OF EP - ESTRADAS DE PORTUGAL, S.A. STRUCTURE AND THE FUNCTIONALITIES COSTA-PERIRA, Francisco 1114 ROAD NETWORK-RESOURCE MANAGEMENT FOR ITS MAINTENANCE 1115 FACTORS INFLUENCING THE RELIABILITY OF PAVEMENT PERFORMANCE MODELS 1116 FACTORS INFLUENCING THE RELIABILITY OF PAVEMENT PERFORMANCE MODELS 1117 DEVELOPMENT OF THE HUNGARIAN HIGHWAY ASSET MANAGEMENT 1118 CONTRIBUTION OF THE STATE ROAD REHABILITATION TO TRAFFIC SAFETY 1119 ROAD SAFETY MANAGEMENT IN LISBON: DEVELOPMENT OF EFFICIENT CORRECTIVE SAFETY MEASURES. 1110 CONTRIBUTION OF THE STATE ROAD REHABILITATION TO TRAFFIC SAFETY 1110 ACCIDENT PREDICTION MODELS FOR URBAN ARSAS A STATE-OF-THE-ART 1110 GODEST PREDICTION MODELS FOR URBAN ARSAS A STATE-OF-THE-ART 1110 MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT 1111 STATE OF PAVEMENT IMPACTS ON HIGHWAY RUNDEFF QUALITY- ARE COASTAL AREAS SPECIAL CASES? 1113 MANAGEMENT OF SURFACE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES 1110 BAROA, SAFETY MINAGEMENT PERFORMANCE MODELS FOR USE IN PAVEMENT MANAGEMENT SYSTEMS PETRIFA, Adelino 1111 A MIXTURE MODEL FOR PREDICTING PATTERNS OF SPATIAL REPEATABILITY IN HEAVY ENTINGE FLEETS ODHER, Eugene 1111 A MIXTURE MODEL FOR PREDICTING PATTERNS OF SPATIAL REPEATABILITY IN HEAVY ENTINGE FLEETS ODHER, Eugene 1111 A MIXTURE MODEL FOR PREDICTING PATTERNS OF SPATIAL REPEATABILITY IN HEAVY ENTINGE FLEETS ODHER, Eugene 1111 A MIXTURE MODEL FOR PREDICTING PATTERNS OF SPATIAL REPEATABILITY IN HEAVY ENTINGE FLEETS ODHER, EUgene 1111 A MIXTURE MODEL FOR PREDICTING PATTERNS OF SPATIAL REPEATABILITY IN HEAVY ENTINGE FLEETS ODHER STATES OF	<u>1095</u>	MECHANICAL BEHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE UGL	Luzia, Rosa
Martins, Mário 1104 MODELING ROAD-TYRE NOISE Martins, Mário 1105 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 MANAGEMENT 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 Vajidi, Marko 1119 ROAD SAFETY MANAGEMENT IS LISBON: DEVELOPMENT OF EFFICIENT CORRECTIVE SAFETY MEASURES. Carvalheira, Carmen 1120 ACCIDENT PREDICTION MODELS FOR URBAN AREAS A STATE-OF-THE-ART GORS, Sandrá Vieira 1121 PAULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT GIBBARO, AND AREAS A STATE-OF-THE-ART 1130 TRAFFIC DEPENDENT MARKOV TYPE MULTIPERIOD PMS MODEL 1131 PAVEMENT IMPACTS ON HIGHWAY RUNDIFF QUALITY- ARE COASTAL AREAS SPECIAL CASES? ANALYSIS OF PAVEMENT IMPACTS ON HIGHWAY RUNDIFF QUALITY- ARE COASTAL AREAS SPECIAL CASES? ANALYSIS OF PAVEMENT PREFORMANCE MODELS FOR USE AND ASSET MANAGEMENT SYSTEMS BARRADAM SAFENCE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES BARRADA, SABING SAFENCE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES BARRADA, AND ANALYSIS OF PAVEMENT PERFORMANCE MODELS FOR USE PAVEMENT MANAGEMENT SYSTEMS FERRIFIC AND TEMPERATURE EFFECT ON THE REFLECTIVE CRACKING MICHODAL AND ASSET MANAGEMENT SYSTEM SERVED SAFE AND ASSET MANAGEMENT SYSTEMS FERRIFIC AND TEMPERATURE EFFECT ON THE REFLECTIVE CRACKING MICHODAL AND ASSET MANAGEMENT SYSTEM SERVED SAFE AND ASSET MANAGEMENT SYSTEMS FERRIFIC AND TEMPERATURE EFFECT ON THE REFLECTIVE CRACKING MICHODAL AND ASSET MANAGE	<u>1096</u>	TRAFFIC SIMULATION TOOLS APPLIED TO PAVEMENT DESIGN	Vasconcelos, António
ASSOY, ATAMAN A MAINTENANCE MANAGEMENT SYSTEM FOR THE STATE OF RIO GRANDE DO SUL PAVED ROADS Pinto, Paulo A MAINTENANCE MANAGEMENT SYSTEM FOR THE STATE OF RIO GRANDE DO SUL PAVED ROADS Pinto, Paulo PAVEMENT MANEGEMENT SYSTEM FOR THE STATE OF RIO GRANDE DO SUL PAVED ROADS Pinto, Paulo Costa-Pereira, Francisco Costa-Pereira, Francisco 1112 PAVEMENT MANEGEMENT SYSTEM FOR FILE STATE OR RIS MAINTENANCE Warela, Fernando Costa-Pereira, Francisco Costa-Pereira, Francisco 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 1119 ROAD SAFETY MANAGEMENT IN LISBON: DEVELOPMENT OF FERICIANT CORRECTIVE SAFETY MEASURES. 1120 ACCIDENT PREDICTION MODELS FOR URBAN AREAS A STATE-OF-THE-ART Gomes, Sandra Vieira 1120 MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT Fintsch, Gerardo 1130 TRAFFIC DEPENDENT MARKOV TYPE MULTIPERIOD PMS MODEL 1132 PAVEMENT IMPACTS ON HIGHWAY RUNOFF QUALITY—ARE COASTAL AREAS SPECIAL CASES? 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 MINDOOL, MANUEL ANALYSIS OF PAVEMENT PERFORMANCE MODELS FOR USIN PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES Barranco, Jose Marcobal 1136 ANALYSIS OF PAVEMENT PERFORMANCE MODELS FOR SPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES Barranco, Jose Marcobal 1137 ANALYSIS OF PAVEMENT PERFORMANCE MODELS FOR USIN PAVEMENT MANAGEMENT SYSTEMS FERRIFICA, Adelino 1138 CONTRIBUTIONS TO THE DEVELOPMENT OF THE PORTUGUESE ROAD ADMINISTRATION'S PAVEMENT MANAGEMENT SYSTEM FERRIFICA ADdelino 1139 CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODEL 1140 PAVEMENT ANA ANAGEMENT SYSTEM ON	<u>1099</u>	HARMONIZATION OF PROJECT AND STRATEGIC LEVEL PAVEMENT MANAGEMENT	Mladenovic, Goran
A MAINTENANCE MANAGEMENT SYSTEM OF BY - ESTRADAS DE PORTUGAL, S.A. STRUCTURE AND THE FUNCTIONALITIES COSTA-PEREIR, FRANCISCO 1112 ROAD NETWORK:RESOURCE MANAGEMENT SYSTEM OF BY - ESTRADAS DE PORTUGAL, S.A. STRUCTURE AND THE FUNCTIONALITIES COSTA-PEREIR, FRANCISCO 1112 ROAD NETWORK:RESOURCE MANAGEMENT FOR ITS MAINTENANCE Gaspar, Laszlo 1115 BECTORS 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. Carvalheira, Carmen 1120 ACCIDENT PREDICTION MODELS FOR URBAN AREAS A STATE-OF-THE-ART Gomes, Sandra Vieira 1121 MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT FIINTSCH, Gerardo 1133 TRAFFIC DEPENDENT MARKOV TYPE MULTIPERIOD PMS MODEL Bako, Andras 1134 PAVEMENT IMPACTS ON HIGHWAY RUNOFF QUALITY—ARE COASTAL AREAS SPECIAL CASES? Antunes, Pedro 1135 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 MINHOLO, MANUEL 1136 ANALYSIS OF PAVEMENT PERFORMANCE MODELS FOR USE IN PAVEMENT MANAGEMENT SYSTEMS FERRIFICA, Adelino 1137 A MIXTURE MODEL FOR PREDICTING PATTERNS OF SPATIAL REPEATABILITY IN HEAVY VEHICLE FLEETS ODFINE, EUgene 1138 CONTRIBUTIONS TO THE DEVELOPMENT OF THE PORTUGUESE ROAD ADMINISTRATION'S PAVEMENT MANAGEMENT SYSTEM FERRIFICA, Adelino 1139 CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODEL 1141 TOWARDS NOISE CLASSIFICATION OF ROAD PAVEMENTS FERRIFICA, Edisobe 1143 PAULITICATION OF THE DEVELOPMENT OF THE PORTUGUESE ROAD ADMINISTRATION'S PAVEMENT MANAGEMENT SYSTEM FERRIFICA, Edisobe 1144 CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBER DIAS, JOSÉ COSTA, Andre	<u>1104</u>	MODELING ROAD-TYRE NOISE	Martins, Mário
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 1115 FACTORS INFLUENCING THE RELIABILITY OF PAVEMENT PERFORMANCE MODELS Gaspar, Laszlo Gaspar, Laszlo 1117 CONTRIBUTION OF THE STATE ROAD REHABILITATION TO TRAFFIC SAFETY Vajdić, Marko 1118 ROAD SAFETY MANAGEMENT IN LISBON: DEVELOPMENT OF EFFICIENT CORRECTIVE SAFETY MEASURES. Carvalheira, Carmen 1120 ACCIDENT PREDICTION MODELS FOR URBAN AREAS A STATE-OF-THE-ART GGmes, Sandra Vieira 1121 MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT TRAFFIC DEPENDENT MARKOV TYPE MULTIPERIOD PMS MODEL 1132 PAVEMENT IMPACTS ON HIGHWAY RUNOFF QUALITY—ARE COASTAL AREAS SPECIAL CASES? ANUANGEMENT OF SURFACE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES Barranco, Jose Marcobal 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 REFLICTIVE CRACKING Minhoto, Manuel 1136 1137 A MIXTURE MODEL FOR PREDICTION PATTERNS OF SPATIAL REPEATABILITY IN HEAVY VEHICLE FLEETS ODFIER, EUgene 1138 CONTRIBUTIONS TO THE DEVELOPMENT OF THE PORTUGUESE ROAD ADMINISTRATION'S PAVEMENT MANAGEMENT SYSTEM Ferreira, Adelino CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODEL 1131 CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODEL PAVEMENT MANAGEMENT SYSTEM ON A FRENCH HIGHWAY NETWORK Giacobi, Cécile TOWARDS NOISE CLASSIFICATION OF ROAD PAVEMENTS Freitas, Elisabete Costa, Andre Dias, Jose Dias, Jose Dias, Jose	<u>1106</u>	RUTTING COMPARISON OF LABORATORY AND FIELD SAMPLES WITH VERIFIED REPEATED CREEP TESTS IN ASPHALT MIXTURES	Aksoy, Atakan
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 FEFICIENT CORRECTIVE SAFETY MEASURES. Carvalheira, Carmen 1120 ACCIDENT PREDICTION MODELS FOR URBAN AREAS A STATE-OF-THE-ART Gomes, Sandra Vieira 1121 MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT Flintsch, Gerardo 1130 TRAFFIC DEPENDENT MARKOV TYPE MULTIPERIOD PMS MODEL Bako, Andras 1131 PAVEMENT IMPACTS ON HIGHWAY RUNOFF QUALITY—ARE COASTAL AREAS SPECIAL CASES? Antunes, Pedro 1132 AMANAGEMENT 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 REFLICETIVE 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 Obrien, 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 1131 TOWARDS NOISE CLASSIFICATION OF ROAD PAVEMENTS 1132 PAVEMENT MANAGEMENT SYSTEM ON A FRENCH HIGHWAY NETWORK Giacobi, Cécile 1137 TOWARDS NOISE CLASSIFICATION OF ROAD PAVEMENTS 1138 CHARACTERISTICS OF ASPHALT BINDERS MODDIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBER 1134 CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBER 1134 CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORAT	<u>1112</u>	A MAINTENANCE MANAGEMENT SYSTEM FOR THE STATE OF RIO GRANDE DO SUL PAVED ROADS	Pinto, Paulo
FACTORS INFLUENCING THE RELIABILITY OF PAVEMENT PERFORMANCE MODELS Gaspar, Laszlo DEVELOPMENT OF THE HUNGARIAN HIGHWAY ASSET MANAGEMENT Gaspar, Laszlo 1117 DEVELOPMENT OF THE HUNGARIAN HIGHWAY ASSET MANAGEMENT 1120 CONTRIBUTION OF THE STATE ROAD REHABILITATION TO TRAFFIC SAFETY Vajdic, Marko 1139 ROAD SAFETY MANAGEMENT IN LISBON: DEVELOPMENT OF EFFICIENT CORRECTIVE SAFETY MEASURES. Carvalheira, Carmen Gomes, Sandra Vieira 1120 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 1136 THE TRAFFIC AND TEMPERATURE EFFECT ON THE REFLECTIVE CRACKING Minhoto, Manuel 1137 A MIXTURE MODEL FOR PREDICTING PATTERNS OF SPATIAL REPEATABILITY IN HEAVY VEHICLE FLEETS Obrien, 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 TOWARDS NOISE CLASSIFICATION OF ROAD PAVEMENTS Freitas, Elisabete 1144 TOWARDS NOISE CLASSIFICATION OF ROAD PAVEMENTS Freitas, Elisabete 1144 CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBER DIAS, José	<u>1113</u>	PAVEMENT MANEGEMENT SYSTEM OF EP - ESTRADAS DE PORTUGAL, S.A. STRUCTURE AND THE FUNCTIONALITIES	Costa-Pereira, Francisco
DEVELOPMENT OF THE HUNGARIAN HIGHWAY ASSET MANAGEMENT Gaspar, Laszio 1118 CONTRIBUTION OF THE STATE ROAD REHABILITATION TO TRAFFIC SAFETY Vajdić, Marko Vajdić, Marko Vajdić, Marko 1119 ROAD SAFETY MANAGEMENT IN LISBON: DEVELOPMENT OF EFFICIENT CORRECTIVE SAFETY MEASURES. Carvalheira, Carmen 1120 ACCIDENT PREDICTION MODELS FOR URBAN AREAS A STATE-OF-THE-ART Gomes, Sandra Vieira 1121 MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT TRAFFIC DEPENDENT MARKOV TYPE MULTIPERIOD PMS MODEL 1132 TRAFFIC DEPENDENT MARKOV TYPE MULTIPERIOD PMS MODEL 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 REPATABILITY IN HEAVY VEHICLE FLEETS Obrien, Eugene 1138 CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODEL 1140 PAVEMENT MANAGEMENT SYSTEM ON A FRENCH HIGHWAY NETWORK 1141 PAVEMENT MANAGEMENT SYSTEM ON A FRENCH HIGHWAY NETWORK 1142 TOWARDS NOISE CLASSIFICATION OF ROAD PAVEMENTS PRELIMINARY RESULTS OF A 2 GHZ HORN ANTENNA GPR ON A PAVEMENT SECTION IN PORTUGAL COSTA, Andre DIAS, José	1114	ROAD NETWORK:RESOURCE MANAGEMENT FOR ITS MAINTENANCE	Varela, Fernando
Table Contribution of the state road rehabilitation to traffic safety 1118 CONTRIBUTION OF THE STATE ROAD REHABILITATION TO TRAFFIC SAFETY 1129 ROAD SAFETY MANAGEMENT IN LISBON: DEVELOPMENT OF EFFICIENT CORRECTIVE SAFETY MEASURES. 1120 CACCIDENT PREDICTION MODELS FOR URBAN AREAS A STATE-OF-THE-ART 1120 MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT 1121 MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT 1120 TRAFFIC DEPENDENT MARKOV TYPE MULTIPERIOD PMS MODEL 1121 PAVEMENT IMPACTS ON HIGHWAY RUNOFF QUALITY—ARE COASTAL AREAS SPECIAL CASES? 1122 PAVEMENT IMPACTS ON HIGHWAY RUNOFF QUALITY—ARE COASTAL AREAS SPECIAL CASES? 1123 MANAGEMENT OF SURFACE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES 1124 BARRAGEMENT OF SURFACE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES 1125 BARRAGEMENT OF SURFACE CHARACTERISTICS OF ASPHALT PAVEMENT MANAGEMENT SYSTEMS 1126 MANALYSIS OF PAVEMENT PERFORMANCE MODELS FOR USE IN PAVEMENT MANAGEMENT SYSTEMS 1127 A MIXTURE MODEL FOR PREDICTING PATTERNS OF SPATIAL REPEATABILITY IN HEAVY VEHICLE FLEETS 1128 CONTRIBUTIONS TO THE DEVELOPMENT OF THE PORTUGUESE ROAD ADMINISTRATION'S PAVEMENT MANAGEMENT SYSTEM 1129 CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODEL 120 SANDS, BRUIND AS ADMINISTRATION'S PAVEMENT MANAGEMENT SYSTEM 121 PAVEMENT MANAGEMENT SYSTEM ON A FRENCH HIGHWAY NETWORK 122 GIGODI, Cécile 123 PRELIMINARY RESULTS OF A 2 GHZ HORN ANTENNA GPR ON A PAVEMENT SECTION IN PORTUGAL 124 CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBER 124 CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBER	<u>1116</u>	FACTORS INFLUENCING THE RELIABILITY OF PAVEMENT PERFORMANCE MODELS	Gaspar, Laszlo
1119 ROAD SAFETY MANAGEMENT IN LISBON: DEVELOPMENT OF EFFICIENT CORRECTIVE SAFETY MEASURES. Carvalheira, 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 1138 CONTRIBUTIONS TO THE DEVELOPMENT OF THE PORTUGUESE ROAD ADMINISTRATION'S PAVEMENT MANAGEMENT SYSTEM 1139 CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODEL 1140 PAVEMENT MANAGEMENT SYSTEM ON A FRENCH HIGHWAY NETWORK 1141 PAVEMENT MANAGEMENT SYSTEM ON A FRENCH HIGHWAY NETWORK 1142 TOWARDS NOISE CLASSIFICATION OF ROAD PAVEMENTS 1143 PRELIMINARY RESULTS OF A 2 GHZ HORN ANTENNA GPR ON A PAVEMENT SECTION IN PORTUGAL 1144 CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBER 1144 CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBER 1018, José	<u>1117</u>	DEVELOPMENT OF THE HUNGARIAN HIGHWAY ASSET MANAGEMENT	Gaspar, Laszlo
ACCIDENT PREDICTION MODELS FOR URBAN AREAS A STATE-OF-THE-ART 129 MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT 130 TRAFFIC DEPENDENT MARKOV TYPE MULTIPERIOD PMS MODEL 131 PAVEMENT IMPACTS ON HIGHWAY RUNOFF QUALITY—ARE COASTAL AREAS SPECIAL CASES? 132 PAVEMENT IMPACTS ON HIGHWAY RUNOFF QUALITY—ARE COASTAL AREAS SPECIAL CASES? 133 MANAGEMENT OF SURFACE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES 135 THE TRAFFIC AND TEMPERATURE EFFECT ON THE REFLECTIVE CRACKING 136 ANALYSIS OF PAVEMENT PERFORMANCE MODELS FOR USE IN PAVEMENT MANAGEMENT SYSTEMS 137 A MIXTURE MODEL FOR PREDICTING PATTERNS OF SPATIAL REPEATABILITY IN HEAVY VEHICLE FLEETS 138 CONTRIBUTIONS TO THE DEVELOPMENT OF THE PORTUGUESE ROAD ADMINISTRATION'S PAVEMENT MANAGEMENT SYSTEM 139 CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODEL 140 PAVEMENT MANAGEMENT SYSTEM ON A FRENCH HIGHWAY NETWORK 141 PAVEMENT MANAGEMENT SYSTEM ON A FRENCH HIGHWAY NETWORK 142 TOWARDS NOISE CLASSIFICATION OF ROAD PAVEMENTS 143 PRELIMINARY RESULTS OF A 2 GHZ HORN ANTENNA GPR ON A PAVEMENT SECTION IN PORTUGAL 144 CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBER 154 CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBER 155 DIAS, JOSÉ	<u>1118</u>	CONTRIBUTION OF THE STATE ROAD REHABILITATION TO TRAFFIC SAFETY	Vajdić, Marko
### MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT 130 TRAFFIC DEPENDENT MARKOV TYPE MULTIPERIOD PMS MODEL Bako, Andras 131 PAVEMENT IMPACTS ON HIGHWAY RUNOFF QUALITY—ARE COASTAL AREAS SPECIAL CASES? Antunes, Pedro 132 PAVEMENT IMPACTS ON HIGHWAY RUNOFF QUALITY—ARE COASTAL AREAS SPECIAL CASES? Antunes, Pedro 133 MANAGEMENT OF SURFACE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES Barranco, Jose Marcobal 135 THE TRAFFIC AND TEMPERATURE EFFECT ON THE REFLECTIVE CRACKING Minhoto, Manuel 136 ANALYSIS OF PAVEMENT PERFORMANCE MODELS FOR USE IN PAVEMENT MANAGEMENT SYSTEMS Ferreira, Adelino 137 A MIXTURE MODEL FOR PREDICTING PATTERNS OF SPATIAL REPEATABILITY IN HEAVY VEHICLE FLEETS Obrien, Eugene 138 CONTRIBUTIONS TO THE DEVELOPMENT OF THE PORTUGUESE ROAD ADMINISTRATION'S PAVEMENT MANAGEMENT SYSTEM Ferreira, Adelino 139 CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODEL Santos, Bruno 141 PAVEMENT MANAGEMENT SYSTEM ON A FRENCH HIGHWAY NETWORK Giacobi, Cécile 142 TOWARDS NOISE CLASSIFICATION OF ROAD PAVEMENTS Freitas, Elisabete 143 PRELIMINARY RESULTS OF A 2 GHZ HORN ANTENNA GPR ON A PAVEMENT SECTION IN PORTUGAL 144 CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBER Dias, José	<u>1119</u>	ROAD SAFETY MANAGEMENT IN LISBON: DEVELOPMENT OF EFFICIENT CORRECTIVE SAFETY MEASURES.	Carvalheira, Carmen
TRAFFIC DEPENDENT MARKOV TYPE MULTIPERIOD PMS MODEL 132 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 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 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 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 RECLYCLED CRUMBLED RUBBER Dias, José	<u>1120</u>	ACCIDENT PREDICTION MODELS FOR URBAN AREAS A STATE-OF-THE-ART	Gomes, Sandra Vieira
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 Obrien, 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 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 RECLYCLED CRUMBLED RUBBER Dias, José	<u>1129</u>	MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT	Flintsch, Gerardo
1133 MANAGEMENT OF SURFACE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES 1135 THE TRAFFIC AND TEMPERATURE EFFECT ON THE REFLECTIVE CRACKING 1136 ANALYSIS OF PAVEMENT PERFORMANCE MODELS FOR USE IN PAVEMENT MANAGEMENT SYSTEMS 1137 A MIXTURE MODEL FOR PREDICTING PATTERNS OF SPATIAL REPEATABILITY IN HEAVY VEHICLE FLEETS 1138 CONTRIBUTIONS TO THE DEVELOPMENT OF THE PORTUGUESE ROAD ADMINISTRATION'S PAVEMENT MANAGEMENT SYSTEM 1139 CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODEL 1141 PAVEMENT MANAGEMENT SYSTEM ON A FRENCH HIGHWAY NETWORK 1142 TOWARDS NOISE CLASSIFICATION OF ROAD PAVEMENTS 1143 PRELIMINARY RESULTS OF A 2 GHZ HORN ANTENNA GPR ON A PAVEMENT SECTION IN PORTUGAL 1144 CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBER 1145 DIAS, José	<u>1130</u>	TRAFFIC DEPENDENT MARKOV TYPE MULTIPERIOD PMS MODEL	Bako, Andras
1135 THE TRAFFIC AND TEMPERATURE EFFECT ON THE REFLECTIVE CRACKING 1136 ANALYSIS OF PAVEMENT PERFORMANCE MODELS FOR USE IN PAVEMENT MANAGEMENT SYSTEMS 1137 A MIXTURE MODEL FOR PREDICTING PATTERNS OF SPATIAL REPEATABILITY IN HEAVY VEHICLE FLEETS 1138 CONTRIBUTIONS TO THE DEVELOPMENT OF THE PORTUGUESE ROAD ADMINISTRATION'S PAVEMENT MANAGEMENT SYSTEM 1139 CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODEL 1141 PAVEMENT MANAGEMENT SYSTEM ON A FRENCH HIGHWAY NETWORK 1142 TOWARDS NOISE CLASSIFICATION OF ROAD PAVEMENTS 1143 PRELIMINARY RESULTS OF A 2 GHZ HORN ANTENNA GPR ON A PAVEMENT SECTION IN PORTUGAL 1144 CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBER Minhoto, Manuel Minhot	<u>1132</u>	PAVEMENT IMPACTS ON HIGHWAY RUNOFF QUALITY— ARE COASTAL AREAS SPECIAL CASES?	Antunes, Pedro
1136 ANALYSIS OF PAVEMENT PERFORMANCE MODELS FOR USE IN PAVEMENT MANAGEMENT SYSTEMS 1137 A MIXTURE MODEL FOR PREDICTING PATTERNS OF SPATIAL REPEATABILITY IN HEAVY VEHICLE FLEETS 1138 CONTRIBUTIONS TO THE DEVELOPMENT OF THE PORTUGUESE ROAD ADMINISTRATION'S PAVEMENT MANAGEMENT SYSTEM 1139 CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODEL 1141 PAVEMENT MANAGEMENT SYSTEM ON A FRENCH HIGHWAY NETWORK 1142 TOWARDS NOISE CLASSIFICATION OF ROAD PAVEMENTS 1143 PRELIMINARY RESULTS OF A 2 GHZ HORN ANTENNA GPR ON A PAVEMENT SECTION IN PORTUGAL 1144 CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBER 1145 Dias, José	<u>1133</u>	MANAGEMENT OF SURFACE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES	Barranco, Jose Marcobal
1137 A MIXTURE MODEL FOR PREDICTING PATTERNS OF SPATIAL REPEATABILITY IN HEAVY VEHICLE FLEETS 1138 CONTRIBUTIONS TO THE DEVELOPMENT OF THE PORTUGUESE ROAD ADMINISTRATION'S PAVEMENT MANAGEMENT SYSTEM 1139 CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODEL 1141 PAVEMENT MANAGEMENT SYSTEM ON A FRENCH HIGHWAY NETWORK 1142 TOWARDS NOISE CLASSIFICATION OF ROAD PAVEMENTS 1143 PRELIMINARY RESULTS OF A 2 GHZ HORN ANTENNA GPR ON A PAVEMENT SECTION IN PORTUGAL 1144 CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBER Obrien, Eugene Control of the Control of Control	<u>1135</u>	THE TRAFFIC AND TEMPERATURE EFFECT ON THE REFLECTIVE CRACKING	Minhoto, Manuel
1138CONTRIBUTIONS TO THE DEVELOPMENT OF THE PORTUGUESE ROAD ADMINISTRATION'S PAVEMENT MANAGEMENT SYSTEMFerreira, Adelino1139CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODELSantos, Bruno1141PAVEMENT MANAGEMENT SYSTEM ON A FRENCH HIGHWAY NETWORKGiacobi, Cécile1142TOWARDS NOISE CLASSIFICATION OF ROAD PAVEMENTSFreitas, Elisabete1143PRELIMINARY RESULTS OF A 2 GHZ HORN ANTENNA GPR ON A PAVEMENT SECTION IN PORTUGALCosta, Andre1144CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBERDias, José	<u>1136</u>	ANALYSIS OF PAVEMENT PERFORMANCE MODELS FOR USE IN PAVEMENT MANAGEMENT SYSTEMS	Ferreira, Adelino
1139 CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODEL 1141 PAVEMENT MANAGEMENT SYSTEM ON A FRENCH HIGHWAY NETWORK 1142 TOWARDS NOISE CLASSIFICATION OF ROAD PAVEMENTS 1143 PRELIMINARY RESULTS OF A 2 GHZ HORN ANTENNA GPR ON A PAVEMENT SECTION IN PORTUGAL 1144 CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBER 1145 CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODEL Santos, Bruno Giacobi, Cécile 1146 COSTANTINE OF ALBERT OF ALBER	<u>1137</u>	A MIXTURE MODEL FOR PREDICTING PATTERNS OF SPATIAL REPEATABILITY IN HEAVY VEHICLE FLEETS	Obrien, Eugene
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 RECLYCLED CRUMBLED RUBBER Dias, José	<u>1138</u>	CONTRIBUTIONS TO THE DEVELOPMENT OF THE PORTUGUESE ROAD ADMINISTRATION'S PAVEMENT MANAGEMENT SYSTEM	Ferreira, Adelino
1142TOWARDS NOISE CLASSIFICATION OF ROAD PAVEMENTSFreitas, Elisabete1143PRELIMINARY RESULTS OF A 2 GHZ HORN ANTENNA GPR ON A PAVEMENT SECTION IN PORTUGALCosta, Andre1144CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBERDias, José	<u>1139</u>	CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODEL	Santos, Bruno
1143 PRELIMINARY RESULTS OF A 2 GHZ HORN ANTENNA GPR ON A PAVEMENT SECTION IN PORTUGAL Costa, Andre Little Characteristics of Asphalt Binders Modified with the incorporation of reclycled crumbled rubber Dias, José	1141	PAVEMENT MANAGEMENT SYSTEM ON A FRENCH HIGHWAY NETWORK	Giacobi, Cécile
1144 CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBER Dias, José	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
1145 TECHNOLOGIES FOR THIN-LAYER MAINTENANCE	1144	CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBER	Dias, José
[Marquardt, Andreas	1145	TECHNOLOGIES FOR THIN-LAYER MAINTENANCE	Marquardt, Andreas



