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Advanced management strategies for road asset management

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Abstract:

Frequent further developments in management methods require detailed information about lifetime, life cycle considerations and financial ratios of road assets. Economic indicators are supplied by a future-orientated asset management making the sustainability of the maintenance efforts measurable. The road maintenance has to ensure not only an economic use of resources, but also the maximum benefit for the road users and the long-term preservation of the financial value of the road assets. The permanent availability at a safe level is a key performance indicator for road networks and a measure of the quality of these networks. Variational calculations can show the road condition development depending on the invested financial funds. With the help of these scenarios it is easy to detect if the asset values will be preserved in the future or there will be a loss in the assets. Detailed life cycle considerations are used for the analysis of different maintenance strategies. With a break down maintenance strategy the status and comfort level is at its lowest, because only already incurred damage will be locally repaired. With a preventive maintenance strategy in the sense of a prevention or minimization of damage and restrictions in the availability maintenance measures are carried out in timely fixed intervals. Final aim of a predictive maintenance strategy is the continuous, uninterrupted availability of the road network. With this strategy, maintenance works with a fixed and reliable lifetime have to be carried out at the optimum time. The choice of the maintenance strategy has a direct influence on the financial needs for the maintenance of roads and the availability of the network to its users. Therefore, advanced management strategies for road asset management are vital to preserve the asset values and assure safe and reliable road networks for passenger and freight transport at all times.

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Optimising road pavement maintenance using vibration monitoringBerthold Best¹, Amir Shtayat², Sara Moridpour², Avina Shroff³, Divyajeet Raol³

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Abstract:

Road maintenance planning determines the type of maintenance and the timeframe for completion. Currently, road maintenance plans are mostly based on condition monitoring in fixed intervals. Mistakes in detection of pavement faults and wrong estimation of the maintenance time result in high maintenance costs. Therefore, there is a need to introduce a framework to predict the deterioration of road pavement using continuous pavement attributes and minimise the cost and time of road maintenance activities. Optimising pavement maintenance has sustainable benefits to the society and road organisations. Road pavement condition has direct influence on ride quality and passenger comfort. Thus, ride quality measures can be used to predict the pavement damage. To measure the ride quality, the use of a vibration monitoring system is comfortable, cheap and available in various models. Using ride quality measures is relatively cheap, accurate and less time consuming compared to manual inspections. This innovative method can bring direct benefits to the society and road authorities by minimising cost and saving time. Road surface monitoring and data collection with the proposed innovative method using a wireless vibration monitoring device and video cameras will be cheaper, more accurate and less time consuming compared to manual inspections which are currently practiced. For the first time, road pavement deterioration prediction models will be developed combining traditional variables (e.g. road geometry, traffic parameters) with ride quality measurements. This will provide the opportunity to predict the status of road pavement and potential maintenance activities through a more accurate and cost/time efficient procedure.

Influence on the material characteristics of asphalt mixtures reheated by radio wavesMatthias Bisse¹, Martin Arlt², Christiane Weise¹¹TU Dresden, ²Leipzig University of Applied Sciences**Abstract:**

Reheating an asphalt pavement in combination with re-compaction offers the possibility to seal cracks and to even the surface. Within the project the combination of reheating and re-compaction of asphalt pavements is referred to as regeneration. In the laboratory scale the reheating was successfully performed using radio waves. Material characteristics of asphalt mixtures will change due to thermal and oxidative aging. And it is a well-known fact that fatigue, stiffness and rutting characteristics of the asphalt mixes have a major influence on the pavement performance. Thus, it is necessary to investigate the impact of the regeneration on the performance characteristics of asphalt mixtures. Within the research project an asphalt base course mix and an asphalt surface course mix were determined. The bitumen content was varied three times to evaluate the influence on the regeneration and the readjusted material characteristics. The regeneration was performed not only once but several times. This paper presents results of fatigue and stiffness tests to illustrate the effectivity of regeneration concerning the sealed cracks. Additionally, the bitumen characteristic were investigated to understand the influence of the reheating. The softening point ring and ball shows a clear influence regarding the number of regeneration cycles. The shear modulus values increase after each regeneration procedure due to aging. The fatigue performance increase after a single regeneration application if the bulk density of the specimen was constant. No further improvement of the fatigue performance could be observed after a second regeneration application. The stiffness performance after one regeneration application increased which is obviously due to thermal and not to oxidative aging. The described investigations concerning the material characteristics were completed with pavement design life calculations. Different case-scenarios considering the layer thickness were examined.

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Early life asphalt surface rejuvenation

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Abstract:

For many pavements, the period between asphalt resurfacing is determined by environmental ageing, surface erosion and ravelling, not due to asphalt fatigue or structural pavement distress. To increase the period between resurfacing, many jurisdictions treat asphalt surfaces with preservation products. The traditional approach to asphalt surface preservation is by replacement of the lost asphalt mastic with a bituminous product or a mineral (fine sand) filled bituminous product. This approach is often referred to as enrichment of the surface. In recent years, a number of non-bituminous products have become available for early life rejuvenation of asphalt surfaces. These products contain high contents of maltene-like molecules intended to re-balance the bitumen rheology, replacing the maltenes that have been converted to asphaltenes as part of the bitumen ageing process. This research reviews various trials and full-scale use of maltene-rich early life asphalt surface rejuvenation treatments. Various reports and datasets are combined and consolidated to determine the state of the practice. It was concluded that the bio-oil based early life asphalt rejuvenators provide a viable alternate to asphalt preservation, are generally safe to use, have minimal impact on surface texture and friction and are rapid curing. Further research is recommended to better understand the relative benefits of early life rejuvenation compared to traditional enrichment as an asphalt preservation strategy.

