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Assessment and Validation of Sustainability Certification System for Road Infrastructure

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Abstract:

The research project named “Life Cycle Engineering approach to develop a novel EU-harmonized sustainability certification system for cost-effective, safer and greener road infrastructures, LCE4ROADS” was completed in December 2016. The project was funded by the European Commission under the Seventh Framework Programme. The concept of the LCE4ROADS project arises from the necessity of an advanced, EU-harmonised holistic and innovative certification system that will integrate LCE concepts for the assessment of future and existing road infrastructures, in terms of environmental, technical, social and economic performance. The LCE4ROADS project has contributed to the implementation of European policies and strategies, boosting the integration of transport in sustainable development promoting technologies and materials that reduce pollutant emissions and the use of natural and financial resources. The main results achieved project can be summarized: - a methodology for the assessment of the sustainability performance of road projects, - a software tool that incorporates the methodology and facilitates the evaluation of road projects according to LCE4ROADS principles, - a compendium of guidelines, which include recommendation for greener, safer and cost-effective products, a handbook for the tool and the LCE4ROADS Guide to certification. - The certification system itself. In this paper, assessment of the LCE4ROADS methodology integrating a Life Cycle Engineering (LCE) in road case study, carried out in the beginning of project, is explained. Furthermore, after the software tool developed in the project, the studies to validate of the LCE4ROADS methodology and associated software tool using data obtained from real road project are given. The main aim of these studies is to evaluate against the LCE4ROADS methodology in order to illustrate the implementation of the LCE4ROADS for the construction, maintenance, rehabilitation and operation works for road infrastructures. Keywords: Life Cycle Engineering, sustainability, software tool, certification system

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Paving the way to an improvement in air quality

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Abstract:

Air quality, especially in metropolitan areas, is a topic of intense discussion and focus, with many city authorities setting targets with the aim of improving air quality and reducing issues related to poor air quality. There are a number of sources which contribute to a deterioration in air quality, these include vehicles, thermal power plants, waste management facilities and construction activities, to name a few. Although emissions from road construction and maintenance activities may not contribute as significantly to air quality related emissions from other sources, reducing the impact of these activities should be considered as playing a part in a holistic approach to improving the air quality of cities. This paper describes a bitumen additive which, in field trials and laboratory testing, has been shown to reduce emissions from bitumen and asphalt mixtures during storage, asphalt manufacture and pavement installation. Laboratory experiments designed to replicate the various aspects of the bitumen supply chain; starting from refineries and storage depots to paving at road construction sites are presented. The laboratory results have shown substantial reductions in a range of air quality indicators, such as SOx, NOx, particulate emission, volatile organic content emission as well as in other potential nuisance vapours such as H2S and odour causing compounds. In addition to the laboratory studies, full scale field evaluations carried out in major cities have reflected the results obtained in the laboratory and show a reduction in the emissions at various points of the asphalt preparation and pavement laying process. Bitumen containing this active additive could play a role as part of a solution in helping to improve air quality in cities.

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Recycled Plastic as an Alternate to Conventional Polymers for Bituminous Binder

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Abstract:

Some recycled soft plastics have been reported to improve the deformation (rutting) resistance and fracture (cracking) resistance of asphalt mixtures by beneficial modification of the bituminous binder. This research evaluates recycled soft plastic for bituminous bitumen modification with a focus on bituminous binder testing, rather than asphalt mixture testing. Elastomeric and plastomeric commercially available waste plastic products for bitumen modification and extension were evaluated in the laboratory, using bituminous binder tests commonly used in the United Kingdom and Australia, as well as the Performance Grading methods developed in the United States. The effect of recycled plastic modification was determined by comparison to the unmodified bitumen properties. The results indicate that both recycled plastic products significantly improved the bituminous binder properties commonly associated with asphalt mixture deformation resistance and temperature resistance. However, the greatest improvement was associated with the indicators of elasticity and mixture fracture resistance. These improvements were consistent across the test methods specified by all three countries. It was concluded that recycled plastic products have the potential to improve bituminous binder products in a similar manner to conventional polymers such as SBS and EVA. Further work is recommended to directly compare the recycled plastic modified products to otherwise similar SBS and EVA modified binders.

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Turning challenges into solutions through innovation

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Abstract:

Nowadays, safety and environmental concerns are acquiring increasing attention in our daily life. Asphalt industry is not an exception, and with more than 90% of the 5.2M Km of the Europe road network [1] this technology has to be adapted to these new challenges. For at least three decades, SBS modified bitumen has been used in paving with the aim of reducing road damages such as rutting, cracking and stripping. On the other hand, in roofing and waterproofing industry, SBS modified bitumen enhances the membrane elongation, increases elasticity, provides excellent low-temperature flexibility and high temperature resistance and more adhesive properties [2]. The specifications and properties of the SBS will impact noticeably in the performance of the modified binder in the final application. Different approaches have been developed to improve asphalt performance through the design of new SBS polymers based on a comprehensive study from polymer macro and microstructure to final application validation. These new SBS grades fulfil with the requirements to be used as modifiers for promising technologies such as Reclaimed Asphalt Pavement and shingles (RAP/RAS), warm-mix and porous asphalt pavement for rain drainage and noise reduction.
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BioRePavation - Innovation In Bio-Recycling

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Abstract:

The main scientific and technical objectives of the BioRePavation project have been to prove that alternative binders can be used to recycle asphaltic pavement with the same level of performance as conventional solutions with petroleum bitumen. To do so, the consortium proposed to build a demonstration where three innovative pavement solutions using bio-materials were tested using an accelerated pavement testing facility (IFSTTAR fatigue carousel): - A bio-based additive from pine chemistry designed to Increase RA content to 70%, even 100% in theory - A Bio-based additive designed to increase compatibility between fresh bitumen and RA: Epoxidized Methyl Soyate - A Bio-bitumen designed for full replacement of fresh bitumen The survey of performance was performed by both measuring the traffic level needed for the pavement solution to reach a distress mechanism and investigating the binder physicochemical evolution using an innovative non-destructive method. BioRePavation also assessed the environmental impacts of the combined use of bio-binders and high-content of RA in asphalt mixes. Special attention was given to airborne emissions that were directly measured in the laboratory. Obtained data were used to perform a risk assessment, as well as a Life Cycle Assessment (LCA) for the aforementioned BioRePavation technologies. Finally, the proof of concept was demonstrated: the innovative pavement mixes assessed in the BioRePavation international project behave better than a conventional reference mix. They now provide durable solutions, assessed by a full scale accelerated test and an environmental analysis, to build roads using high rate recycling and involving biomaterials as additive or alternative to bitumen.