PAPER	TITLE	SPEAKER
1089	A COMPARISON BETWEEN THE LIFE OF A RECYCLED ASPHALT PAVEMENT AND A NEW ONE	Martínez, Adriana
1112	A MAINTENANCE MANAGEMENT SYSTEM FOR THE STATE OF RIO GRANDE DO SUL PAVED ROADS	Pinto, Paulo
1137	A MIXTURE MODEL FOR PREDICTING PATTERNS OF SPATIAL REPEATABILITY IN HEAVY VEHICLE FLEETS	Obrien, Eugene
1015	A NEW DETERMINISTIC OPTIMIZATION MODEL PROPOSED TO BE USED IN THE PMS OF A PORTUGUESE MUNICIPALITY	Meneses, Susana
1027	A ROAD USER COSTS MODEL FOR PORTUGUESE TRUNK ROADS	Santos, Bertha
1120	ACCIDENT PREDICTION MODELS FOR URBAN AREAS A STATE-OF-THE-ART	Gomes, Sandra Vieira
1080	AN ALTERNATIVE DEFLECTION ANALYSIS FOR THE EVALUATION OF THE PAVEMENT CONDITION	Oliveira, Joel
1136	ANALYSIS OF PAVEMENT PERFORMANCE MODELS FOR USE IN PAVEMENT MANAGEMENT SYSTEMS	Ferreira, Adelino
1033	ANALYSIS OF URBAN PAVEMENT SURFACE PROFILES ORIENTED TO ENVIRONMENTAL PERFORMANCE INDICATORS.	Nicolosi, Vittorio
1092	ASPHALT RUBBER MIXTURES IN PORTUGAL: FATIGUE RESISTANCE	Miranda, Henrique
1041	BASIC PARAMETERS OF OPTIMUM, COST-EFFECTIVE BRIDGE MAINTENANCE AND REHABILITATION	Lublóy, László
1053	BREAKING THE SILOS IN ASSET MANAGEMENT: COMPREHENSIVE OPTIMIZATION IN LONG-TERM PLANNING OVER MULTIPLE ASSET TYPES	Mrawira, Donath
1008	BRIDGE MANAGEMENT PLAN AND STRATEGY	Jurić, Smiljan
1144	CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBER	Dias, José
1006	CHARACTERIZATION OF ROAD BASES AND SUBBASES MADE OF RECLAIMED ASPHALT PAVEMENT AND RECYCLED CONCRETE AGGREGATE	Taha, Ramzi
1082	CONDITION ASSESSSMENT ON CYCLE PATHS WITH A NEWLY DEVELOPED MEASURING TECHNOLOGY	Anger, Randolf
1139	CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODEL	Santos, Bruno
1118	CONTRIBUTION OF THE STATE ROAD REHABILITATION TO TRAFFIC SAFETY	Vajdić, Marko
1138	CONTRIBUTIONS TO THE DEVELOPMENT OF THE PORTUGUESE ROAD ADMINISTRATION'S PAVEMENT MANAGEMENT SYSTEM	Ferreira, Adelino
1028	COST 354 - PERFORMANCE INDICATORS FOR ROAD PAVEMENTS	Litzka, Johann
1067	DEM SIMULATION OF FIELD ASPHALT COMPACTION	Micaelo, Rui
1060	DEVELOPMENT OF A TECHNICO-ECONOMIC OPTIMIZATION MODEL FOR PAVEMENT MAINTENANCE WORKS	Lepert, Philipe
1117	DEVELOPMENT OF THE HUNGARIAN HIGHWAY ASSET MANAGEMENT	Gaspar, Laszlo
1065	EFFECT OF ASPHALT LAYER THICKNESS VARIABILITY ON PREDICTED FLEXIBLE PAVEMENT LIFE	Valle, Paola Dalla
1048	ENGINEERING STRUCTURES MANAGEMENT SYSTEM:EXAMPLE ON A FRENCH HIGHWAY NETWORK	Simon, Isabelle
1070	EVALUATING EFFECT OF FILM THICKNESS ON AGING OF ASPHALT THROUGH THIN FILM OVEN TEST	Chanda, Satish
1091	EVALUATION OF SOIL-CEMENT STRENGTHS IN REGIONAL ROADS OF CASTILLA Y LEÓN	Gonzalo Orden, Hernán
1035	EXPERIMENTAL ANALYSIS OF INNOVATIVE JOINTS IN REHABILITATION OF AIRPORT PAVEMENTS	Mauro, Pozzi
1116	FACTORS INFLUENCING THE RELIABILITY OF PAVEMENT PERFORMANCE MODELS	Gaspar, Laszlo
1003	FAMLIT- A NEW PAVEMENT ASSESSMENT TOOL	Martin, Tim
1099	HARMONIZATION OF PROJECT AND STRATEGIC LEVEL PAVEMENT MANAGEMENT	Mladenovic, Goran
1002	HIGH PRODUCTIVITY VEHICLES AND PAVEMENT ECONOMIC IMPACTS	Martin, Tim
1061	IDENTIFYING STRUCTURAL CHANGES IN PAVEMENT PROFILES FROM TRAFFIC SPEED DEFLECTOGRAPH DATA USING MML INFERENCE	Byrne, Matt
1009	IMPLEMENTATION OF A COMMUNAL PMS IN GERMANY - STATE-OF-THE-ART -	Grossmann, Andreas
1031	IMPLEMENTATION OF A STOCHASTIC PMS MODEL	Socina, Mihai
1075	INFLUENCE OF TEMPERATURE ON THE FATIGUE LIFE OF FLEXIBLE PAVEMENTS	Silva, Hugo
1054	INTEGRATION OF PAVEMENT MANAGEMENT SYSTEMS AND BRIDGE MANAGEMENT SYSTEMS	Neves, Luis
1071	LABORATORY OPTIMIZATION OF CONTINUOUS BLEND ASPHALT RUBBER	Pereira, Paulo
1000	LIFETIME ENGINEERING IN ROAD ASSET MANAGEMENT	Gaspar, Laszlo
1026	MAINTENANCE MANAGEMENT FOR THE CLASSIFIED ROAD NETWORK	Krmek, Mario
1133	MANAGEMENT OF SURFACE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES	Barranco, Jose Marcobal