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New thin layer surface treatment with very quick opening to traffic

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Abstract:

The durability of an asphalt pavement depends on many factors that range from a good design of its structure (based on the amount, type and loads of traffic it will support) to the care of the road surface with surface treatments applied in the right time to prevent a specific type of damage. The objective of the present work is a new surface treatment consisting of applying a warm mix asphalt (one centimeter thick already compacted) being able to manufacture with a great variety of aggregates and without the need to use a polymer modified bitumen. A bitumen with a high softening point and low viscosity at temperatures between 100 ° and 160 ° C is obtained, offering a correspondingly lower traffic opening to the corresponding mixture at 30 minutes after being placed. This treatment can be applied at any time of the day or night using any model of hot asphalt paver spreader. In order to implement this treatment a package of three additives is needed. First additive will improve the lubricity aggregate-bitumen at more than 110°C increasing significantly compaction time. Second additive will increase Softening Point of the bitumen at minimum 95°C increasing significantly durability of mixture and prevents from rutting problems. Third additive is a fluxant that prevents from cracking at lower temperatures. .

Cold-in-place rejuvenation of aged bituminous pavements using bio-based emulsions.

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Abstract:

This paper deals with a new cold-in-place recycling solution of aged bituminous pavements combining the use of a bio-based emulsion with a specific train in order to achieve the French energy transition law objectives that promotes sustainable development, preservation of natural resources and low footprint constructions. This innovative process was laureate in 2017 of the 'Streets & Roads' innovation projects competition promoted by the French public institute CEREMA (Ministry of the ecology and the sustainable development), This solution allows 100% RAP recycling by rejuvenating aged bitumen of the existing old pavement. The main components of the bio-based emulsion are plant-origin and more particularly by-products from paper industry derived from forest holdings (free from competition with the food chain). Furthermore, laboratory tests were performed in order to compare bio-based emulsion with traditional coating bitumen emulsion (acting as a reference). Various cold mixes asphalts including 100% RAP contents (grave emulsion and cold asphalt mixes) were evaluated according to the French Guide (Setra, "Cold-in-place recycling of old bituminous pavements", 2003). The results showed that the performance of the bio-based emulsion is similar than the traditional bitumen emulsion. In addition, a comparative natural aging follow-up of aforementioned cold-mixes was carried out. Rheological parameters (stiffness evolution) and chemical indicators (oxidation, hydrolysis and esterification) confirmed the bio-based emulsion ability to be used in 100% RAP cold mixes design. Moreover, several comparative experimental worksites were realized using cold-in-place recycling train. Base courses containing 100% RAP mixes with bio-based emulsion or bitumen emulsion were implemented in various French areas thus confirming the suitability and the good performances of cold mixes asphalt based on bio-based emulsion. Follow-up is very encouraging.

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FWD test-site monitoring of road pavement assessment with glass and carbon grids reinforcement

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Abstract:

A growing need for an effective and sustainable resource management, whether economic or environmental, is an important facilitator for the development of new reinforcement and rehabilitation techniques of pavements. There are several solutions usually adopted for propagation delay and hence the surface appearance at the reinforcing layer of cracks from the underlying layers, namely impregnated geotextile, pre-bituminized grids (glass fiber and carbon fiber grids), and porous asphalt mixtures, among others, being very important the development and application of methods for assessing the strength of the bond between layers. The techniques used for the application of two-dimensional surface elements between the existing layer and the reinforced layer, are usually referred to as anti-crack interface. The primary function of these elements is to absorb the stress concentration generated at the interface between existing layers and the reinforcement, avoiding cracks propagation to upper layers. A comparative study, developed at the laboratory and in situ, regarding the behavior of the interface between the wearing course and the underlying layer by applying different reinforcement elements, has been developed in order to evaluate its influence on the pavement performance. This paper presents and discusses the major FWD results obtained from in situ tests performed under different climatic conditions, in order to assess the performance of a test-site performed with glass and carbon fibers grids applied to the reinforcement of the road pavement.

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OPA8-Inlay as heavy maintenance measure for OPA8 Porous Asphalt.