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Cleaner Solution Environmental - Natural Rubber Modified Bitumen (NRMB) for sustainable road paving in Thailand

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Abstract:

In Thailand, the estimated annual consumption of bitumen in road paving industry and road maintenance for the whole country is about 1 million tons a year. The government spends substantial budget on road maintenance projects every year. Road surfaces are under-going severe traffic loads, especially on the highways where there are high traffic volume and loads. Conventional bitumen has been used throughout the country for road surface with normal traffic volume. However, for the main roads with increased traffic such as highways, the surface will be damaged and fatigued quickly as the ability of conventional bitumen is limited. There is a continual trend to changes in binder usage from conventional bitumen to modified bitumen with five percent natural rubber as is called “Natural Rubber Modified Bitumen” or NRMB. Its direct advantage is to the road users on a better road with enhanced friction, load bearing capacity and durability, which helps reduce an accident. Indirect advantage is to rubber farmers with enhanced volume of rubber usage. It is estimated that 50,000 tons of rubber is used annually in Thailand for bitumen modification. This number substitutes the use of bitumen and promotes the use of natural rubber, which helps rubber farmers in sales volume and stabilized the price. The environmental benefit of the modifications is also perceived in terms of hydrocarbon reduction by using natural rubber, which is biodegradable, to substitute bitumen. The government has also benefited from saving government budgets on longer-term road maintenance due to prolonged life of road. Estimated saving is about 66 billion baht from 2002 to 2012. This paper describes the usages and benefits of natural rubber in asphalt modifications in both hot (NRMB) and cold application (Para Slurry Seal Emulsion) specifically in Thailand road networks.

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Development and Evaluation of Pavement Materials utilizing Renewable Resources deriving from Plants

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Abstract:

Long-life pavement is in high demand as a part of reducing expenses for public works and maintenance costs. In Japan, Asphalt concrete mixture is widely used for over 90% of road pavements and expressways because it is easy to construct and repair. Meanwhile, cement concrete pavement, which is more durable than asphalt pavement, is limited to some constructions due to issues such as recyclability and constraint on regulation time at repair. In recent years, despite the fact that sustainable materials are being promoted in various industries, asphalt, which is derived from petroleum, is used as the main material for road pavements. In order to solve the above problems, the authors have studied the materials used for pavement materials to develop alternative materials for asphalt mixtures. As a result, the authors have reached the development of sustainable materials from plants. The developed material can be easily constructed like asphalt pavement, and its strength does not depend on temperature like an asphalt mixture and it has strength close to that of cement concrete in the service temperature range. Since the developed material shows thermos-plasticity, unlike cement concrete, it can be recycled like asphalt pavements. In addition, plants as raw materials are widely available and can be easily procured. Although some plant-derived materials may be less resistant to water, but the developed material has a markedly higher resistance to water and oil than asphalt and binds very strongly to the aggregate. In this paper, the selecting process of the substance and the evaluating result of the characteristics of the developed materials by the various laboratory tests are shown. Furthermore, an inspection result of the performance of the developed mixtures obtained from trial and actual construction is shown.

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Impact of bio-based rejuvenator on bitumen and asphalt mix performance - laboratory and field evaluation

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Abstract:

The transformation of Europe's economy into a more sustainable one constitutes a key part of the current strategy of the European Commission. Within the paving sector, the re-use of reclaimed asphalt (RA) offers a perfect case to fulfill this goal. At present, the additional focus to both environmental as well as economic advantages of RA re-use demands further optimization in terms of higher percentages of re-use and/or in enabling multiple recycling of RA in the future. A major obstacle to the durable re-use of RA is the advanced ageing state of the binder in RA. Hence, it is recognised that rejuvenators may be needed to regenerate the old binder. Therefore, BRRC initiated the research program Re-RACE (Rejuvenation of Reclaimed Asphalt in a Circular Economy) to investigate the impact of rejuvenators on the performance of both bitumen as well as asphalt mixtures containing RA. In this context, a collaboration between a supplier of a bio-renewable rejuvenator, an asphalt producer and BRRC facilitated the set-up of full-scale test sections comprising an AC14 base course (70% RA) with and without the use of rejuvenator. The realization of latter test sections was closely monitored allowing for the follow-up of the production process, the laying and compaction stage, and finally the sampling of all constituents and bulk materials. After construction, additional test specimens were taken by coring. This enabled to investigate the true effect of the rejuvenator by characterizing the binder by both empirical as well as rheological testing. In parallel, the performance of the asphalt mixtures was studied while evaluating compactibility, water sensitivity, the resistance to rutting and the fatigue behavior. As rejuvenators are added differently during real production as compared to the laboratory practice, special attention was paid at all times to validate laboratory results on the basis of field experience.

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Recycled plastics from different sources for asphalt pavement

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Abstract:

New construction projects are developed with the aim of incorporating used polymeric material to the asphalt mixes to reduce the environmental impact and to improve the performance of the asphalt layers. The polymers and plastics are part of the solid waste as the consumption of these materials grows continuously in the modern society. Their volume contribution to the total waste is very high. The amount of the synthetic polymers in landfills in the world has increased in the last decades and in various countries, only a small percentage of the generated waste is recycled. The main plastic waste sources are industrial (scrap and non-conforming plastic material), agricultural (plastic recipients and films) and urban (human consumption and solid urban - dubbed USW, urban solid waste). Most of the USW may be divided in three classes: • simple plastic waste, adequately classified and separated, • mixed plastic waste, as the different plastic types are mixed, and, • mixed plastic waste combined with paper, cardboard and/or metals Between the benefits derived from this project is the reduction of environmental problems such as: landfill waste accumulation, contamination, quarries exploitation impact. In addition, improvement of the resistance of the asphaltic mixtures and road maintenance reduction are two of the most relevant advantages of this technology implementation. We consider in the scope of this project, the technical support to the national responsible entity in charge of the definition of alternatives for waste management and the drafting of the regulatory framework for the public hiring of the road construction.