1095	MECHANICAL BEHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE UGL	Luzia, Rosa
1059	MIX DESIGN FOR COLD-IN-PLACE PAVEMENT RECYCLING; DOES IT GUARANTEE PERFORMANCE?	Sufian, Zulakmal
1104	MODELING ROAD-TYRE NOISE	Martins, Mário
1129	MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT	Flintsch, Gerardo
1013	MULTIDIMENSIONAL APPROACH TO DESCRIBE BRIDGE DETERIORIATION	Petschacher, Markus
1030	NEW AND OLD TECHNOLOGIES FOR THE DETERMINATION OF DENSITY OF HMAS	Moro, Antonino
1132	PAVEMENT IMPACTS ON HIGHWAY RUNOFF QUALITY- ARE COASTAL AREAS SPECIAL CASES?	Antunes, Pedro
1141	PAVEMENT MANAGEMENT SYSTEM ON A FRENCH HIGHWAY NETWORK	Giacobi, Cécile
1024	PAVEMENT MANAGEMENT SYSTEM ON THE STRATEGIC AND OPERATIVE LEVEL	Heller, Slawomir
1113	PAVEMENT MANEGEMENT SYSTEM OF EP - ESTRADAS DE PORTUGAL, S.A. STRUCTURE AND THE FUNCTIONALITIES	Costa-Pereira, Francisco
1088	PERFORMANCE-BASED MIX DESIGN METHOD FOR BITUMINOUS HOT-MIX RECYCLING IN PLANT	Capitão, Silvino
1143	PRELIMINARY RESULTS OF A 2 GHZ HORN ANTENNA GPR ON A PAVEMENT SECTION IN PORTUGAL	Costa, Andre
1045	PRIVATE PARTICIPATION IN MANAGING ROAD ASSETS	Gutiérrez-Bolívar, Oscai
1068	RECYCLING OF ASPHALT PAVEMENTS WITH ASPHALT RUBBER	Minhoto, Manuel
1078	RELATION BETWEEN ZERO SHEAR VISCOSITY AND ZERO FREQUENCY COMPLEX VISCOSITY AT DIFFERENT TEMPERATURES	Nguyen, Viet Hung
1029	ROAD ASSET MANAGEMENT AND TRANSPORTATION OF HAZARDOUS MATERIALS	Praticò, Filippo
1019	ROAD ASSET MANAGEMENT –MAIN MAINTENANCE MEASURES: BACKLOG AND EFFECTIVENESS	Potucek, Jaro
1114	ROAD NETWORK: RESOURCE MANAGEMENT FOR ITS MAINTENANCE	Varela, Fernando
1119	ROAD SAFETY MANAGEMENT IN LISBON: DEVELOPMENT OF EFFICIENT CORRECTIVE SAFETY MEASURES.	Carvalheira, Carmen
1081	ROADEX – A ROADS TECHNICAL COLLABORATION ACROSS THE EUROPEAN NORTHERN PERIPHERY	Munro, Ron
1106	RUTTING COMPARISON OF LABORATORY AND FIELD SAMPLES WITH VERIFIED REPEATED CREEP TESTS IN ASPHALT MIXTURES	Aksoy, Atakan
1018	SECTION BASED PROBABILISTIC PERFORMANCE PREDICTION FICTION OR FUTURE?	Weninger-Vycudil, Alfre
1072	SKID RESISTANCE AND TEXTURE OF COMPACTED ASPHALT MIXES EVALUATED BY THE IFI IN LABORATORY	Pereira, Paulo
1090	SPANISH NATIONAL ROAD NETWORK PAVEMENT MANAGEMENT SYSTEM	Rojo, Álvaro Navareño
1083	SPEED MANAGEMENT IN REGIONAL AND NATIONAL SINGLE CARRIAGEWAY THROUGH ROADS: AN INTEGRATED APPROACH	Silva, Ana Maria
1077	STUDY ON THE CONSEQUENCES OF AFFIXING THE CE MARKING TO BITUMINOUS MIXTURES	Palha, Carlos
1021	SUSTAINING INFRASTRUCTURE SERVICES BY APPLICATION OF ASSET MANAGEMENT	Mante, Bart R.
1145	TECHNOLOGIES FOR THIN-LAYER MAINTENANCE	Marquardt, Andreas
1066	THE EFFECT OF DRAINAGE CONDITION ON THE LIFETIME OF PAVED ROADS IN NORTHERN EUROPE	Saarenketo, Timo
1017	THE NEW AUSTRIAN METHOD FOR THE STRUCTURAL ASSESSMENT OF PAVEMENT CONSTRUCTIONS FOR PMS PURPOSES	Simanek, Petra
1135	THE TRAFFIC AND TEMPERATURE EFFECT ON THE REFLECTIVE CRACKING	Minhoto, Manuel
1093	THE USE OF DATA MINING TECHNIQUES FOR ROAD MAINTENANCE PLANNING	Giuliana, Giovanni
1087	THE USE OF THE GYRATORY COMPACTOR IN THE DESIGN OF PORTUGUESE BITUMINOUS MIXTURES	Gardete, Dinis
1064	THEORETICAL BASIS FOR THE TREATMENT OF LONG DRAINAGE PATHS ON MOTORWAYS	Griffiths, Geoffrey
1142	TOWARDS NOISE CLASSIFICATION OF ROAD PAVEMENTS	Freitas, Elisabete
1130	TRAFFIC DEPENDENT MARKOV TYPE MULTIPERIOD PMS MODEL	Bako, Andras
1096	TRAFFIC SIMULATION TOOLS APPLIED TO PAVEMENT DESIGN	Vasconcelos, António
1014	TRANSPORTATION ASSET MANAGEMENT IN THE UNITED STATES	Wlaschin, Julius B.
1056	VARIATION OF THE INTERNATIONAL ROUGHNESS INDEX VALUES IN FUNCTION OF THE HEAVY TRAFFIC	Laszlo, Petho