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Abstract:

The durability of Porous Asphalt is lower than conventional dense asphalt, especially in the case if noise reduction is the end of life criterion. After reaching the end of life the Porous Asphalt is replaced in full. This is not very economical with regards to raw materials and resources. As a cost-effective life-extending maintenance measure, an ultra-thin Porous Asphalt overlay system was developed in the Netherlands and approved on standard Porous Asphalt in 2003 by the Dutch road authorities (Rijkswaterstaat). With this maintenance system first a polymer modified bitumen emulsion (bond coat) is sprayed on the existing pavement and on top a thin overlay, which is placed using one single machine pass. The emulsion coats and rejuvenates the old Porous Asphalt, this without creating permeability problems (splash & spray) and ensures a good adhesion with the thin overlay resulting in a Porous Asphalt system with the same functional properties as a completely new Porous Asphalt layer. OPA8 is based on 'derived of' the German Porous Asphalt and has a higher noise reduction and life than the standard Dutch Porous Asphalt and was developed in 2013. In order to have an economically maintenance system a variant of the mentioned proven technique was developed. Laboratory tests were carried out and a trial section was laid in 2018. In this case 27 mm of the old OPA8 is milled off and replaced with 30 mm OPA8-Plus (improved OPA8) on top of a bond coat using one single machine pass with a so-called spray paver. The test results show that the system also can be applied with OPA8-Plus. After application the OPA8-Inlay has the same functional properties as standard OPA8. Key words: porous asphalt; ravelling; durability; polymer modified binder; noise reduction.

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Field Performance of Micro Surfacing Treatments for Pavement Preservation

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Abstract:

Micro surfacing is a pavement preservation treatment that can be used to protect the pavement structure from moisture and correct minor surface defects. As with other preservation treatments, performance of treated sections depends in great part on proper candidate selection and timely intervention. Estimates for pavement life extension typically range from 3 to 7 years; however, the criteria for defining performance varies among sources. As part of the National Center for Asphalt Technology (NCAT) and the Minnesota Department of Transportation Road Research Facility (MnROAD) Pavement Preservation Study, micro surfacing test sections were placed on both low and high traffic volume roads in Auburn, Alabama. Test sections include single, double and cape seal applications, and have been monitored periodically to assess structural condition, surface distress and ride quality. The overall objective of the study is to determine the life-extending benefit of several pavement preservation treatments as a function of traffic, climate and existing pavement condition. This paper describes the observed performance of a subset of test sections located in the southern region of the United States, characterized for its hot, wet, no-freeze environment. The results showed that micro surface application can significantly extend the life of the pavement compared to the untreated sections. The Pavement Preservation Study is still underway, and data collection efforts continue to develop final performance models. The long-term results are expected to provide valuable information that will help agencies estimate the performance of their treated pavement more accurately according to their local conditions.

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High performance ultra-thin asphalt layer

Aida Garcia Bòria, Alfredo Bobis Rojas

Sorigué

Abstract:

For 10 years we have been developing a technique to consolidate and improve the performance of ultra-thin asphalt layers. This achievement satisfies the necessity of re-establishing the surface properties of worn-out pavements with good structural and evenness conditions to increase safety and maintain these features over time. It is the result of the synergy among different fields. The emulsion used as bond coat is made from polymer modified bitumen; it is specially designed to guarantee adherence with the underlay and merge with the asphalt mix to reinforce the binder performance. The hot bituminous mix is costumed in each case to meet the needs of each road. Small changes in the formulation lead to textures from 0.8 to 1.5 mm. Lastly, the paver integrates a spraying ramp where the emulsion is uniformly sprayed before the screed. The outcome is the joint implementation of this emulsion with high irrigation dosage (0.8 to 1.5 kg/m²), followed by the spread of 1-1.5 cm thick asphalt layer. The high bitumen content provided from both, the bituminous mix and the emulsion, avoids aggregate relocation and improves frost resistance. Mix endowments between 20 and 35 kg/m² involve no previous milling works and benefit road users minimizing execution times and traffic congestion. This sustainable technique reduces the volume of asphalt produced and raw materials consumption, cutting CO₂ emissions. Cubic shaped aggregates of maximum size 12 mm provide a single grained structure with negative texture to maintain the initial properties regarding contact patch, surface drainage and noise absorption. Thereby, we reach greater skid resistance and safer conditions for longer time than conventional methods. Its smoothness reduces rolling resistance and fuel consumption. Our experience of 1.5 million m² executed supports the suitability of this system for Administrations who work on preventive road maintenance programs to obtain long-lasting high performance pavements.

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New fluxing agent for Road applications

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Abstract:

The context of this innovation is a will between two companies to create more sustainable roads without any compromise between efficiency and respect of the workers and environment. Fluxing agents are mainly used in road maintenance technics, and those additives are added in bitumen in large quantities, up to 20% in some cases. Today, fluxing agents can be categorized in 2 parts: •

Efficient with strong labelling • Not labelled with limited efficiency. A new fluxing agent brings the best of both worlds: it has no label, and brings a high level of efficiency and versatility. The sustainability has been one of the priorities and the result speaks for itself: this additive has no toxic and ecotoxic classification and is biodegradable. So it is completely safe for the workers and the environment. Furthermore, fluxing agent global consumption can be decreased significantly, as the new solution is 20 to 45% more efficient, depending on the road technics considered. And last but not least, 45% of the raw materials are biosourced. The high efficiency observed is due to a high fluxing power, specific solubility in the bitumen, and narrow boiling range. All of these bring unique application properties (quicker cohesion build up, faster recovery of bitumen properties) with unique added value (less bleeding for surface dressing, extension of the application season for microsurfacing, higher durability of the cold mixes). On top of that, it is versatile as it can be used with all the road technics which use fluxing agents and various types of binders (pure and polymer modified bitumen in anhydrous or emulsion forms). 12 field trials have already been done during 2017 and 2018 in France, confirming the added value of this breakthrough additive. More field trials are about to come, with an expansion outside France: UK, US and Canada.