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Asphalt concrete mixture containing 40 % reclaimed asphalt – comparison of initial testing and trial section control tests

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Abstract:

The reuse of reclaimed asphalt (RA) is becoming more and more a common practice in many European countries. Long-term experience with high rates of RA already exist for various mixtures e.g. in Germany and the Netherlands. The Czech Republic has been moving towards recycling with specifications and equipment set up in recent years. To bring recycling to an advanced level, the use of rejuvenator is considered by some asphalt producers for increasing the RA content in new asphalt mixtures, or if the RA binder is showing increased level of ageing (low penetration and high softening point values), or if it is needed to improve the processing at the mix plant and during paving where mixtures containing RA are considered to be used. While there are already numerous studies and/or research projects at lab scale evaluating the benefits of rejuvenators, it still requires at local level to provide practical validation as well as to compare mix design expectations and laboratory mix performance with on-site mixtures and their particular characteristics. This paper presents results of full scale asphalt plant production for asphalt concrete and pavement application of such mixture containing 40 % RA. Two different rejuvenating agents have been used and compared with a reference mix with no additives as well as additionally with a softer bitumen as an alternative known technical option. In the first stage mix design was provided and for all later used variants volumetric as well as performance-based characteristics were determined. In the second stage asphalt mixtures from a trial section were sampled from the plant production for further laboratory evaluation. The outcomes show that with locally available RA and current plant processes mixtures with 40 % RA and a suitable rejuvenator can perform similarly to traditional asphalt concrete without RA not harming the long-term durability and improve resistance to rutting.

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Types of asphalt rejuvenators and the different scenarios for the use of RAP in HMA production

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Abstract:

The use of Reclaimed Asphalt Pavement (RAP) in HMA is rising worldwide. An effective rejuvenator additive has a major role in successful recycling. Several proposals for asphalt rejuvenators are available in the market, depending on their chemistry (petroleum-base, vegetal-base, amine-base, others…) that offer, combined or alone, different characteristics (bitumen thinner, asphalt workability enhancer, adhesion promoter…). This paper presents the use of multiple asphalt rejuvenators in different scenarios (high RAP content in parallel or double drum, low/medium RAP content in standard asphalt plant process, soft virgin bitumen blends…). The study focuses on establishing best practices to choose the most convenient rejuvenator additive by increasing the use of RAP in asphalt pavement mixtures while maintaining high-quality pavement infrastructures and resulting in cost, cycle life and energy savings. The use of selective vegetal-base “green” rejuvenators that regenerate the chemical and physical characteristics of the bitumen, but also improve the properties of asphalt mixes, have turned out to be the best technical and environmental option.

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Possible recycling of cigarette butts in stone mastic asphalt

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Abstract:

Trillions of cigarettes are produced every year around the globe, resulting in a large amount of mephitic waste cigarette butts (CBs) being dumped into the environment. Waste CBs take years to decompose with most containing a cellulose-acetate based filter, tar, nicotine, tobacco, and many highly toxic chemicals that leach into the soil and waterbodies thereby resulting in contamination and toxicity. In the area of asset management, the road and highway sector is the largest in the world. This research work has investigated the possible recycling of CBs in stone mastic asphalt. Waste CBs were processed and encapsulated with bitumen before the preparation of the mix. Modified stone mastic asphalt samples were prepared by replacing up to 2% of coarse aggregate with bitumen encapsulated CBs in accordance with the existing AASHTOO and Austroads guidelines. Laboratory tests were conducted on the CB modified asphalt samples and the results were compared with those of the standard control samples prepared without CBs. The preliminary results found are promising and show that recycling encapsulated CBs in asphalt concrete could contribute a solution to CB pollution around the world. This paper presents the experimental procedures and discusses some of the significant outcomes of the study.

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Environmental impacts of hot, warm, half warm and cold recycled bituminous mixtures

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Abstract:

For some years, reducing bituminous mix temperatures has been a common trend among asphalt producers because it is a very effective way to reduce energy consumption and atmospheric emissions of asphalt plants, along with other reasons. However, the energy demand of bituminous mixtures production is not only related to mix temperature, but also to the specific production technology used to achieve the temperature reduction, which among other relevant factors. In bituminous mixtures containing Reclaimed Asphalt Pavement (RAP), the usability of aged bitumen in turn depends on the production temperature, being more effective in hot bituminous mixes that in other ones. Therefore, it is not a trivial task to relate environmental impact of bituminous mixtures to production temperatures and RAP content, especially from a life cycle perspective. In their paper the authors will display a methodology developed to accurately compare life cycle environmental impacts of hot, warm, half-warm and cold bituminous mixes produced with some of the technologies currently used in Europe, further considering corresponding environmental gains due to use of RAP. On the other hand, an increasing number of public administrations are trying to encourage the production of low temperature mixes by including specific technologies in their specifications or on the selection criteria used in selection procedure, perhaps invading areas of decision that should belong to producers. This circumstance also justifies the opportunity to review the typical, and generally oversimplified, relationship used to defend environmental advantages of low temperatures production and high RAP contents. In any case, it seems that public incentives to promote the energetic efficiency and environmental gains should not be aimed to any particular bituminous mix production technology. According to the findings of this study, to specify by performance, including environmental performances, is a better way to progress towards efficiency and sustainability.

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The Influence of the mastic properties and grain geometry on the durability of porous asphalt

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Abstract:

Porous Asphalt (PA) is characterized by its open structure. It is used for noise reduction and higher travelling comfort in rainy conditions. Alongside these benefits the service life of PA is shorter than other motorway surfaces which is caused by the clogging of the pores and ravelling. The open structure of the PA is created by the grain skeleton, which consists only of one grain class, and asphalt mastic. The mastic has the function to connect the grain skeleton without clogging the air voids. Therefore both components – grain skeleton and mastic – are of great significance in terms of durability. For this reason the grain skeleton, particularly the grain geometry, is under the focus of this research. To analyze the grain geometry a computer-based test method without laser scans is used. The results are compared with tests for geometrical properties of aggregates such as shape index (DIN EN 933-4). The grain shapes are also examined on the basis of sectional images of drill cores from asphalt test plates. In addition, the computer-based test method determines the distribution of the individual phases of the specimens. CT images are used to verify the results. Furthermore, the supporting component of porous asphalt – the mastic – is considered in this research. The composition of the mastic can have a major impact on ravelling, thus these mastic properties are considered in more detail. The mastic as well as the binder will be tested in the dynamic shear rheometer (DSR). One the one hand, they are tested in the virgin condition. On the other hand, they are claimed by different boundary conditions before testing. Results of the mastic properties and grain geometry should reveal a composition of PA, which provide a longer service life.