PAPER	TITLE	SPEAKER
1106	RUTTING COMPARISON OF LABORATORY AND FIELD SAMPLES WITH VERIFIED REPEATED CREEP TESTS IN ASPHALT MIXTURES	Aksoy, Atakan
1082	CONDITION ASSESSSMENT ON CYCLE PATHS WITH A NEWLY DEVELOPED MEASURING TECHNOLOGY	Anger, Randolf
1132	PAVEMENT IMPACTS ON HIGHWAY RUNOFF QUALITY- ARE COASTAL AREAS SPECIAL CASES?	Antunes, Pedro
1130	TRAFFIC DEPENDENT MARKOV TYPE MULTIPERIOD PMS MODEL	Bako, Andras
1133	MANAGEMENT OF SURFACE CHARACTERISTICS OF ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF MICROGRINDING AND BLASTING TECHNIQUES	Barranco, Jose Marcobal
1061	IDENTIFYING STRUCTURAL CHANGES IN PAVEMENT PROFILES FROM TRAFFIC SPEED DEFLECTOGRAPH DATA USING MML INFERENCE	Byrne, Matt
1088	PERFORMANCE-BASED MIX DESIGN METHOD FOR BITUMINOUS HOT-MIX RECYCLING IN PLANT	Capitão, Silvino
1119	ROAD SAFETY MANAGEMENT IN LISBON: DEVELOPMENT OF EFFICIENT CORRECTIVE SAFETY MEASURES.	Carvalheira, Carmen
1070	EVALUATING EFFECT OF FILM THICKNESS ON AGING OF ASPHALT THROUGH THIN FILM OVEN TEST	Chanda, Satish
1143	PRELIMINARY RESULTS OF A 2 GHZ HORN ANTENNA GPR ON A PAVEMENT SECTION IN PORTUGAL	Costa, Andre
1113	PAVEMENT MANEGEMENT SYSTEM OF EP - ESTRADAS DE PORTUGAL, S.A. STRUCTURE AND THE FUNCTIONALITIES	Costa-Pereira, Francisco
1144	CHARACTERISTICS OF ASPHALT BINDERS MODIFIED WITH THE INCORPORATION OF RECLYCLED CRUMBLED RUBBER	Dias, José
1136	ANALYSIS OF PAVEMENT PERFORMANCE MODELS FOR USE IN PAVEMENT MANAGEMENT SYSTEMS	Ferreira, Adelino
1138	CONTRIBUTIONS TO THE DEVELOPMENT OF THE PORTUGUESE ROAD ADMINISTRATION'S PAVEMENT MANAGEMENT SYSTEM	Ferreira, Adelino
1129	MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN HIGHWAY ASSET MANAGEMENT	Flintsch, Gerardo
1142	TOWARDS NOISE CLASSIFICATION OF ROAD PAVEMENTS	Freitas, Elisabete
1087	THE USE OF THE GYRATORY COMPACTOR IN THE DESIGN OF PORTUGUESE BITUMINOUS MIXTURES	Gardete, Dinis
1000	LIFETIME ENGINEERING IN ROAD ASSET MANAGEMENT	Gaspar, Laszlo
1116	FACTORS INFLUENCING THE RELIABILITY OF PAVEMENT PERFORMANCE MODELS	Gaspar, Laszlo
1117	DEVELOPMENT OF THE HUNGARIAN HIGHWAY ASSET MANAGEMENT	Gaspar, Laszlo
1141	PAVEMENT MANAGEMENT SYSTEM ON A FRENCH HIGHWAY NETWORK	Giacobi, Cécile
1093	THE USE OF DATA MINING TECHNIQUES FOR ROAD MAINTENANCE PLANNING	Giuliana, Giovanni
1120	ACCIDENT PREDICTION MODELS FOR URBAN AREAS A STATE-OF-THE-ART	Gomes, Sandra Vieira
1091	EVALUATION OF SOIL-CEMENT STRENGTHS IN REGIONAL ROADS OF CASTILLA Y LEÓN	Gonzalo Orden, Hernán
1064	THEORETICAL BASIS FOR THE TREATMENT OF LONG DRAINAGE PATHS ON MOTORWAYS	Griffiths, Geoffrey
1009	IMPLEMENTATION OF A COMMUNAL PMS IN GERMANY - STATE-OF-THE-ART -	Grossmann, Andreas
1045	PRIVATE PARTICIPATION IN MANAGING ROAD ASSETS	Gutiérrez-Bolívar, Oscar
1024	PAVEMENT MANAGEMENT SYSTEM ON THE STRATEGIC AND OPERATIVE LEVEL	Heller, Slawomir
1008	BRIDGE MANAGEMENT PLAN AND STRATEGY	Jurić, Smiljan
1026	MAINTENANCE MANAGEMENT FOR THE CLASSIFIED ROAD NETWORK	Krmek, Mario
1027	A ROAD USER COSTS MODEL FOR PORTUGUESE TRUNK ROADS	krmek, Mario
1056	VARIATION OF THE INTERNATIONAL ROUGHNESS INDEX VALUES IN FUNCTION OF THE HEAVY TRAFFIC	Laszlo, Petho
1060	DEVELOPMENT OF A TECHNICO-ECONOMIC OPTIMIZATION MODEL FOR PAVEMENT MAINTENANCE WORKS	Lepert, Philipe
1028	COST 354 - PERFORMANCE INDICATORS FOR ROAD PAVEMENTS	Litzka, Johann
1041	BASIC PARAMETERS OF OPTIMUM, COST-EFFECTIVE BRIDGE MAINTENANCE AND REHABILITATION	Lublóy, László
1095	MECHANICAL BEHAVIOUR OF TWO CRUSHED MATERIALS USED IN PORTUGUESE UGL	Luzia, Rosa
1021	SUSTAINING INFRASTRUCTURE SERVICES BY APPLICATION OF ASSET MANAGEMENT	Mante, Bart R.
1145	TECHNOLOGIES FOR THIN-LAYER MAINTENANCE	Marquardt, Andreas
1002	HIGH PRODUCTIVITY VEHICLES AND PAVEMENT ECONOMIC IMPACTS	Martin, Tim
1003	FAMLIT- A NEW PAVEMENT ASSESSMENT TOOL	Martin, Tim
1089	A COMPARISON BETWEEN THE LIFE OF A RECYCLED ASPHALT PAVEMENT AND A NEW ONE	Martínez, Adriana