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Using pavement heat transfer systems for optimized pavement rehabilitation

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Abstract:

Heat transfer systems in asphalt roads are able to collect solar induced heat energy. The energy can directly be used or stored in thermal probes. In combination with temperature sensors, a heat pump and the analyses of fatigue and plastic deformation behavior the possibility to optimize rehabilitation measures arises. Within the project a comparison between a typical Spanish and a typical German asphalt wearing course was conducted. Based on the concept of dissipated energy the fatigue behavior of the Spanish BBTM 11 B with 45/80-60 B and the German SMA 8 S with 25/55-55 A and 50/70 were evaluated. The tests were done at different testing temperatures and frequencies. For this, the Spanish UGR-FACT method was transferred and adapted to German standard testing conditions. The analyses was done using different damage criterions, with the ROWE-approach allowing for the determination of the macro crack initiation and the approach of MORENO NAVARRO additionally for the plastic deformation properties. It could clearly be shown, that next to the well known influence parameters as type of binder and type of mix also the testing temperature has a significant influence, which questions the German design method where the prognosis of the fatigue behavior is based on tests with only one temperature. The testing frequency itself did not provide any differentiation possibilities. The results allow for theoretical calculations to quantify the possible influence of road heating and cooling systems on the pavement life time.

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Regeneration of asphalt using radio wavesMartin Arlt¹, Matthias Bisse², Bernd Karwatzky¹, Ulf Roland^{1,3}, Ulf Trommler³, Christiane Weise²¹University of Applied Sciences Leipzig, Germany, ²Technische Universität Dresden, Germany,³Helmholtz Centre for Environmental Research, Germany**Abstract:**

The maintenance of road infrastructure has received more and more attention during the last years. Therefore, pavement healing methods utilizing microwaves and induction energy were developed. Dielectric heating with radio frequency at 13.56 MHz sets a new attempt for the healing and regeneration of roads. The radio-wave technology allows the direct heating of any asphalt without additional amendments. At this frequency, the electromagnetic field energy heats the aggregate within the asphalt. Whereas the bitumen is less affected and is indirect heated via the hot rock. This represents a heat generation within the bulk material of the pavement rather than an energy input from outside or a heat development within the binder. Thus, the asphalt heats more uniformly throughout the whole medium. The paper will illustrate the potential of dielectric heating utilizing radio waves. Two relevant aspects of road maintenance will be evaluated, crack repairing and binder aging as a result of the thermal repairing process. The potential for crack repair will be evaluated at macro-cracks artificially induced by three-point bending tests at low temperatures. Since the effect of heating asphalt with radio waves is not well known, two asphalt concretes are used in this study, differing in maximal aggregate size and bitumen content. The innovative radio-frequency-based procedure of repairing cracks uses the intrinsic healing capacity of asphalt and applies an extrinsic force for compaction and recovery of the original specimen shape. As this procedure exceeds the bare healing of asphalt, this paper claims the recovery process as being in fact a regeneration of asphalt. The influence on the bitumen aging is investigated with fivefold repetitions of the regeneration. It is shown that the regeneration of asphalt utilizing the radio-wave technology is viable and the influence on the binder aging is examined showing an acceptable impact on its structure and properties.

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The benefits of spray applied asphalt surface preservation system on the strategic network

Paul Acock

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Abstract:

The use of spray applied Asphalt Preservation systems is known to have a fast application process, mostly applied at night to increase productivity, reduce traffic congestion and to keep within time restricted road closures. These innovative preventative maintenance systems have been applied to motorway networks and airfield runways alike for many years now, and some networks have had additional re-applications to preserve their asphalt infrastructure as they whole life cost benefits. Developments within the UK and European roads industry for a number of years, asphalt preservatives, both seal and protect the asphalt surface course in its current condition (at the point of application). Developments in the specification guidance has exhibited greater adoption within the strategic network in line with many large DBFO operators continue to make financial savings by utilizing preservation within their asset management plans. The paper further looks into this innovative maintenance system, which forms part of the asset management strategy. Road authorities have engaged with pavement teams in order to clarify the different systems on the market and to give further guidance on the use of preservations systems on the Strategic Road Network (SRN). Reference sites have been installed on the network which are being monitored, include onsite inspections, rheological data gathering, deterioration curves of the existing asphalt and best practice for when preservation systems need to be applied and predictions of life extension these systems would bring. Together with data reviews with a view to developing a full specification in due course. Along with other data, these sites will deliver important information with regard to performance over time of a surface preservation system under challenging conditions throughout its service life, with the intention of extending the life of the road with minimum interventions.