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Investigating the long-term aging of bitumen extended with non-fossil hydrocarbons

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Abstract:

In recent years, the road industry is moving towards more sustainable solutions, aimed at minimizing the carbon footprint and energy consumption and increasing the use of recycled materials, without compromising the durability of road pavements. Within this context, one of the main current trends is to employ industrial residues and by-products deriving from renewable materials (i.e. bio-materials not subjected to depletion) in partial substitution of petroleum-based bitumen. However, great concerns on the durability of such materials still exist. In this regard, the present study focuses on the long-term aging of bio-binders obtained by partially replacing a plain 50/70 bitumen with different percentages of a bio-oil generated as a by-product by the wood and paper industry. Aging was simulated in the laboratory with Rolling Thin Film Oven Test (RTFOT) plus Pressure Aging Vessel (PAV). The binders were then subjected to conventional and viscosity tests, as well as chemical analysis using Fourier Transform Infrared (FTIR) spectroscopy. For comparison, the same tests were also performed on a conventional bitumen having similar penetration to that of one bio-binder. Overall, the results indicate that the bio-oil does not undergo over-aging and the long-term aging performance of the bio-binders studied is satisfactory.

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Analysis of thermal, rheological, and colloidal compatiblity of bitumen modified with engineered bio-based rejuvenators and rheology modifiers

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Cargill BioIndustrial

Abstract:

Increasing incorporation of highly aged bituminous material into pavements on one hand, and the potential deterioration of the quality of soft bitumen has accentuated the need to engineer the properties of bitumen with various “rheology modification” and the properties of high-recycled mixtures with “Rejuvenation” technology. While it is understood that any modified formulation will need to adhere to high standards of compatibility and long term stability and durability, consensus on the definition of “Rejuvenation” and the associated mechanisms does not exist. The present study utilizes chemical fractionation, thermal analysis, and thermo-rheological analysis for to evaluate the impact of an engineered bio-based additive from a chemically modified vegetable-oil source. Chemical fractionation was performed using an “Iatroscan” and used to derive colloidal stability indices. The viscoelastic response was analyzed via thermo-rheological parameters such as ΔTc, derived from 4-mm Dynamic Shear Rhoemeter master curve modeling and Bending Beam Rheometry. The glass transition properties were measured using a Differential Scanning Calorimeter (DSC). A selection of virgin and reclaimed bitumen at various levels of aging from across Europe, South America, and North America were utilized to develop a database to investigate relationships between measures of bitumen compatibility, colloidal stability, and thermal and visco-elastic properties. The trends were further assessed in the context of the impact of bio-based rheology modification and rejuvenation. The results show clear relationships can be established across rheological, thermal, compositional properties, and used to show more consistent measures of bitumen compatibility, especially with progression of aging as a result of the modification. Such trends present opportunities to utilize emerging compatibility parameters in bitumen modification and mixture rejuvenation specification.

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Asphalt concrete performance with selected types of plant-based yarns

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Abstract:

The presented paper describes the use of natural fibres (yarns) from renewable natural resources originating in technical plants adapted for use in various types of asphalt mixtures to improve the range of mechanical and functional properties. The objective of so far done research was to examine the effect of using vegetable (plant-based) yarns as reinforcement in ACbin (asphalt concrete for binder layers) mix types following previous experience with SMA mixtures. Yarns made from flax and jute were chosen based on previous advanced analyses and research, including economic feasibility. Effective yarn element length and yarn content were searched for. Control asphalt mixture was designed and prepared without any fibres to reach a more clear comparison. Experimental results showed an improvement in stiffness modulus, lower indirect tensile strength ratio (ITSR) and good resistance to permanent deformation of blends containing vegetable fibres. In the road construction, this is a rather new topic, but the results prove that vegetable fibres can be perspective way, as simple and in line with the policy of sustainable development, to improve the properties of the bitumen mixtures.

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Project LIFE BATTLE CO2. Sustainability in asphalt manufacturing

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Abstract:

The Project LIFE BATTLE CO2 “Biomass incorporation in asphalt manufacturing towards less emissions of CO2” represents an innovative effort in the sustainability of the asphalt mixes, focused on the substitution of fossil fuels during the manufacturing process in the asphalt plant. The manufacturing stage of the asphalt mixes represents 50% of the GHG emissions of the asphalt mix considering a cradle to construction approach (including raw materials, raw materials transportation, manufacturing, distribution and construction works). During the manufacturing stage, aggregates heating and bitumen heating are the most energy demanding processes, including the consumption of fossil fuels. Aggregates are usually heated using natural gas or fuel, while bitumen is heated with gasoil. The high dependence on fossil fuels during the manufacturing process is the reason for the CO2 emissions in the asphalt plant, and the project LIFE BATTLE CO2 has been focused on this issue. The Project has developed several prototypes (at semi-industrial scale) specially designed for the aggregate heating and for the bitumen heating using biomass as fuel in both cases for the asphalt manufacturing. The substitution of fuel by biomass in the aggregate heating process has resulted in 75 % decrease in the GHG emissions in the asphalt plant. The substitution of gasoil by biomass in the bitumen heating resulted in 12 % decrease in the asphalt plant. A decrease of 87 % in the GHG emissions in plant was obtained, as well as a reduction of 40% in carbon footprint of the life cycle of the asphalt mix in a “cradle to construction” scope. The project has been also focused on developing the Product Category Rules for the asphalt mixes according to the ISO 14025 Environmental Labels and Declarations – Type III.