	MODELING ROAD-TYRE NOISE	Martins, Mário
1035	EXPERIMENTAL ANALYSIS OF INNOVATIVE JOINTS IN REHABILITATION OF AIRPORT PAVEMENTS	<u>Mauro, Pozzi</u>
1015	A NEW DETERMINISTIC OPTIMIZATION MODEL PROPOSED TO BE USED IN THE PMS OF A PORTUGUESE MUNICIPALITY	Meneses, Susana
1067	DEM SIMULATION OF FIELD ASPHALT COMPACTION	Micaelo, Rui
1068	RECYCLING OF ASPHALT PAVEMENTS WITH ASPHALT RUBBER	Minhoto, Manuel
1135	THE TRAFFIC AND TEMPERATURE EFFECT ON THE REFLECTIVE CRACKING	Minhoto, Manuel
1092	ASPHALT RUBBER MIXTURES IN PORTUGAL: FATIGUE RESISTANCE	Miranda, Henrique
1099	HARMONIZATION OF PROJECT AND STRATEGIC LEVEL PAVEMENT MANAGEMENT	Mladenovic, Goran
1030	NEW AND OLD TECHNOLOGIES FOR THE DETERMINATION OF DENSITY OF HMAS	Moro, Antonino
1053	BREAKING THE SILOS IN ASSET MANAGEMENT: COMPREHENSIVE OPTIMIZATION IN LONG-TERM PLANNING OVER MULTIPLE ASSET TYPES	Mrawira, Donath
1081	ROADEX – A ROADS TECHNICAL COLLABORATION ACROSS THE EUROPEAN NORTHERN PERIPHERY	Munro, Ron
1054	INTEGRATION OF PAVEMENT MANAGEMENT SYSTEMS AND BRIDGE MANAGEMENT SYSTEMS	Neves, Luis
1078	RELATION BETWEEN ZERO SHEAR VISCOSITY AND ZERO FREQUENCY COMPLEX VISCOSITY AT DIFFERENT TEMPERATURES	Nguyen, Viet Hung
1033	ANALYSIS OF URBAN PAVEMENT SURFACE PROFILES ORIENTED TO ENVIRONMENTAL PERFORMANCE INDICATORS.	Nicolosi, Vittorio
1137	A MIXTURE MODEL FOR PREDICTING PATTERNS OF SPATIAL REPEATABILITY IN HEAVY VEHICLE FLEETS	Obrien, Eugene
1080	AN ALTERNATIVE DEFLECTION ANALYSIS FOR THE EVALUATION OF THE PAVEMENT CONDITION	Oliveira, Joel
1077	STUDY ON THE CONSEQUENCES OF AFFIXING THE CE MARKING TO BITUMINOUS MIXTURES	Palha, Carlos
1071	LABORATORY OPTIMIZATION OF CONTINUOUS BLEND ASPHALT RUBBER	Pereira, Paulo
1072	SKID RESISTANCE AND TEXTURE OF COMPACTED ASPHALT MIXES EVALUATED BY THE IFI IN LABORATORY	Pereira, Paulo
1013	MULTIDIMENSIONAL APPROACH TO DESCRIBE BRIDGE DETERIORIATION	Petschacher, Markus
1112	A MAINTENANCE MANAGEMENT SYSTEM FOR THE STATE OF RIO GRANDE DO SUL PAVED ROADS	Pinto, Paulo
1019	ROAD ASSET MANAGEMENT –MAIN MAINTENANCE MEASURES: BACKLOG AND EFFECTIVENESS	Potucek, Jaro
1029	ROAD ASSET MANAGEMENT AND TRANSPORTATION OF HAZARDOUS MATERIALS	Praticò, Filippo
1090	SPANISH NATIONAL ROAD NETWORK PAVEMENT MANAGEMENT SYSTEM	Rojo, Álvaro Navareño
1066	THE EFFECT OF DRAINAGE CONDITION ON THE LIFETIME OF PAVED ROADS IN NORTHERN EUROPE	Saarenketo, Timo
1139	CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODEL	Santos, Bruno
1083	SPEED MANAGEMENT IN REGIONAL AND NATIONAL SINGLE CARRIAGEWAY THROUGH ROADS: AN INTEGRATED APPROACH	Silva, Ana Maria
1075	INFLUENCE OF TEMPERATURE ON THE FATIGUE LIFE OF FLEXIBLE PAVEMENTS	Silva, Hugo
1017	THE NEW AUSTRIAN METHOD FOR THE STRUCTURAL ASSESSMENT OF PAVEMENT CONSTRUCTIONS FOR PMS PURPOSES	Simanek, Petra
1048	ENGINEERING STRUCTURES MANAGEMENT SYSTEM:EXAMPLE ON A FRENCH HIGHWAY NETWORK	Simon, Isabelle
1031	IMPLEMENTATION OF A STOCHASTIC PMS MODEL	Socina, Mihai
1059	MIX DESIGN FOR COLD-IN-PLACE PAVEMENT RECYCLING; DOES IT GUARANTEE PERFORMANCE?	Sufian, Zulakmal
1006	CHARACTERIZATION OF ROAD BASES AND SUBBASES MADE OF RECLAIMED ASPHALT PAVEMENT AND RECYCLED CONCRETE AGGREGATE	Taha, Ramzi
1118	CONTRIBUTION OF THE STATE ROAD REHABILITATION TO TRAFFIC SAFETY	Vajdić, Marko
1065	EFFECT OF ASPHALT LAYER THICKNESS VARIABILITY ON PREDICTED FLEXIBLE PAVEMENT LIFE	Valle, Paola Dalla
1114	ROAD NETWORK:RESOURCE MANAGEMENT FOR ITS MAINTENANCE	Varela, Fernando
1096	TRAFFIC SIMULATION TOOLS APPLIED TO PAVEMENT DESIGN	Vasconcelos, António
1018	SECTION BASED PROBABILISTIC PERFORMANCE PREDICTION FICTION OR FUTURE?	Weninger-Vycudil, Alfred
1014	TRANSPORTATION ASSET MANAGEMENT IN THE UNITED STATES	Wlaschin, Julius B.
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General Program

Day 0			
15:00 - 19:00	Registration (DEC main hall, level 2)	Sunday, 6 July 2008	
Day 1		Monday, 7 July 2008	
08:00 - 17:00	Registration (DEC main hall, level 2)	mondoy, rodiy 2000	*
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	Session B1	
13:00 - 14:20	Modelling Asset Performance - part 1	Asset Condition Evaluation - part 1	SECURIOR CONTROL CONTR
	Session A2	Lunch (tent with exit from Exhibition level, level 4)	
14:20 - 16:05	Modelling Asset Performance - part 2	Asset Condition Evaluation - part 2	
16:05 - 16:25	modeling reserve from the control of	Coffee break (fevel 4)	
10.35 10.10	Session A3	e Session B3	
16:25 - 18:10	Implementation of Management Systems - part1	Asset Management - part 1	
18:15 - 20:00			AGAZAM TELEVISIONE COSTIBLA (PLACE SERVICE COSTIBLA COSTIBLA COSTIBLA COSTIBLA COSTIBLA COSTIBLA COSTIBLA COST
20:30 - 23:30	Perpetion	at S6 Velha (Old Cathedral near the old campos of the University of Co	
Day 2		Tuesday, 8 July 2008	
08:00 - 17:00	Registration (DEC main hall, level 2)	racsaay, o sary 2000	
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	West Session 84 (1994)	
	Implementation of Management Systems - part2	Asset Management - part 2	
11:30 - 13:10	Session AS Pavement Technologies - part1	Session 85	
13:10 - 14:20	i avement reuniologies - part1	Asset Manag. and Implem. of Manag. Sys - part 3 Lunch (tent with exit from Exhibition level, level 4) - 18	
	Session A6	Session 86	DAWG
14:20 - 16:05	Pavement Technologies - part2	Pavement Technologies - part3	PAWG page and the same and the
16:05 - 17:00	Diagram A. Sessian A. Sessian A.	Session B7 4	PART CONTRACTOR DAWS OF THE PROPERTY OF THE PARTY OF THE
	Pavement Technologies - part4	Pavement Technologies - part5	
17:00 - 17:30		Coffee break (level 4) (4)	
17:30 - 18:15		Closing Session (Room: Auditorio Laginha Serafim, level 3)	
19:30 - 00:30 Day 3	Banquet at Convent	o de Sandelgas (Sandelgas, Islabout 20 km from colmbra esing CN 111), r.	ational nighway)
08:00 - 20:30		Wednesday, 9 July 2008	
06.00 - 20.50	Technical Visit to Operations Centre of BRISA (n	nain Portuguese motorways concessionaire) and visit to Sintra and the	



Day 0		Sunday, 6 July 2008	3
15:00 - 19:00	Registration (DEC main hall, level 2)	Monday, 7 July 2008	
Day 1 08:00 - 17:00	Registration (DEC main hall, level 2)	ivioliday, 7 July 2006	
09:00 - 10:00	<u> </u>	en di alegaci na di Secondario	orest Orion
10:00 - 11:00		ACTUCE by Hamio Zanghampour (Rolom) Audiu	
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	B1.1 - COST 354 - PERFORMANCE INDICATORS FOR ROAD	
	PAVEMENT PERFORMANCE MODELS	PAVEMENTS	
11:30 - 11:42		J. Litzka, B. Leben, F. La Torre, A. Weninger-Vycudil, M. L.	
	L. Gáspár (ref. 1116)	Antunes (ref. 1028)	
	A1.Z - DEVELOPIVIENT OF A TECHNICO-ECONOMIC	DI.Z - THE INEW AUSTRIAN WETHOU FOR THE STRUCTURAL	
	OPTIMIZATION MODEL FOR PAVEMENT MAINTENANCE	ASSESSMENT OF PAVEMENT CONSTRUCTIONS FOR PMS	
11:42 - 11:54	P. Lepert, F. Brillet (ref. 1060)	A. Weninger-Vycudil; P. Simanek (ref. 1017)	
	A1.5 - BREAKING THE SILUS IN ASSET WANGEMENT: COMPREHENSIVE OPTIMIZATION IN LONG-TERM PLANNING	B1.3 - FAMLIT- A NEW PAVEMENT ASSESSMENT TOOL	
11:54 - 12:06	OVER MILITIPLE ASSET TYPES		
	D. Mrawira, L. Amador (ref. 1053)	N. Michel, R. Hassan, J. Roberts (ref. 1003) - Tim Martin	
	A1.4 - SECTION BASED PROBABILISTIC PERFORMANCE	B1.4 - BASIC PARAMETERS OF OPTIMUM, COST-EFFECTIVE	
12.00 12.10	PREDICTION FICTION OR FUTURE?	BRIDGE MAINTENANCE AND REHABILITATION	
12:06 - 12:18	A. Weninger-Vycudil, G. Samek, T. Rohringer (ref. 1018)	L. Lublóy (ref. 1041)	
	A1.5 - MULTIDIMENSIONAL APPROACH TO DESCRIBE	B1.5 - SKID RESISTANCE AND TEXTURE OF COMPACTED	
	BRIDGE DETERIORIATION	ASPHALT MIXES EVALUATED BY THE IFI IN LABORATORY	
12:18 - 12:30	M. Petschacher, K. Gragger (ref. 1013)	G. Trichês, L. Fontes, J. Pais, A. Ferreira, P. Pereira (ref. 1056)	
	A1.6 - A ROAD USER COSTS MODEL FOR PORTUGUESE	B1.6 - VARIATION OF THE INTERNATIONAL ROUGHNESS	
	TRUNK ROADS	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-B1	
13:00 - 14:20			Free Print Committee