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CRACK PROPAGATION OF BITUMINOUS MIXTURES REINFORCED BY GEOGRIDS USING DIGITAL IMAGE CORRELATION

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Abstract:

In the rehabilitation of flexible pavements, the reinforcement by geogrids has substantially increased recently, aiming to extend the service life of pavements. This work aims at evaluating the effect of fiberglass geogrid reinforcement in the crack propagation of bituminous mixtures. To conduct the research, five pre-notched beams constituted of two bituminous mixtures layers, with and without geogrid, were tested. Two different fiberglass geogrids, maximum strength resistance of 100 and 50kN/m, and two types of emulsion as tack coat to glue the geogrid on the bituminous mixture layers, were combined for fabrication of three reinforced specimens. Also, two unreinforced specimens were fabricated. One beam is composed of two bituminous mixtures layers glued by emulsion. The last beam, having the same size, is made of a single bituminous mixture layer. The specimens were subjected to the four-point bending fracture tests (4PBF), designed at the University of Lyon/ENTPE. A 3D Digital Image Correlation (DIC) device was used to determine the strain evolution around the crack and the crack tip location during the tests. The results showed that the effect of geogrids is clearly noticeable when the specimen is subjected to high strain and the crack starts to propagate into the beams.

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Percolated asphalt coating as an anti fuel solution in a heavy traffic motorway

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Abstract:

Resistance to fuel of asphalt pavement surfaces is of capital importance in the maintenance of pavements that are exposed to frequent oil spills. It is well known the adverse impacts of hydrocarbons spills on strength and durability of asphalt pavements. Some solutions based on fuel resistant asphalts have been developed in the last years as, for example, highly modified binder combined with a very dense and compactable mix design. However, these kinds of solutions have not been proved sufficiently effective in a special case of a heavy traffic motorway in Spain, with high slope and affected by continuous gasoil spills from trucks. For this special case, a pilot section was constructed in the highway, to test a solution based on a percolated asphalt coating. The study of the pavement behaviour in this pilot section is still not concluded, although during the first year, the performance of this solution has been proved much more effective than the ones previously applied. Practical issues like percolation of the cement slurry on porous asphalt surfaces with high slopes or the treatment for assuring the skid resistance of the surface are also discussed in the paper.

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TURKEY PAVEMENT MANAGEMENT SYSTEM SOFTWARE DEVELOPMENT WORKSŞenol Altıok¹, Muhammet Komut¹, Nazan Ünal¹, Koray Kaya², Fırat Erkmen²¹Department of Research and Development, Republic of Turkey General Directorate of Highways,²Komsa Engineering**Abstract:**

Pavement Management Systems (PMS) is a system that detects optimum solutions after determination current condition of the road pavements, by the forecasting future conditions of the pavement, determination Maintenance and Rehabilitation method alternatives and choosing the best alternatives through the calculation of the Benefit/Cost ratios. With this system, guidance is provided to decision makers by the way coordination of the all activities aimed that operation of road pavements with spending budget which belongs to the community, with the most affordable cost, as safe and economical. Pavement Management System development works has been started since 2009 with the countrywide road pavement performance tests. Hot Mix Asphalt roads in the road network all over the country have tested and analyzed with the Profilometer, Deflectometer and Pavement Friction Tester which have been provided to the Turkish Directorate of Highways. Within the scope of these analyses, required maintenance and rehabilitation alternatives and benefit/cost ratios have been determined. In accordance with obtained results and data, development of a cost effective Pavement Management System and software have been decided with considering the national conditions. This system has been developed based on world bank HDM4 models according to Turkish local conditions. In this system which have been designed as a web based over the all highways intranet network, inventory database, performance test analyses, maintenance and rehabilitation determining, cost/benefit analyses, network level priority analyses modules have been created. In this study, importance and properties of "Turkey Pavement Management System" that have been developed since 2009 until today, are presented with sample PMS analysis and evaluations of different road sections in Turkey in project and network level details.

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LARGE SCALE TESTS FOR GEOGRID REINFORCED UNPAVED ROADS

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Abstract:

ABSTRACT: This paper intends to present and discuss the performance of geogrid reinforced and unreinforced granular fill layer in unpaved road systems using large scale cyclic plate load tests. A large scale cyclic plate load test facility was developed for studying the permanent deformation (rutting) characteristics. Cyclic loads at a fixed frequency were applied on reinforced and unreinforced laboratory unpaved road sections through a rigid circular plate. An unpaved road structure consisting of granular road material over a soft clay soil subgrade. To prepare reinforced sections geogrid was placed within the granular road material at the desired location. Also, geotextile was placed at the interface between road material and soft clay soil subgrade for separation. The model unpaved road structure was constructed in a steel tank and resilient modulus test. A total of 5 large scale laboratory and 20 resilient modulus tests were conducted to evaluate the effects of geogrid reinforcement. The test results indicate that considerable improvement in bearing capacity was observed when geogrid was placed within the granular road material at all levels of deformations. Permanent deformation (rutting), plastic surface deformation and vertical stress development under cyclic loading was greatly reduced and by the inclusion of geogrid. The optimum placement position of geogrid was found to be within the granular road material at a depth of one-third of the plate diameter below the surface.