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DIGITALIZATION OF EPDs FOR ASPHALT – EXPERIENCE FROM SWEDEN AND INPUT FROM NORWAY

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Abstract:

There is a major socioeconomic challenge in converting current construction processes into more climate-neutral and cost-effective processes based on an entire life-cycle perspective so that the high-level European climate policy goals can be achieved. Different actors, clients, contractors, asphalt manufacturers need a clear guidance to be able to make smarter choices during procurement, technical design, optimization of pavement production processes etc., in order to meet increasing demands for measurement, reporting and reduction of carbon emissions from asphalt pavements. An industry-joint project has been conducted with the aim of reaching consensus among Swedish asphalt manufacturers, clients, entrepreneurs and raw material manufacturers about how an Environmental Product Declaration (EPD) should be used as a certificate of environmental performance for asphalt pavements in Sweden. Since the development of an EPD is costly and resource-intensive requiring expert knowledge, the experience from Norwegian asphalt industry in the creation of a digital solution for the development of EPDs for asphalt pavements has been evaluated. The project has found out that Swedish asphalt manufacturers show a great interest in use of EPDs, but that Swedish clients in the construction industry do not have a uniform requirement for calculation, reporting, optimization and follow-up of the climate impact. This complicates the transition to a more climate-neutral process for Swedish asphalt manufacture. In Norway, the asphalt industry has established a practice for technical design and procurements towards using EPDs as certificate for the environmental impact of asphalt pavements.

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Utilization of depolymerised plastic waste in modification of bituminous binders

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Abstract:

Nowadays, the concept of a circular economy is focused on the effort to use renewable materials or to recycle waste. Mainly plastic waste is a serious environmental problem and it should be solved by the wide range of applications. The depolymerisation process of plastic waste could be performed at severe conditions to prepare pyrolysis oils or under mild conditions to reach only a partial depolymerisation. The product from the mild depolymerisation could be solid with polymer structure and it could be used as a bitumen additive. Such an additive has a potential to improve physico-mechanical properties of a pavement and its resistance to load. The effect of 2 – 4 wt.% of depolymerisate from polyethylene on bitumen properties was investigated using both the traditional methods and the performance-related tests. The storage stability of the binder was very good and its ageing was similar to the original binder. The resistance to permanent deformation was improved and the resulted mastercurves and Black diagrams indicated better viscoelastic performance. Concurrently, the low-temperature properties were not affected by the short-term and long-term ageing procedures. The creep and recovery tests revealed possible difficulties with relaxation of the binder. The overall evaluation was very positive and the potential for the depolymerisate usage in bituminous binders seemed to be promising.

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Modelling the nonlinear behavior of unbound granular materials in flexible pavements with thin asphalt layer

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Abstract:

In Germany, roads are usually constructed empirically with a minimum asphalt surface layer of 120 mm. Experience from other countries shows, however, that it is possible to build flexible pavements with thin asphalt wearing courses of 40 to 50 mm and a satisfactory service life. The advantage of such constructions is that they require less material and energy resources and can be realized quickly and cost-effectively compared to thicker asphalt structures. This is especially interesting for low volume roads. To analyse the overall behaviour of a road construction, respectively the performance of each pavement layer in dependence of all acting thermic and traffic conditions, a mechanistic empirical design approach should be applied. In case of flexible pavements with thin asphalt layers the nonlinear behaviour of unbound granular materials in unbound granular base layers must be considered. This contribution presents selected results of a research about the performance and durability of flexible pavements realized with one thin single asphalt layer. The research carried out covers a wide range of widely used unbound base materials and asphalt mixes, both with large quality differences and under consideration of a wide span of temperature and traffic conditions as well as construction types. The performance of the selected construction types was modelled using the finite element method. For the unbound base course materials, among others, a nonlinear stress dependent material model describing both material dependent stiffness and Poisson's ratio was used after comprehensive validation. With the help of finite element modelling the input data for design life calculation can be provided to analyse the overall behaviour of flexible pavements with thin asphalt layers taking into account nonlinear material behaviour.

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A systematic study of bituminous binders extended with a renewable material

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Abstract:

Road construction and maintenance are progressively moving towards more sustainable solutions, for example, by an increased use of various materials from renewable resources. In this paper, a plant-based oil (PBO) from the forest and paper industry was systematically studied as potential renewable bitumen extender. First, laboratory analysis was conducted on a selected oil. Then, different bituminous binders were prepared containing PBO and studied extensively in terms of quality and performance. It was found that the PBO studied was fully miscible with the bitumen, and by properly selecting a base bitumen and a dosage of the oil, desired standard binder grades were obtained. The extended binders showed an improved resistance to long-term aging as assessed by the pressure aging vessel (PAV), and an improved adhesion with stone aggregates as evaluated by the rolling bottle test and the indirect tensile strength ratio (ITSR). Regarding other performance properties, such as asphalt stiffness, fatigue and permanent deformation, no significant differences were observed between extended and reference bitumens. Two full-scale field trials were also carried out, and HSE observations and pavement performance follow up is presented. In addition, further experimental aspects on recyclability of this type of materials will be addressed.

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Fatigue cracking resistance of nylon fiber-reinforced asphalt mixtures

Jose Manuel Berenguer

Eiffage Infraestructuras

Abstract:

The vast quantity of waste materials (such as End-of-Life Tires (ELT)) accumulating throughout the world is creating costly disposal problem. The use of these materials was proved to be economical, environmentally sound and effective in increasing the performance properties of the asphalt mixture in recent years. The influence of nylon fibers on the fatigue cracking resistance of asphalt concrete is investigated using fracture energy. This paper is going to focus on evaluate the behavior of different asphalt mixtures with different ELT´s nylon fiber contents. The experimental program is designed with two phases: In the first phase, laboratory tests as indirect tension strength test, resistance to fatigue and stiffness tests were carried out according to current European standards. According the obtained test results the optimal dosages of nylon fibers were obtained, and the increased fracture energy represents a potential for improving asphalt fatigue life. Then, during the second phase, the validation is being carried out at pilot scale through the execution of some test sections, to determine their long-term performance and characteristics used in real world applications.