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: SE 4.2 (level 4)
	Room: Auditorio Laginha Serafim (level 3) Session A2	Room: AFD 3.1 (level 3) Session B2	100111. 35 4.2 (16Vel 4)
14:20 - 16:05	Session A2	Jession 02	
14.20 - 16.03	Modelling Asset Performance - part 2	Asset Condition Evaluation - part 2	
	A2.1 - MULTI-CRITERIA OPTIMIZATION APPLICATIONS IN	B2.1 - AN ALTERNATIVE DEFLECTION ANALYSIS FOR THE	
44.20 44.22	HIGHWAY ASSET MANAGEMENT	EVALUATION OF THE PAVEMENT CONDITION	
14:20 - 14:32	Z. Wu, G. Flintsch, A. Ferreira, L. Picado-Santos (ref. 1129)	J. Oliveira, H. Silva, P. Pereira, A. Almeida (ref. 1080)	
	A2.2 - A MIXTURE MODEL FOR PREDICTING PATTERNS OF	B2.2 - EFFECT OF ASPHALT LAYER THICKNESS VARIABILITY	
14:32 - 14:44	SPATIAL REPEATABILITY IN HEAVY VEHICLE FLEETS	ON PREDICTED FLEXIBLE PAVEMENT LIFE	
14.32 - 14.44	N. Harris, E. Obrien, S. Wilson (ref. 1137)	P. Valle, A. Collop, N. Thom (ref. 1065)	
	A2.3 - ANALYSIS OF PAVEMENT PERFORMANCE MODELS	PROFILES FROM TRAFFIC SPEED DEFLECTOGRAPH DATA	
14:44 - 14:56	FOR USE IN PAVEMENT MANAGEMENT SYSTEMS	LISING MMI INFERENCE	
	A. Ferreira, L. Picado-Santos, Z. Wu, G. Flintsch (ref. 1136)	<u>M. Byrne (ref. 1061)</u>	
	A2.4 - TRAFFIC DEPENDENT MARKOV TYPE MULTIPERIOD	ORIENTED TO ENVIRONMENTAL PERFORMANCE	
14:56 - 15:08	PMS MODEL	INDICATORS	
	A. Bakó, K. Ambrus-Somogyi, T. Hartványi, I. Szüts (ref. 1130)	V. Nicolosi, M. D'Apuzzo, B. Festa, L. Mancini (ref. 1033)	
	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	
15:08 - 15:20	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	
15:20 - 15:32	M. Martins, L. Picado-Santos, E. Freitas (ref. 1104)	E. Freitas, J. Paulo, J. Coelho, P. Pereira (ref. 1142)	
45.00 45.41	A2.7 - TRAFFIC SIMULATION TOOLS APPLIED TO PAVEMENT DESIGN	B2.7 - CONDITION ASSESSSMENT ON CYCLE PATHS WITH A NEWLY DEVELOPED MEASURING TECHNOLOGY	
15:32 - 15:44	A. Vasconcelos, A. Silva , A. Seco, J. Silva (ref. 1096)	R. Anger, A. Schniering (ref. 1082)	
15:44 - 16:05	DISCUSSION	DISCUSSION-B2	
16:05 - 16:25		Coffee break (level 4)	



8:00 - 17:00	Registration (DEC main hall, level 2)		
6:05 - 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	
	A3.1 - MAINTENANCE MANAGEMENT FOR THE CLASSIFIED	B3.1 - LIFETIME ENGINEERING IN ROAD ASSET	
6:25 - 16:37	ROAD NETWORK	MANAGEMENT	
0.23 10.37	A. Künkel-Henker, Mario Krmek (ref. 1026)	L. Gáspár (ref. 1000)	
	A3.2 -IMPLEMENTATION OF A COMMUNAL PMS IN	B3.2 - TRANSPORTATION ASSET MANAGEMENT IN THE	
6:37 - 16:49	GERMANY - STATE-OF-THE-ART	UNITED STATES	
.0.37 - 10.43	R. Roos, M. Stöckner, A. Grossmann (ref. 1009)	J. Wlaschin (ref. 1014)	
	A3.3 - A MAINTENANCE MANAGEMENT SYSTEM FOR THE	B3.3 - ROAD ASSET MANAGEMENT –MAIN MAINTENANCE	
6:49 - 17:01	STATE OF RIO GRANDE DO SUL PAVED ROADS	MEASURES: BACKLOG AND EFFECTIVENESS	
.0.45 - 17.01	R. Rodrigues, F. Gonçalves, P. Pinto, E. Taffe Jr. (ref. 1112)	J. Potucek (ref. 1019)	
	A3.4 - PAVEMENT MANEGEMENT SYSTEM OF EP -	B3.4 - HARMONIZATION OF PROJECT AND STRATEGIC LEVEL	
17:01 - 17:13	ESTRADAS DE PORTUGAL, S.A. STRUCTURE AND THE	PAVEMENT MANAGEMENT	
7.01	F. Pereira, E. Duarte, T. Moital (ref. 1113)	K. Tsunokawa, G. Mladenovic, A. Djurekovic, S. Marin (ref. 1099)	
L7:13 - 17:25	A3.5 - CONTRIBUTIONS TO THE DEVELOPMENT OF THE PORTUGUESE ROAD ADMINISTRATION'S PAVEMENT	B3.5 - BRIDGE MANAGEMENT PLAN AND STRATEGY	
17.13	L. Picado-Santos, A. Ferreira (ref. 1138)	B. Kuvačić, S. Jurić (ref. 1008)	
	A3.6 - PAVEMENT MANAGEMENT SYSTEM ON A FRENCH	B3.6 - SUSTAINING INFRASTRUCTURE SERVICES BY	
17:25 - 17:37	HIGHWAY NETWORK	APPLICATION OF ASSET MANAGEMENT	
17.123	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	
£1.37 - £1.43	M. Socina (ref. 1031)	O. Gutiérrez-Bolivar, M. Torrens (ref. 1045)	
17:49 - 18:10	DISCUSSION	DISCUSSION	
18:15 - 20:00			COST 354



Day 2 08:00 - 17:00	Registration (DEC main hall, level 2)	Tuesday,8 July 2008	1 172
		PERF PREDICTION, OPPORT AND CHALL FOR	PMS by Gerardo Flimson (Room) Auditorio
09:00 - 10:00		Laginha Serafim, level 3)	
10:00 - 10:20	Room: Auditorio Laginha Serafim (level 3)	Coffee break (level 4) 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	
10.20 - 10.32	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	
20.32 20.44	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	
10.44 10.30	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		
10.50 - 11.10	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	



Day 2		Tuesday,8 July 2008	
8:00 - 17:00	Registration (DEC main hall, level 2)	D	B
	Room: Auditorio Laginha Serafim (level 3) Session A4.	Room: AFD 3.1 (level 3) Session B4	Room: SE 4.2 (leve
0:20 - 11:30	Implementation of Management systems - part 2	Asset Management - part 2	
	Session A5	Session B5	
1:30 - 13:10	Pavement Technologies - part 1	Asset Manag. and Implem. of Manag. Sys - part 3	
1:30 - 11:42	A5.1 - TECHNOLOGIES FOR THIN-LAYER MAINTENANCE	SINGLE CARRIAGEWAY THROUGH ROADS: AN INTEGRATED	
11.50 - 11.42	A. Marquardt	A. Seco, A. Silva, C. Galvão (ref. 1083)	
1:42 - 11:54	A5.2 -	B5.2 -CONSIDERING ROBUSTNESS OBJECTIVES IN A ROAD NETWORK PLANNING MODEL	
11.42 - 11.54	A. Marguardt (ref. 1145)	B. Santos, A. Antunes (ref. 1139)	
11-54 12-06	A5.3 - MIX DESIGN FOR COLD-IN-PLACE PAVEMENT RECYCLING; DOES IT GUARANTEE PERFORMANCE?	B5.3 - ROADEX – A ROADS TECHNICAL COLLABORATION ACROSS THE EUROPEAN NORTHERN PERIPHERY	
11:54 - 12:06	Z. Sufian, N. Aziz, M. Motori, M. Hussain (ref.1059)	R. Munro, T. Saarenketo, K. Palo (ref. 1081)	
12.06 12.10	A5.4 (ex- A6.2) - LABORATORY OPTIMIZATION OF CONTINUOUS BLEND ASPHALT RUBBER	B5.4 - THE USE OF DATA MINING TECHNIQUES FOR ROAD MAINTENANCE PLANNING	
12:06 - 12:18	L. Fontes, P. Pereira, G. Trichês, J. Pais, R. Luzia (ref. 1071)	B. Festa, L. Sparavigna, G. Giuliana (ref. 1093)	
	A5.5 - PERFORMANCE-BASED MIX DESIGN METHOD FOR BITUMINOUS HOT-MIX RECYCLING IN PLANT	B5.5 - CONTRIBUTION OF THE STATE ROAD REHABILITATION TO TRAFFIC SAFETY	
12:18 - 12:30	A. Baptista, L. Picado-Santos, S. Capitão, J. Oliveira (ref. 1088)	M. Sršen, N. Sukalić, M. Vajdić (ref. 1118)	
12.20 42.42	MADE OF RECLAIMED ASPHALT PAVEMENT AND RECYCLED	B5.6 -SPANISH NATIONAL ROAD NETWORK PAVEMENT MANAGEMENT SYSTEM	
12:30 - 12:42	R. Taha, K. Alshamsi (ref. 1006)	A. Navareño, V. Gómez (ref. 1090)	
	DICTICCION	DEVELOPMENT OF EFFICIENT CORRECTIVE SAFETY MAGASLINES	
12:42 - 12:54	DISCUSSION	C. Carvalheira, L. PSantos, S. Gomes, J. Cardoso (ref. 1119)	
12:54 - 13:10	DISCUSSION	DISCUSSION	
13:10 - 14:20	TO STATE OF THE PROPERTY OF TH	Lunch (tent with exit from Exhibition level, level 4)	



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	Session B6	DAWG
14.20 - 10.03	Pavement technologies - part 2	Pavement technologies - part 3	
	A6.1 - THE USE OF THE GYRATORY COMPACTOR IN THE	B6.1 - EVALUATION OF SOIL-CEMENT STRENGTHS IN	
14.20 14.22	DESIGN OF PORTUGUESE BITUMINOUS MIXTURES	REGIONAL ROADS OF CASTILLA Y LEÓN	
14:20 - 14:32	D. Gardete, L. Picado-Santos, S. Capitão, H. Silva (ref.	L Bayrage LL Orden (not 1001)	
	1087)	J. Berzosa, H. Orden (ref. 1091)	
	A6.2 (ex- A5.4) - RECYCLING OF ASPHALT PAVEMENTS	B6.2 - MECHANICAL BEHAVIOUR OF TWO CRUSHED	
	WITH ASPHALT RUBBER	MATERIALS USED IN PORTUGUESE UGL	
14:32 - 14:44		D. I. S. J. B. J. C. J. D. D. J. J. J. J. (1005)	
	J. Pais, P. Pereira, M. Minhoto, A. Baptista (ref. 1068)	R. Luzia, L. Picado-Santos, P. Pereira (ref. 1095)	
	A6.3 - A COMPARISON BETWEEN THE LIFE OF A RECYCLED	B6.3 - NEW AND OLD TECHNOLOGIES FOR THE	
	ASPHALT PAVEMENT AND A NEW ONE	DETERMINATION OF DENSITY OF HMAs	
14:44 - 14:56			
	M. Centeno, H. Orden, A. Martínez (ref. 1089)	F. Praticò, A. Moro, R. Ammendola (ref. 1030)	
	A6.4 - ASPHALT RUBBER MIXTURES IN PORTUGAL: FATIGUE		
	RESISTANCE	B6.4 - DEM SIMULATION OF FIELD ASPHALT COMPACTION	
14:56 - 15:08	H. Miranda, F. Batista, J. Neves, M. Antunes, P. Fonseca		
	(ref. 1092)	R. Micaelo, M. Azevedo, J. Ribeiro, N. Azevedo (ref. 1067)	
	A6.5 - INFLUENCE OF TEMPERATURE ON THE FATIGUE LIFE	B6.5 - STUDY ON THE CONSEQUENCES OF AFFIXING THE CE	
		MARKING TO BITUMINOUS MIXTURES	
15:08 - 15:20	OF FLEXIBLE PAVEMENTS	IVIANNING TO BITOWINGOS IVIATORES	
	H. Silva, J. Oliveira, L. Picado-Santos (ref. 1075)	H. Silva, C. Palha, D. Gardete, S. Capitão (ref. 1077)	
	AB.6 - KUTTING CUMPAKISUN OF LABORATORT AND FIELD	BO.O - MANAGEMENT OF SURFACE CHARACTERISTICS OF	
	SAMPLES WITH VERIFIED REPEATED CREEP TESTS IN	ASPHALT PAVEMENTS BY MEANS OF THE APPLICATION OF	
15:20 - 15:32	ASPHALT MIXTURES	MICROGRINDING AND BLASTING TECHNIQUES	
	A. Aksoy, E. Iskender, H. Ozen (ref. 1106)	J. Marcobal (ref. 1133)	
	A6.7 - THE TRAFFIC AND TEMPERATURE EFFECT ON THE	B6.7 - EXPERIMENTAL ANALYSIS OF INNOVATIVE JOINTS IN	
15:32 - 15:44	REFLECTIVE CRACKING	REHABILITATION OF AIRPORT PAVEMENTS	
15.54 - 15.44	M. Minhoto, J. Pais, P. Pereira (ref. 1135)	G. Rios, F.Fiori, M. Pozzi (ref. 1035)	
15:44 - 16:05	DISCUSSION	DISCUSSION	
16:05 - 17:00	Session A7	Session B7	DAWG
	Pavement Technologies - part4	Pavement Technologies - part5	

7 de 8



Sessions Program

Day 2		Tuesday, 8 July 2008	1 March 11 at 1
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	B7.1 - PAVEMENT IMPACTS ON HIGHWAY RUNOFF QUALITY— ARE COASTAL AREAS SPECIAL CASES?	
	J. Dias, L. Picado-Santos (ref. 1144)	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	B7.2 - THEORETICAL BASIS FOR THE TREATMENT OF LONG DRAINAGE PATHS ON MOTORWAYS	
2012/ 2012	R. Choundhary, S. Chandra (ref. 1070)	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	B7.3 - THE EFFECT OF DRAINAGE CONDITION ON THE LIFETIME OF PAVED ROADS IN NORTHERN EUROPE	
	V. Nguyen, G. Airey, M. Liao (ref. 1078)	T. Saarenketo (ref. 1066)	
16:41 - 17:00	DISCUSSION	DISCUSSION	
17:00 - 17:30 17:30 -18:15		Coffee break (level 4) 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	F111 national highway)

Day 3 Wednesday, 9 July 2008

08:00 - 20:30

Technical Vist to Operations Centre of BRISA (main Portuguese motorways concessionality) and Vist to Single and the sea sure at 5 Martinito do Portuguese motorways concessionality and Vist to Single and the sea sure at 5 Martinito do Portuguese motorways concessionality.