Keywords: cyclic plate loading test, geogrid, geotextile, resilient modulus test, permanent deformation, soft clay

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Evaluation of multi-recycling capacity of bituminous mixturesVitor Antunes^{1,2}, José Neves^{1,3}, Ana Cristina Freire²¹Instituto Superior Técnico, Universidade de Lisboa, ²National Laboratory for Civil Engineering, ³Ceris - Instituto Superior Técnico, Universidade de Lisboa**Abstract:**

Bituminous mixtures have a key attribute that they can be 100% recycled without downgrading its functionality. This represents the highest value application and has significant economic and environmental benefits. Every year billions of dollars are spent on road construction and maintenance globally. These operations produce a considerable amount of reclaimed asphalt pavement (RAP), which is a valuable waste. Its re-use reduces the depletion of quality resources in landfilled. RAP recycling is a step forward in the direction of sustainable approaches as defended by the recent policies years. RAP incorporation in new bituminous mixtures can be associated with different techniques, rejuvenators and additives. This incorporation represents the first cycle of the material's life. The circular economy presupposes that materials have several cycles during their life. Therefore, the multi-recycle capacity of the bituminous mixtures need to be evaluated. The main objective of the paper is to analyse the multi-recycled capacity of RAP in new mixtures. For that, a laboratory study involving a surface dense bituminous mixture will be described. A RAP incorporation percentage of 25% was evaluated and to take advantage of the binder properties a commercial vegetable rejuvenator was used. The long-term oven ageing protocol was used to simulate the ageing of the mixtures. The stiffness modulus, resistance to fatigue, water sensitivity and permanent deformation resistance were assessed for different compositions. The study showed that bituminous mixtures have potential to be multi-recycled. Test results confirmed that multi-recycled bituminous mixtures had at least an equivalent performance over the primary material.

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Image-based 3D reconstruction using traditional and mobile-phone data-sets for road pavement distress analysis

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Abstract:

The issue of road networks being in deplorable conditions is one that is widespread globally. One of the main precursors for this is that when preparing maintenance management systems, many road agencies rely on data which is often outdated or inaccurate. This is due in many cases to insufficient budgets which are unable to adequately address both maintenance and rehabilitation. It is therefore critical that road agencies have better tools at their disposal to help combat these issues. One of the possible techniques that have been identified is the use of structure from motion techniques to adequately identify road pavement distresses. This paper advances previous work in this area and explores the accuracy of using mobile phones to collect the imagery as opposed to traditional methods relying on professional cameras and equipment. This would provide a lower cost and readily available alternative for practitioners. The techniques have been applied on a distressed pavement in Palermo, Italy using data-sets from a mobile phone and a professional camera to analyse the quality and adequacy of using data-sets from the mobile phone. The results indicate that the mobile phone data-sets can adequately utilize the techniques and therefore this incites the possibility of integrating mobile integrations with the technology specifically focused on pavement management systems.

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Empirical Assessment of benefits provided by Asphalt Pavements with Inlay Systems

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Abstract:

The structural maintenance of the existing traffic route network is one of the biggest challenges for the future. For this purpose, it is important to preserve the usability of the roads as long as possible by innovative construction methods. One conservation method that has been in use for more than 30 years is the use of asphalt inlay systems for rehabilitation of cracked road pavements. Initially, the paving fabrics and grids originally derived from geotechnics, were installed according to the trial-and-error method. This procedure resulted in damage for example because of lack of bond to the asphalt layers. In the meantime specialised asphalt grid systems were developed. Due to the reinforcing or stress-relieving effect of the inlays, the tensile stresses that occur in the area of the cracks are being absorbed and distributed, or decoupled from the new asphalt layer. In theory this will lead to a delayed crack propagation and a long-term crack-free road surface. However, still there is a considerable lack of confidence in these systems in the pavement society. In order to provide proof for the improved performance of asphalt pavements with inlay systems, the empirical background of the benefits and risks was researched by means of an extensive literature review complemented by an expert survey. The result of this practical evaluation is the documentation of the client's and customer's background with regard to the conditions of use for asphalt paving. 90 % of the participants believe that asphalt inlays can have a positive effect on durability of the pavement. Also, the reasons and motivations for using asphalt inlays and the satisfaction with effectiveness, constructions costs as well as the recycling ability of reclaimed asphalt was surveyed and analysed.

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Research and Application of Ultra-Thin Wearing Course with Large Porosity in Maintenance EngineeringMingliang Li¹, Jun Li¹, Haizhu Lu², Long Chen³¹Research Institute of Highway Ministry of Transport, Xitucheng Road No.8, Beijing, P. R. China,²Jiangsu Expressway Maintenance Engineering Technology Co., Ltd., Tianyuan West Road No.168, Nanjing, P. R. China, ³Dalian university of technology, Linggong Road No.2, Dalian, P. R. China**Abstract:**

In order to improve the driving safety and the noise reducing function of existing pavement, an ultra-thin layer wearing course with large porosity are developed. They are considered to be used as an overlay in maintenance of asphalt pavement, and built with thickness between 10mm and 25mm. In this paper, research focuses on the surface with a maximum aggregate size 10mm. Properties of binder are investigated firstly. In consideration of certain extreme weather condition and heavy traffic load in China, only modified asphalt is taken into account. Technical indicators and rheological properties of SBS modified asphalt and high-viscosity modified asphalt are investigated. It finds that there is a prominent improvement of material performances by using high-viscosity modified asphalt. Mixtures with target air voids contents from 15% to 20% are designed. Important factors presenting the high temperature property, moisture feature, anti-raveling performance and long-term application performance are investigated in lab. Meanwhile, sound absorption is also observed for samples with different air voids content and layer thickness. Considering a better bonding property between the porous wearing course and the underlying structural layer, the bonding strength of different materials are also tested and compared. It shows that the asphalt rubber stress absorbing membrane interlayer both show prominent tensile and shear strength, and suggested to be used as bonding material for porous thin layer wearing course. In the end, trial sections were constructed in Jiangsu province of China. Feasibility of using the ultra-thin wearing course mixture is proved. The achievements from the study will provide technical support for the maintenance scheme of porous asphalt and dense asphalt with moderate surface damage. It will also improve the skid resistance and the noise reducing function of the pavement, and has better social and environmental benefits.