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Mechanical behavior of asphalt concrete containing waste foundry sand

Paulo Paiva Oliveira Leite Dyer[1], Luis Miguel Gutiérrez Klinsky[2], Silvelene Alessandra Silva[3], Maryangela Geimba de Lima[4]

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Abstract:

Currently, the concerns about sustainable development made many traditional industrial sectors rethink their production methodologies and raw materials used. At the road projects this vision is no different since, this sector requires the consumption of large amounts of exhaustible natural resources. In the same way, the industrial sectors that manufacture consumer goods produce huge quantities of industrial waste; highlighted are the steel industries, responsible to produce metallic parts using the casting process, were the main by-products are the Waste Foundry Sand (WFS). The WFS is considered a non-hazardous by the major environmental agencies worldwide, however it is disposed in industrial landfills, reducing their service life. This scenario created a motivation for the development of this study. Samples of WFS were obtained from a sanitary landfill and characterized according to the road engineering standards parameters. The WFS was used to replace 50% of fine aggregates in a hot mix asphalt, produced with a bitumen characterized as 30-45 pen-grade. Specimens were produced in Superpave Gyratory Compactor to assess the mechanical parameters of splitting tensile strength (STS), indirect tension test for resilient modulus (ITTRM), dynamic modulus (E*) and flow number. An asphalt mix without waste foundry sand was used as a control mix. Results in the laboratory test program showed that there is no statistical difference between the control and the asphalt mix containing WFS. The mixture with WFS was also analyzed using environmental tests. Results indicate that the substances from the residues remained encapsulated in the asphalt matrix showing that this concrete have almost no environmental risk if applied in the construction of a highway. It is concluded that there is a technical environmental viability to reuse the waste foundry sand in asphalt mixes. As a result, the society would need to use less the landfills to dispose the WFS.

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Is there potential of using recycled pulverzied admixtures in asphalt mixtures as a substitute for limestone filler?

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Abstract:

The general effort to reduce the exploitation of non-renewable resources and to minimize the amount of materials (waste and industrial by-products) placed on landfills form the key targets of sustainable development and circular economy. The generation of various waste materials increases continuously every year. Similarly the trend of expedient reuse or recycling of such waste materials in various construction areas and for various structures has a growing tendency and is widely supported in developed countries. Within an ongoing experimental study done by CTU Prague one of the key efforts was to find possible solutions to utilize mineral material in the form of crushed and milled (pulverized) concrete, blast furnace slag and milled gypsum boards containing calcium sulphate dehydrate with or without any additional additives. One of the possible areas for possible utilization of these different materials is its use as an alternative admixture and finely ground admixture coming from either a by-product or as treatment of C&D waste which might by applicable as an activated filler in the asphalt mixtures. The laboratory testing included empirical characteristics and determination of mechanical or functional characteristics especially stiffness modulus, resistance to water susceptibility and resistance to crack propagation which were performed on selected asphalt mixtures. For the determination of the resistance of asphalt mixture to ageing and its thermal sensitivity if added pulverized materials are used as substituents to traditional limestone filler in an asphalt mix, long-term laboratory ageing was processed and mechanical as well as functional tests were performed again. In this experimental study the alternative fillers were not tested on specific tests for fillers like sand equivalent, delta ring test or methylene blue test.

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Designing energy efficient roads – Optimising the rolling resistance of roads in the laboratory

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Abstract:

In order to reduce energy consumption and CO2-emissions, road agencies encourage the development of energy efficient roads by reducing the rolling resistance and hence reducing the fuel consumption. Although various literature studies indicate that the texture, the evenness, and the stiffness are important, there is no clear design methodology to optimise the rolling resistance of road surfaces in the laboratory. Therefore, the goals of this research are (1) to establish the technical feasibility of an energy-saving asphalt road surface with low rolling resistance, (2) to develop a reliable method for measuring rolling resistance in the laboratory (validated with in-situ measurements), and finally (3) to draft a functional design specification for the construction of an energy-saving asphalt road surface as part of a tender process. In this research, a new laboratory machine has been developed to determine the rolling resistance of roads. This laboratory method has also been validated by means of in-situ measurements using a rolling resistance trailer. Using these laboratory and in-situ measurements, a road surface has been developed with demonstrably improved rolling resistance that also meets all other required road surface properties such as skid resistance, noise reduction and service life. Furthermore, the impact of the optimized road surface with a low rolling resistance on the fuel consumption, the energy savings, and the reduction of CO2-emissions has been determined. Next, the potential on the whole Dutch and European road network has been assessed. This paper provides a practical method to determine the rolling resistance in the laboratory in order to design energy efficient roads. In addition, the results of this research contribute to a deeper understanding regarding the tyre-road rolling resistance with respect to noise, skid resistance and lifespan.

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LE2AP, towards sustainable 100% surface-to-surface warm in-plant asphalt recycling

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BAM Infra Asphalt

Abstract:

The historic Paris Agreement on Climate Change aims to keep the global temperature rise limited to preferably 1.5°C but no more than 2.0°C in this century. The Dutch government and Rijkswaterstaat also stated their ambition of having a 50% circular and 100% climate neutral asphalt industry in 2030. As such, sustainable technologies enabling low temperature production and high percentage recycling are increasingly important. With the support of the European LIFE+ program, a technology is developed allowing the production of high quality surfacing layers (SMA and PA) comprising up to 95% reclaimed asphalt surfacing layer at 105-115°C. The reclaimed asphalt is first decomposed into reclaimed stone with 1% bitumen and the reclaimed mortar with 10-12% bitumen. The reclaimed mortar is heated, rejuvenated, enriched and homogenised to obtain a high-quality mortar, which is then foamed and mixed with pre-heated reclaimed stones of around 100°C, to produce new surface layers with high quality. This paper aims to discuss the production technics which enable the full-scale demonstration of this technology, especially the main challenge: realization of the mortar production line. The paper discusses three development phases. Phase I, proof-of-concept: a mortar line was developed for the production and installation of porous asphalt test sections in 2016 using makeshift equipment with a production speed of 20 ton/hour. Phase II, optimization: the mortar line is further optimized during the demonstration of SMA sections in 2018, using the makeshift equipment and with a production speed of 80 ton/hour but still limited capacity. Phase III, industrialisation: in this phase the aim is to develop a mortar line which is to be incorporated in an asphalt plant allowing full capacity production of high-quality surface layers comprising up to 95% reclaimed asphalt produced at 105-115°C with limited energy use and CO2-emissions and even larger reduction of CxHy and other pollutants.