RECYCLING OF ASPHALT PAVEMENTS WITH ASPHALT RUBBER

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Abstract

Pavement recycling has been an important rehabilitation technique to deal with reclaimed materials from old pavements which are usually sent to landfills. The application of this technique contributes to: i) the accomplishment of the requirements defined by the European legislation for the amount of material sent to landfills; ii) the reduction in the use of new raw materials used to produce pavement layers. The reduction of materials to be used in pavement rehabilitation has also been possible through the use of asphalt rubber binder (i.e. asphalt modified by crumb rubber from ground tyres) in the production of asphalt mixtures. These mixtures, named asphalt rubber mixtures, have shown an excellent performance in pavement rehabilitation in terms of fatigue and reflective cracking. This behaviour is based on the physical properties of the asphalt rubber which are transferred from the rubber to the net asphalt. The use of asphalt rubber in pavement recycling produces a binder which is a blend of the reclaimed mix binder and the new asphalt rubber added to the reclaimed asphalt mix. This recycled binder presents properties mainly based on recycling rates and on the binders used in recycling. The behaviour of the recycled mixture depends on these factors. This paper presents the results of the properties evaluated for recycled mixtures derived from the type of binder presented in the reclaimed asphalt mix and recycling rate. The influence of the reclaimed asphalt mixes and recycling rate was studied to optimize the behaviour of the recycled mixtures. The mechanical performance in terms of stiffness and fatigue resistance was also evaluated for the recycling design process.

INTRODUCTION

Hot mix asphalt recycling in plant is defined as a technique to produce hot mix asphalt in plant with a certain percentage of reclaimed asphalt granulates as raw material. This percentage can vary between 0 % and almost 100 %, depending on the type of plant and the type of mixture to be produced. Recycling is the re-use of (waste) materials in the same way they had been used for their initial purpose (PIARC, 2003). This process involves the aim of extending the life and usefulness of something that seems to have no more purpose.

Recycling of road pavements have become effective during the last few years by the recycling of old pavements and by the use of crumb rubber recycled from ground tyres. The recycling of reclaimed asphalt mixtures is well known and used worldwide to recover used material and to reduce the use of new ones. The recycling of rubber from ground tyres is also a very used process to modify asphalt in order to produce asphalt rubber with which asphalt rubber

mixtures are obtained. These mixtures present an excellent performance in pavement rehabilitation due to the properties of the asphalt rubber binder.

The application of asphalt rubber binder in pavement recycling is very recent. Tia and Ruth (2003), from the USA, were pioneers in this process. They carried out laboratory investigation to determine if the amount of crumb rubber in asphalt rubber had any adverse effects on the recycling and recycled mix properties.

The research allowed concluding that the recycling of mixtures with 33 and 50% of reclaimed asphalt mix are insensitive to the crumb rubber content up to 9% of the total binder. The use of 20% of crumb rubber in the binder of a recycled mixture with 40% of reclaimed asphalt mix can be combined with 60% virgin aggregate without incurring in any significant problems in construction and in service performance, provided that the aggregate gradation of the mixture is properly selected.

The use of crumb rubber modifier in hot mix asphalt mixtures can be traced back to the 1940s, when natural rubber was introduced into asphalt to increase its engineering performance. Since the 1960s, researchers and engineers have used crumb rubber recycled from used tyres in hot mix asphalt mixtures (Pais et al, 2008).

Considering the performance of asphalt rubber mixes, mainly in pavement overlays, pavement rehabilitation using recycled pavements should be carried out with asphalt rubber to increase the pavement overlay life due to reflective cracking. In this case, the existing pavement is milled and the reclaimed asphalt mix is used to produce a new mix by adding raw aggregates and an asphalt rubber binder.

The results presented in this work summarize part of a project in which the study of pavement recycling with asphalt rubber is the main goal. The project studied two reclaimed asphalt mixes to produce recycled mixtures in which the raw materials are composed of new aggregates and asphalt rubber. The main goal of this project is the study of the performance of recycled mixtures for several design parameters, such as asphalt rubber properties, recycling ratio and reclaimed asphalt characteristics. The performance of recycled mixes will be evaluated through fatigue, permanent deformation and reflective cracking resistance. The last two properties will be evaluated afterwards.

The part of the project presented in this paper shows: i) the characterization of the reclaimed asphalt mixtures; ii) the design of the asphalt rubber to be used in the recycling; iii) the prediction of the recycled binder properties (i.e. the binder resulting from the addition of the asphalt rubber to the binder of the reclaimed asphalt mixture); iv) the evaluation of the mechanical properties of the recycled mixtures in terms of stiffness and fatigue resistance.

RECLAIMED ASPHALT MIXTURES

For this study two sources of reclaimed asphalt mixtures were obtained from two different pavements under rehabilitation. The materials correspond to old wearing courses milled by the traditional process resulting in a material with an aggregate gradation different from the one used to produce the original material. Due to the climatic influence, the binder presents characteristics that are different from those of the original binder, mainly in terms of stiffness. The reclaimed asphalt mixtures, F1 and F2, were tested in laboratory in order to characterize their physical properties, i.e. aggregate gradation and asphalt content; the binder was

recovered to evaluate: i) penetration; ii) softening point; iii) apparent viscosity. These values are presented in Table 1. The penetration of the recovered asphalt was reduced from a 35/50 pen to a 10/20 pen. The different penetrations of F1 and F2 asphalt have some influence in the recycled mixture, once the asphalt stiffness of F1 asphalt is about 50% higher than one of F2 asphalt. The other characteristics are identical in both materials.

Table 1 – Characteristics of recovered asphalt of the reclaimed mixes

 ecovered asphalt	Penetration (mm/10)	Softening point (°C)	Viscosity (cP)
 F1	12	68	275
F2	18	65	313

The aggregate gradation of the reclaimed asphalt mixes, after extracting the asphalt, is presented in Figure 1 together with the gradation limits for the recycled asphalt rubber mix, which is a typical gap-graded asphalt rubber mix.

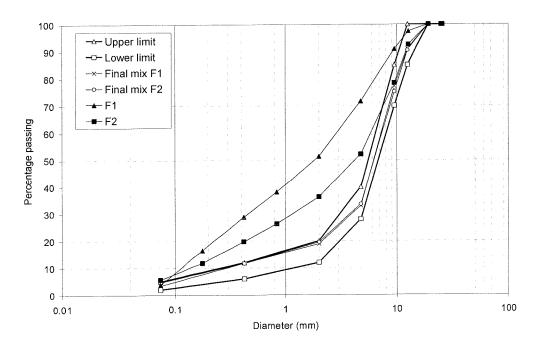


Figure 1 – Aggregate gradation of reclaimed mixes, recycled mix specification limits and final mix

The aggregate gradation curves for F1 and F2 reclaimed mixes exhibit a continuous gradation characterized by the presence of a significant amount of fine aggregates if compared to the gradation of the gap-graded mix used to produce the asphalt rubber mix of this work. F1 reclaimed mix presents more fines than mix F2, what will affect the design of recycled mixes.

The calculation of the recycling ratio, i.e. the amount of reclaimed material used in the production of the recycled mixture, allowed concluding that for F1 material the recycling ratio can reach 30% and for F2 material the recycling ratio can reach 45%.

Reclaimed asphalt mix F1 presented an asphalt content of 5.9% (in relation to the total weight of the mix) obtained by the ignition method, whereas the F2 material exhibited an asphalt content of 5.0%.

DESIGN OF THE ASPHALT RUBBER

The design of the asphalt rubbers to be applied when recycling the reclaimed mix considered two types of binders: a) 35/50 pen asphalt; b) 50/70 pen asphalt. These binders are the ones adopted in Portugal for the different temperature conditions in the country. Due to the climatic conditions the 35/50 pen asphalt is the principal binder used for all types of asphalt mixes applied in pavement construction and rehabilitation. The 50/70 pen asphalt is used for pavements in the coldest parts of the country.

The main characteristics of these binders (penetration, softening point and apparent viscosity) are presented in Table 2. The 35/50 pen asphalt used in this work exhibits a softer behaviour compared to the typical 35/50 pen asphalt as the penetration of the binder used is near the maximum limit of this property.

Softening point Viscosity Asphalt Penetration (cP) (mm/10)(°C) type 54 172 35/50 48 52 230 50/70 56

Table 2 - Characteristics of the new asphalt used in this work

The crumb rubber from waste tyres used in this study was obtained through the cryogenic process. The rubber gradation was tested following the requirements of ASTM C136 and the Greenbook recommendations. The rubber used followed the ADOT requirements type B namely with a grain gradation between 0.18 and 0.6 mm.

In accordance with the materials defined above, eight types of asphalt rubber were produced, four for each asphalt type. For the 50/70 pen asphalt, the content of crumb rubber was 18, 20, 22 and 24%. For the 35/50 pen asphalt, the content of crumb rubber was 18, 19, 20 and 21%. The difference in the content of crumb rubber used in these two asphalts results from the fact that the 50/70 is softer than 35/50 pen asphalt. The softer binders can be mixed with more crumb rubber without increasing the viscosity of the asphalt rubber.

The different types of asphalt rubber were produced in laboratory at a temperature of 175 °C, a digestion time of 45 minutes and tested in relation to penetration, softening point, resilience and viscosity. The results of the design of the crumb rubber are shown in Table 3 and represented in Figure 2 where it is observable that the increase of crumb rubber reduces penetration: the more content of crumb rubber, the harder asphalt rubber becomes. The same conclusion may be drawn for viscosity and softening point. In terms of resilience, the increase of the content in crumb rubber produces a more elastic asphalt rubber.

As expected these two types of asphalt used to produce the asphalt rubber produce different final products. The main difference between them appears from the fact that 50/70 pen asphalt allows adding about 1% more crumb rubber than 35/50 pen asphalt.

The design of asphalt rubber intends to define the crumb rubber content necessary to produce asphalt rubber. The main reason for choosing crumb rubber is because of the viscosity of

asphalt rubber, as it is important in order to ensure a correct mixing of the binder with the aggregates and a correct compaction of the final mix.

Asphalt rubber	Asphalt type	Rubber content	Penetration (mm/10)	Softening point (°C)	Viscosity (cP)	Resilience (%)
A1	50/70	18%	22	67	2013	53
A2	50/70	20%	21	71	2758	58
A3	50/70	22%	20	73	4975	61
A4	50/70	24%	19	78	8537	64
B1	35/50	18%	22	69	2104	55
B2	35/50	19%	21	71	2705	56
B3	35/50	20%	19	73	3533	56
B4	35/50	21%	19	73	5229	59

Table 3 - Asphalt rubber characteristics

The production of asphalt rubber mixes is mainly made by using the continuous blend process, in which asphalt rubber is produced near the asphalt mix plant with the help of specific equipment, and supplied to the asphalt mix plant in accordance with needs. To reach the asphalt mix plant, asphalt rubber needs to have a specific viscosity to be pumped appropriately. Present equipment can supply asphalt rubber with a viscosity inferior to 5000 cP.