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The effect of a multi-component hydraulic binder on the properties of recycled base course layer with foamed bitumen

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Abstract:

In article, the optimization of the binder composition intended for a deep cold recycling was presented. For this purpose the simplex-centroid experiment plan (mixture plan) was used. It allowed to control performing of the entire experiment and assessment of the impact of the hydraulic binder composition on the properties of the recycled base layer. As a result, regression experimental models describing the changes in the properties in the function of the amount of each components were defined. In experiment two different mineral mix composition of recycled base were considered. The foamed bitumen were made using road bitumen 70/100. Seven hydraulic binder compositions were prepared in laboratory in proportion required by experiment plan. Each hydraulic binder compositions were made based on the selection of the appropriate percentage of each component whose total amount was 100%. The main purpose of the articles was to assess the influence of the hydraulic binder composition on resistance to climatic factors and rheological properties of the recycled mineral-cement base course layer with foamed bitumen. This objective was achieved through standard methods related to evaluation of the water and frost resistance such as: modified AASHTO T283 method and TSR. In case of rheological properties evaluation a direct tensile and compression method on cylindrical samples (DTC-CY) was used. The recommended composition of a mixed hydraulic binder in aspect of enhancing the durability of the recycled base layer was the final effect.

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Synthesis and characterization of encapsulated healing agents for asphaltRaquel Casado¹, Lucía Miranda², Carlos Martín-Portugués¹, Francisco José Lucas²¹Acciona Construction, ²Repsol**Abstract:**

Considering the dataset produced by the OECD/ITF and the specific country information on asphalt production reported by EAPA, it has been demonstrated that road maintenance activities have decreased during the last recent years in many European countries. This is one of the reasons why national road authorities and asset managers are interested in road technologies to reduce future maintenance needs. Self-healing technology is a new and promising field within material technology and a good example for preventive maintenance. It aims to reduce the level of damage and to extend or renew the functionality and lifetime of the damaged part. The application of self-healing technology into the road design process has the potential to improve road construction and maintenance processes by increasing the lifespan of roads and hence reducing the need for road maintenance. A new method to find efficient strategies within the pavement rehabilitation is the incorporation of encapsulated rejuvenators into the asphalt mixtures. These capsules should release the healing agent to seal cracks or limit its growth. There are two main methods described recently in literature for capsules preparation. The first one is the encapsulation of rejuvenator into a polymeric shell, usually prepared by in-situ polymerization of methanol-melamine-formaldehyde (MMF) prepolymer. The second one is related to the use of porous aggregate as a carrier of the rejuvenator. Both methods aim to obtain capsules with high thermal and mechanical strength but their scaling-up is complex and may require significant investment. In this study an effective, simple and cost-effective impregnation method of asphalt rejuvenator in porous aggregates developed by the authors is presented. Conclusions from the study indicated that this method is versatile and suitable for several porous aggregates, which will facilitate future replication. This work is being carried out with the financial contribution from a National project, REPARA v2.0.

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Effect of Cape Seals on Pavement Structural PerformanceMd Rahman¹, Adriana Vargas-Nordbeck²¹Graduate Research Assistant, National Center for Asphalt Technology at Auburn University,²Assistant Research Professor, National Center for Asphalt Technology at Auburn University**Abstract:**

Cape Seal is the combined treatment of slurry seal or microsurfacing on top of chip seals to promote better water-proofing, prevention of reflective cracking and overall expected longer life of pavement. Studies also found the cape seals performing well to seal down the minor surface cracking. As part of the National Center for Asphalt Technology (NCAT) and the Minnesota Department of Transportation Road Research Facility (MnROAD) Pavement Preservation Study, cape seals were placed as preservation treatments on low and high traffic volume test sections, both in Alabama and Minnesota roadways. Three types of cape seals were included in the study, consisting on a micro surfacing layer applied over either a conventional chip seal, a fiber membrane reinforced chip seal, or a scrub seal. After treatment application, no further maintenance and rehabilitation has been performed. All test sections are monitored periodically by measuring surface distress and roughness. Although preservation treatments are not expected to add structural capacity, deflection testing is performed to assess the effectiveness of the treatments in protecting the structural integrity of the existing pavement. Untreated sections were left in place in each test location for comparison. The objective of the study was to evaluate the structural performance of pavements treated with cape seals as a function of traffic, climate, initial condition and treatment type. Cracking, rutting, and ride quality data are also presented to provide a comprehensive evaluation. Data collection efforts continue for the ongoing study, but preliminary findings show cape seals have been effective in extending the life of the pavements.