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Road surface label: determination and prediction methods for noise, durability, skid and rolling resistance

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Abstract:

The UNECE road surface label, developed by the Dutch working group, contains four indicators: noise reduction, rolling resistance reduction, wet skid resistance and lifespan. The label values (A to G) are determined by measurements, modelling, or a combination. The values must be reliable and objective. The labelling system therefore requires determination and prediction methods that are accurate and reproducible, available and well described, and representative for the influence of the road surface on the real-world environment. For each sub-label, methods need to be available to measure the quality of pavements in-situ, to assess Conformity of Production. For research and innovation, there is also a need for laboratory methods, to enable manufacturers to predict and improve their pavement performance before applying it outside. For some sub-labels, measurement methods are available and standardized, e.g. the CPX-/SPB-methods for rolling noise. For skid resistance, competing methods exist for longitudinal and sideway friction. Rolling resistance measurement methods are under development, but at an early stage. For lifespan, a measurement method that gives short-term results is not straightforward. For the laboratory, several methods for all four sub-labels are available, but not all are standardized and some lack predictive power. The paper describes the general requirements for determination methods, as well as the process steps of standardization ('from idea to ISO'). The availability of in-situ and laboratory methods is demonstrated for all four sub-labels. These methods are described in terms of their suitability and 'readiness'. The result of this investigation is a description of the most important research needs for determination methods, needed to further implement the road surface label internationally. The outcome contributes to a deeper understanding of the four label-indicators and is a step towards harmonisation. This paper is one of three papers on the road surface label submitted to the 7th E&E congress.

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Multi-recycling of asphalt mix with Reclaimed Asphalt and rejuvenator

Porot Laurent, Gomes Vitor

Kraton Chemical

Abstract:

Asphalt materials are effectively 100 % reusable. The reuse and recycling of Reclaimed Asphalt (RA) from old pavements has become normal practice. In recent years, the interest of using rejuvenators has brought recycling to the next level for increasing the RA content in new asphalt mix, or with very aged RA binder, or to improve the processing at the mix plant and pavement construction. In Europe, Germany or The Netherlands have been recycling RA for more than 20 years. In Japan, for more than 40 years, RA is reused up to 80 % and the use of a rejuvenator is a common practice. The question of multi-recyclability, therefore, is becoming more of interest. Japan is already at the third if not fourth cycle, Germany already at least second generation of recycling asphalt materials into asphalt materials. So far there are limited studies looking at multi cycle of recycling. Most often they are based on binder evaluation using laboratory binder aging procedures. This paper presents a laboratory investigation of multi-recycling asphalt mix containing RA and a bio-based rejuvenator. For this purpose an asphalt mix was made with 50 % of RA treated with rejuvenator. The mix was aged in lab for short term and long term procedure. After this aging it was reused again after rejuvenation into a new asphalt mix at a 50 % content and re-aged. At each different stages, binder from mix was extracted and recovered for further analysis. Compared to standard binder aging conditioning, the results from mix aging have shown a similar trend in the changes of the properties. The bio-based rejuvenator was able to restore the main properties of the binder even after the second cycle of recycling. It demonstrates the benefit of the rejuvenator to restore and maintain the durability and properties over time.

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Binder and mix aging with Polymer modified Bitumen – a laboratory evaluation

Porot Laurent, Jellema Erica, Kluttz Robert

Kraton Polymers

Abstract:

Polymer modified Bitumen (PmB) has been commonly used for more than 40 years in the paving industry. It brings multiple benefits to the road with high performance in the materials, especially with higher rutting resistance, high cracking performance and overall better durability and reliability in the road. At the same time, the reuse of old asphalt pavement into new asphalt materials is becoming common practice. On a long-term perspective the benefits of having PmB in pavement and to be further reused at the end of the life is not widely considered. Most often Reclaimed Asphalt (RA) is reused in the same way whether it contains polymer or not. There are already some testing protocols used to characterise the aging of the binder and they are part of current material specifications. However, more research efforts are made to consider, not only aging on binder alone, but in the complex materials of asphalt mix. This paper presents some comparative results on both binder and asphalt mix with laboratory aging protocols. It was conducted on two different PmB, one having a 3.5 % moderate level of SBS polymer and one having a high level of modification. These PmBs were compared with a standard paving unmodified binder. The binders themselves were subject to short-term aging with RTFOT and further long-term aging with Pressure Aging vessel (PAV). The asphalt mixes were subject to short-term and long-term aging in oven. From the mixes, the binder was extracted and recovered at different periods of time for further characterisation. In addition to physical properties, the chemical changes were tracked using FTIR. The outcomes demonstrate the long-term benefit and potential recyclability of SBS modification at both binder and asphalt level.

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The use of reclaimed polymers to improve the mechanical performance of bituminous mixtures

R. Tauste, G. Travé, F. Moreno-Navarro, M. Sol-Sánchez, M. C. Rubio-Gámez

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Abstract:

Nowadays it exists a great environmental concern referring to the consumption of waste plastic materials and their disposal. The reuse of these materials as bitumen modifiers could provide an interesting solution to help to address this problem along with the possibility to obtain the benefits of polymer-modified bitumens at a lower cost (which also could help to extend the service life of road pavements). For this purpose, this study assessed the viability of incorporating reclaimed polymers to produce high performance asphalt mixtures, which were compared to traditional mixtures manufactured with polymer modified and neat binders. To evaluate the mechanical behaviour of these mixtures, binder drainage, moisture susceptibility, stiffness modulus, wheel tracking and UGR-FACT tests were performed. The results show that the use of reclaimed polymers could help to improve some of the properties of bituminous mixtures, which could open their use in roads or asphalt layers were the application of modified materials is advisable but their cost limit their application.

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Analysis of the effect of rejuvenators on the performance of aged asphalt binders

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Abstract:

In the following years, the investment of developed countries in maintenance tasks will far overwhelm the construction of new infrastructures. One of the main activities will be the rehabilitation of pavements that generates large quantities of reclaimed asphalt pavements (RAP). The reuse of this material incorporated to the asphalt mixture in high percentages provide considerable economic and environmental benefits but it also could lead to a premature appearance of cracking or ravelling. To overcome these problems, the use of rejuvenators could play a key role. In this study, the effect of rejuvenators of different nature was determined through rheological analysis. For this purpose, aged binder extracted from RAP was blended with different types of rejuvenators at different dosages. According to the results, the type of rejuvenator used will have a great impact in the final performance of the aged bitumen.