Based on the obtained results, a content of 22% crumb rubber may be used to produce asphalt rubber with 50/70 pen asphalt, as it was used in this study (asphalt rubber A3). For the 35/50 pen asphalt, only 20% crumb rubber can be used (asphalt rubber B3).

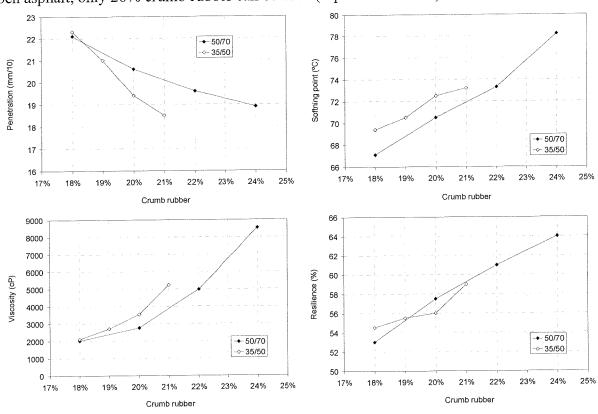


Figure 2 – Influence of crumb rubber content on the asphalt rubber characteristics

An analysis of Figure 2 allows the conclusion that the influence of the content in crumb rubber is more significant to values which are higher than 18%. From this value viscosity increases exponentially and no more than 3% to 5% of crumb rubber can be added. The influence of the content of crumb rubber on the other asphalt rubber characteristics follows a linear trend.

RECYCLED BINDER

The next phase of this work aimed at the evaluation of the characteristics of the binder resulting from the addition of asphalt rubber to the recovered asphalt from reclaimed mixes, simulating a recycling process. For this study both asphalt rubbers defined above (A3 and B3) were used together with the recycling ratios previously defined. For F1 material, which allows using up to 30% of reclaimed material, three recycling ratios were defined: 10, 20 and 30%. For F2 material, which allows using up to 45% of reclaimed material, 10, 25 and 40% recycling ratios were defined.

The results of this study (Table 4 and Figure 3) are related to the characteristics assessed for recycled binders, i.e. penetration, softening point, resilience and viscosity, as well as to the value of content in crumb rubber for recycled mixes. The results related to the characterization of the recycled binder allow the conclusion that the penetration exhibits a different trend depending on the reclaimed material. The increase of the ratio of F1 material produced a penetration decrease that was not expected. For the remaining characteristics, the increase of the recycling ratio produced a decrease in viscosity, softening point and resilience, as expected, as the asphalt rubber was modified by a conventional asphalt, in this case aged due to climatic conditions.

In practical terms, the recycled binder is a mix of recovered asphalt from a reclaimed mix in a percentage given by the recycling ratio and asphalt rubber. Thus, the characteristics of the recycled binder are a function of the characteristics of those two components. Relatively to penetration and softening point, this approach can be considered valid and the characteristics of the recycled binder can be calculated once the characteristics of the components are known. For viscosity, due to the digestion of the crumb rubber, mainly after mixing, the calculation is not valid. The calculated viscosity gives values 50% higher than the measured viscosity.

Table 4 - Recycled binder characteristics

Asphalt rubber Reclaimed Asphalt	Recycling	Penetration	Softening	Viscosity	Resilience	Crumb rubber
	ratio	(mm/10)	point (°C)	(cP)	(%)	content (%)
	10%	19	72	3484	53	19.8
A3	20%	18	72	2816	48	17.6
F1	30%	15	74	1430	47	15.4
	10%	19	73	2512	49	18.0
B3	20%	18	72	1549	44	15.0
F1	30%	16	70	966	42	12.0
	10%	22	76	2275	54	18.0
B3	25%	23	75	1354	50	15.0
F2	40%	24	70	800	44	12.0
	10%	20	75	3525	56	19.8
A3	25%	21	73	1946	52	17.6
F2	40%	21	71	916	47	15.4

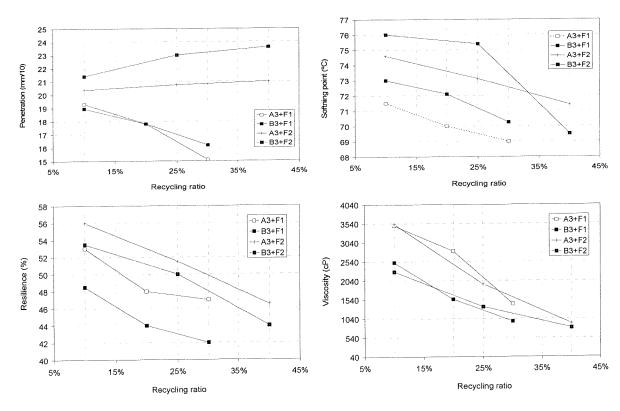


Figure 3 – Influence of recycling ratio on the recycled binder characteristics

The analysis of the influence of the recycling ratio, asphalt rubber and recovered asphalt on the recycled binder, expressed in Figure 3, allows the conclusion that any recycling ratio can be used to produce a recycled mix because the recycled binder presents characteristics which make possible the production of asphalt mixes. This can be mostly observed through viscosity. As the recycling ratio increases the recycled binder remains less modified by the crumb rubber and the expected performance of the recycled asphalt mixes will be reduced if compared with the performance of typical asphalt rubber mixes.

RECYCLED MIXTURES

The recycled mixture with 30% of F1 reclaimed material and B3 asphalt rubber, produced with the 35/50 per asphalt and 20% of crumb rubber, was characterized in terms of Marshall properties, stiffness modulus and fatigue resistance for 5 binder contents (8.5, 9.0, 9.5, 10.0 e 10.5%).

The Marshall test results expressed by the stability, flow, bulk density and void content are presented in Table 5. The Marshall stability as well as the bulk density are almost constant for all binder contents of the recycled mixes. The only variables which exhibit some variability with the binder content are the flow and the void content. Both variables present typical values for asphalt rubber mixes not allowing to define the binder content for the recycled mixture.

The test procedure for stiffness and fatigue resistance for all mixtures included placement of the specimens in an environmental chamber during 2 hours to reach the test temperature. The test configuration employed in this study was the four-point bending test in controlled strain. In controlled strain mode, the strain is kept constant and the stress decreases during the test.

Binder content	Marshall stability	Flow	Bulk density	Void content	
(%)	(kN)	(mm)	(g/cm3)	(%)	
8.5	8.1	4.2	2.25	5.0	
9.0	8.4	5.4	2.26	3.8	
9.5	8.4	4.4	2.25	3.8	
10.0	8.3	3.7	2.24	3.6	
10.5	8.3	5.5	2.25	3.2	

Table 5 - Marshall test results

The frequency sweep test was used to measure the stiffness and the phase angle of mixtures when subjected to different loading frequencies. In this study, seven frequencies were tested (10; 5; 2; 1; 0,5; 0,2; 0,1 Hz) in 100 cycles. The results of frequency sweep tests to determine the stiffness of the mixtures, conducted at 20 °C, are shown in Figure 4.

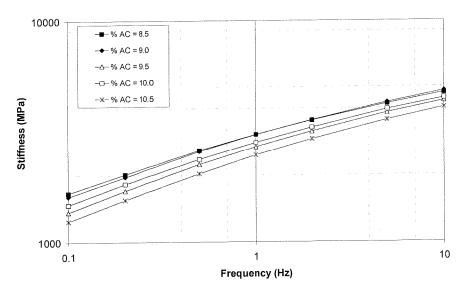


Figure 4 - Stiffness of recycled mixtures

The stiffness of the recycled mixes increases with the decrease of the binder content and exhibits the maximum value of 4700 MPa at 10 Hz for the mixture with 8.5% binder content. The mixture with 10% binder content has 4000 MPa at 10 Hz, which is only 20% less than the maximum obtained in this study.

Flexural fatigue tests were conducted according to the AASHTO TP 8-94 (Standard Test Method for Determining the Fatigue Life of Compacted HMA Subjected to Repeated Flexural Bending). All tests were carried out at 20 °C and at 10 Hz. The flexural beam device allows testing beam specimens up to dimensions of 50 mm by 63 mm by 380 mm. Fatigue failure was assumed to occur when the flexural stiffness reduces to 50 % the initial value. The fatigue tests were conducted in strain control applying 3 different strain levels (400x10⁻⁶, 600x10⁻⁶ and 800x10⁻⁶) and for each one 3 specimens were tested through a sinusoidal loading without rest periods.

The mixtures with 9.0%, 9.5% and 10.0% binder content were tested with only 2 strain levels. Despite this fact, the results presented a high precision, as illustrated in Figure 5.

The analysis of this figure allows the conclusion that, as expected, the increase of the binder content of the asphalt mixture increases the fatigue resistance. This fact allows that, in terms of design of the asphalt mixture, the binder content can be defined as a function of the expected traffic. However, this choice must also be based on the resistance to the permanent deformation of the asphalt mixtures to ensure that rutting does not occur for the design traffic.

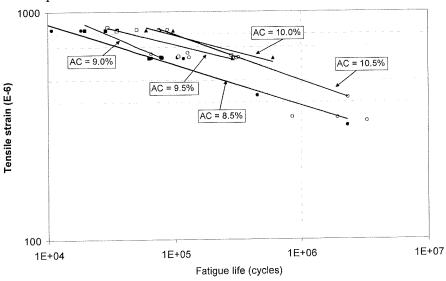


Figure 5 – Fatigue curves for the recycled mixtures

The fatigue test results expressed in terms of fatigue law (Equation 1) are presented in Table 6, as well as the N_{100} (fatigue life for a tensile strain of 100×10^{-6}) and ϵ_6 (tensile strain for a fatigue life of 1×10^6).

$$N = a * \left(\frac{1}{\varepsilon}\right)^b \tag{1}$$

where: N = fatigue life;

 $\varepsilon = \text{tensile strain } (10^{-6});$

a, b = coefficients.

Table 6 - Coefficients of the fatigue laws

Binder content (%)	a	ь	R^2	N ₁₀₀	ε ₆
8.5	9.764E+19	5.419	0.966	1.42E+09	382
9.0	7.246E+14	3.574	0.865	5.16E+07	302
9.5	3.834E+22	6.163	0.859	1.81E+10	491
10.0	1.653E+22	5.940	0.895	2.18E+10	537
10.5	2.130E+19	4.941	0.998	2.79E+09	498

The fatigue resistance of the recycled mixtures was compared to the typical mixtures with asphalt rubber. Thus, it can be concluded that they have an identical performance as the typical asphalt rubber mixtures (Figure 6). Some differences can be found in this comparison due to the binder content. Nevertheless, it can be established that for an average binder content of 9.0-9.5%, the performance is identical, suggesting that recycling does not affect the fatigue performance.

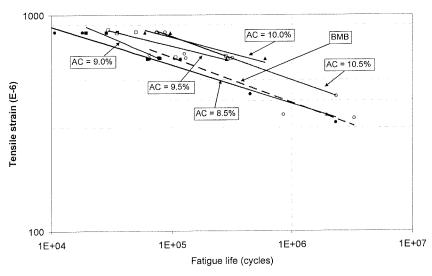


Figure 6 – Comparison between recycled mixtures and asphalt rubber mixture

CONCLUSION

This paper presented the results of a study carried out to determine recycling of a reclaimed asphalt mixture using as new binder an asphalt rubber. The study comprised learning about the reclaimed material, the design of the asphalt rubber, the prediction of the recycled binder properties and the fatigue performance of the recycled mixtures.

The design of asphalt rubber defines the crumb rubber content to be used to produce asphalt rubber. The values obtained, 22% of crumb rubber content for 50/70 pen asphalt and 20% crumb rubber for 35/50 pen asphalt, are the typical values for asphalt rubber. The 50/70 pen asphalt with more crumb rubber probably will be the best solution for recycling because it will have a better performance in recycled asphalt mixes.

The results of the characterization of the recycled binder allowed the conclusion that penetration can exhibit different trends depending on the reclaimed material as a result of the reduced recycling ratios.

The analysis of the fatigue results performed on the recycled mixtures allowed the conclusion that the increase of the binder content of the asphalt mixture increases the fatigue resistance and the fatigue resistance obtained for the recycled mixtures compares well with the typical mixtures with asphalt rubber.

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