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**ON THE PERFORMANCE OF GEOGRIDS FOR ASPHALT PAVEMENT REINFORCEMENT:
LABORATORY EVALUATION AND SELECTED CASE STUDIES**

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¹RoadMat, ²Afitexinov

Abstract:

The use of geogrids for pavement reinforcement has been continuously increasing over the past decades. Their main role remains to limit crack reflection and they are therefore typically used on cracked pavements before renovating the upper asphalt layers. Still, evaluating their performance is not a simple task because most available testing methods are still at an early development stage with sometimes limited field validation. As a consequence, no clear guidelines currently exists for selecting this type of products in preparation of a construction project. This paper presents the laboratory results gathered so far on fiber-glass reinforced geocomposites in view of their use in real jobsites. Fatigue testing and the potential to delay crack reflection as measured with the Cerema Autun device, are presented and discussed in the light of recent jobsites on Paris Charles de Gaulle Airport and French highway A7. In addition, the correct positioning of the geogrids on the asphalt support was further evaluated using the Leutner test. This clarifies the conditions under which the placement of these materials will be optimized. From this work, a clearer picture tends to emerge on how to specify these very specific products in order to maximize their benefit for extending pavement life time.

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Asphalt reinforcement interlayers as reflective cracking mitigation system in rehabilitated pavements

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Abstract:

The conventional method for rehabilitation of cracked pavements is the installation of new asphalt layers. This procedure is often not an effective solution, as the action from external forces, such as traffic and temperature variations, contributes to the rapid propagation of the cracks from the deteriorated asphalt layers to the surface of the new overlay. This phenomenon, known as reflective cracking, is one of the major modes of failure in rehabilitated pavements. In order to delay the development of reflective cracks asphalt reinforcement interlayers have been largely used in the last decades, providing consistent results in the addressing the issue of crack propagation. Similarly, different researches have shown a significant reduction in reflective cracking associated with the use of geosynthetics. Through basic theory and practical experiences this paper will demonstrate the success and extended pavement life that can be achieved by using asphalt reinforcement interlayers in highway applications. Special attention is given to the performance on site, e.g. the loss of tensile strength due to the paving procedure and the importance of using alkali-resistant materials when in direct contact with concrete or cement stabilized materials. Additionally, requirements and relevant characteristics presented in the currently available guidelines are described. The increased pavement life achieved by the use of this technology not only prevents excessive disruption to traffic flow and local business, but it also demonstrates strong environmental and economic benefits.

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Maintenance of porous low noise pavement by large-scale road grindingFrançoise Beltzung¹, Tobias Balmer²¹Centre de Compétences du Domaine Routier, HEIG-VD, Yverdon, Switzerland, ²Weibel AG, Bern, Switzerland**Abstract:**

Low noise wearing courses are an effective measure to mitigate road traffic noise emission at its source. In Switzerland a trend of using so-called semi dense asphalt (SDA) with porosity of 12-20% and a maximum grain size 4 or 8 mm has emerged about a decade ago. Despite the initial noise reduction values of -5 to -9 dBA, the acoustical and mechanical lifetime of such pavements remains below expectations. This acoustic ageing is dominated by clogging of the open pores and altering macro-texture due to ravelling. Our preliminary work on small test sections has shown that an accurate grinding of the surface is an effective way to regain up to -5 dBA in noise reduction. Depending on the state of clogging and extension of ravelling at the time of the maintenance, the program may require different intensities of grinding followed by sweeping and high-pressure washing. The purpose of this paper is to put forward a maintenance process which is effective in rehabilitation the acoustic performance of aged SDA wearing courses at large-scale. Two roads that were treated in 2018 with a grinding depth of 1.5 to 3 mm showed positive results with an average gain in noise reduction of -3 dBA, measured with the close-proximity (CPX) method. At each location the treatment was evaluated by the measurements of grinding depth, skid resistance, air permeability, macro-texture and CPX rolling noise. Performance of the grinding method depending on grinding depth and tooling are discussed in detail. Additionally, the long-term behaviour was monitored by visual inspections of the macro-texture and sequential CPX measurements. Our first results indicate that the treated surface remains stable and noise level gains are preserved over the available time window of the initial monitoring phase.

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Life extension of porous asphalt pavements through the application of a rejuvenating bituminous emulsion

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Abstract:

The BCR - Brisa Concessão Rodoviária network has about 422 km of surface course with porous asphalt, corresponding to 38% of its total extension (1 100 km). The main objective of this paper is to present the study to be developed by LNEC together with BRISA and Latexfalt Ibéria for the characterization and monitoring of the application of a bitumen rejuvenation solution in this type of bituminous mixture, located in the BCR network. One of the most frequent pathologies in this type of surface layer is ravelling, usually due to the premature aging of the bitumen that surrounds the aggregates. This type of pathology leads to increased noise and loss of grip due to the presence of loose aggregates. One of the methods to avoid the increasing of ravelling of the surface layer material, and therefore to increase its life cycle, is to apply a modified emulsion with rejuvenating characteristics of the bitumen of the porous asphalt, preventing the progression of ravelling. The presented solution is a non-evasive method, without the use of milling or the placement of new bituminous mixtures. This technique consists of the rejuvenation of the binder (bitumen) in the porous asphalt mixture, increasing its life cycle. The product used was a rejuvenating bituminous emulsion for porous asphalts, which main function is to return elasticity to the bitumen of the porous asphalt, to avoid ravelling and without reducing its draining capacity.