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Frameworks for life cycle assessment of road pavements and asphalt mixes

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Abstract:

Road pavements are complex and dynamic systems which need to be properly managed during their whole life cycle to ensure they deliver their function to society. The use of life-cycle management techniques (LCM) is even prescribed by the European standard CEN CWA 17089:2016 "Indicators for the sustainability assessment of roads". This is probably the first effort globally aiming at standardising the definition of sustainable roads and identify indicators to develop sustainable practices for the design, construction and management of road pavements. Hence, stakeholders recognise the need of introducing sustainability at core of pavement engineering practices, however road authorities as well as asphalt producers/contractors are also aware that nowadays life cycle Assessment (LCA) exercises are very much dependent on the analyst's work and assumptions. In turns, this often lead to differences amongst methodologies and in some cases finally makes results incomparable from one case to another. Hence this study wants to underline the need of differentiating frameworks to perform LCA of road pavements and asphalt mixes respectively and provides guidelines targeted to road authorities and asphalt producers/contractors. As a result, the different groups of stakeholders should be able to use these frameworks to carry out environmental impact assessment of each system independently as well as understanding interdependencies towards a much needed dialogue and collaboration.

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The use of lignin as bio-binder in asphalt applications

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Abstract:

Several investigations have shown interest in the use of durable material for road constructions, including bio-based oil, The introduction of lignin in asphalt applications opens the door for a new bio-binder in infrastructure. With a 50/50 blend of bitumen and lignin, the laboratory tests revealed equal performance with regular asphalt. Several trials started already all in top-layer applications and including a test at the harbour of Antwerp for heavy-duty performance. The total amount of bitumen used worldwide is estimated on 70 million ton annually. The current amount of lignin produced worldwide is probably 50 million ton and will increase. The advantage of using lignin is the positive impact on our environment. Lignin is a natural resource released during the production of pulp in the paper industry. It is an extensive waste stream, which is mainly used for energy production. Paper is formed on the carbon dioxide in our atmosphere and therefore binding carbon in a positive way. The waste of pulp production is not a production as such; it is a left over from the use of bio-material. By using the lignin in road constructions, the bound carbon will stay captured. The use of lignin contributes to lower emission because of the lower production temperature of asphalt production. Predictions show that bitumen-producing refineries will decrease resulting in a lack of supply for infrastructure. Recycling and use of durable material will be the answer for our children and their future.

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The clock is thicking towards 2030, how to reduce CO2 emmisions.

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Abstract:

The Paris Agreement requires all Parties to put forward their best efforts through nationally determined contributions (NDCs). In Norway Department of Transportation has difined a goal of 50% reduction in emmissions from the construction and maintenance of raods. Hence, the asphalt industry is also required to reduce its CO2 emissions by 50% by 2030. The current combined emissions from asphalt operations in Norway amount to 380,000 tons, approximately 51 kg CO2 per ton of asphalt produced. The past years, the Asphalt Industry has taken several steps towards a more sustainability asphalt industry to contribute to such reduction. Warm mix Asphalt, Reclaimed Asphalt, alternative fuels, dry aggregate is tooles that all will contribute to reduction in emissions. To be able to prove a reductions in emissions according to the Paris Aggrement, and national requirements, a set and rules has to be determined. EAPA published a " Guidance Document for Product Category Rules" which was used in Norway to produce a PCR for asphalt production (npcr-025-2017-version-1-1-part-b-for-asphalt). Once this national rules was determind, a web-tool has been developed operated by a 3rd part. This tool eneables all asphalt manufacturers to document the actual emmissions from each plant. Further the Road owner or client can produse an LCA for a project .This paper give examples of emmisions from an asphalt plant and what can be done to meet the Paris and national goals to reduse CO2 emmissions. The numbers are based on average values in Norway and type of production equipment is not taken into account.

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Physicochemical interactions of reactive surfactants with bitumen

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Abstract:

The use of reclaimed asphalt pavements (RAP) is gaining popularity in Europe, especially in the reconstruction of asphalt pavements. This fact has encouraged the seeking of modifying agents (rejuvenators and/or softeners) able to soften aged bitumen to optimise the reuse of RAP. Here, a set of reactive surfactants have been evaluated in terms of the effect caused on bitumen properties after modification. The selected reactive surfactants (dodecenyl succinic anhydride, DSA, and dodecylbenzenesulfonic acid, DBSA) consist of an aliphatic tail of 12 carbons in length and a polar head that contains a reactive group able to react with polar bitumen molecules. Blends of bitumen with 3 wt%. additive have been prepared and analysed by means of rheological, thermal and analytical techniques. The obtained results point out that the addition of DSA reduces the stiffness and the viscosity of a model bitumen in the whole in-service temperature range, being more effective than a selected benchmark: engine oil. By contrast, the use of DBSA gives rise to an opposite effect, especially in the intermediate-high temperature range, where a remarkable increase of elastic and viscous properties is noticed In general, the resulting data evidence the existence of chemical interactions of the reactive group of surfactants with polar compounds in bitumen that affect the colloidal stability. The different outcomes obtained seem to be caused by the nature of the new chemical bonds: ion pairs for DBSA and covalent links form DSA. Keywords: Physicochemical rejuvenation, viscoelasticity, reactive surfactants.

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Dense graded crumb rubber asphalt development for sub-tropical climate

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Abstract:

The use of crumb rubber modified (CRM) binder can provide increased durability and cracking resistance. Although crumbed rubber modified bitumen is used extensively worldwide, the application has been very limited in asphalt mixes in Australia and has not been used in dense graded asphalt due to the complexity of the design. The first of its kind in Queensland, a research and development (R&D) project with the Moreton Bay Regional Council (MBRC) was established to provide a fit for purpose solution using crumb rubber technology in dense graded asphalt. The paper discusses the crumb rubber binder blend properties. Further to conventional test methods, the benchmarking of the rheological properties was carried out by means of the dynamic shear rheometer. Details on the volumetric properties and performance-based test results are provided in the paper and manufacturing, construction and field procedures are also discussed. Based on the laboratory and field validation it was concluded that the newly developed dense graded crumb rubber mix is well balanced and has a high performance. Additionally, it uses environmentally friendly and sustainable technology while potentially reducing maintenance costs.