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DISCUSSION ON THE PROCEDURE TO BUILD THE CHARACTERISTIC CURVES OF FINE AGGREGATE MATRICES

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Abstract:

An existing viscoelastic continuum damage (VECD) model, which accounts for the effects of rate-dependent damage growth, has been successfully applied to represent the reduction of the material integrity as a function of damage accumulation (characteristic curve) of asphalt concrete mixtures. A common problem experienced by researchers when applying the VECD model to characterize the damage of fine aggregate matrices (FAMs) is that the inherent heterogeneity of asphalt mixtures can lead to different linear-viscoelastic properties and characteristic curves of replicates of some FAMs. In this study, two or three replicates of ten FAMs were tested and some FAMs have shown results reinforcing such findings of the literature. An adjustment of the characteristic curves by using the average of the linear-viscoelastic properties of the replicates of these FAMs is presented, as a proposed procedure to build a unique material characteristic curve that is able to differentiate each FAM. In most cases, the procedure made it possible to obtain superposed characteristic curves. However, it was observed that a higher number of replicates may be needed for some materials, once that the application of the proposed procedure was not enough to generate similar characteristic curves among the replicates of some of the FAMs. The results also showed that it is possible to obtain a unique characteristic curve of replicates even when they are tested at different stress levels.

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High performing asphalt for racing conditions in sub-tropical climates – the Australian experience

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Abstract:

Asphalt surfaces for racing conditions need to be extremely durable to withstand high temperatures and extreme horizontal shear forces. In 2014 a number of sections of the Street Circuit of the City of Gold Coast in Queensland exhibited distress in the form of ravelling. In response, the author of this paper developed a highly engineered asphalt mix to provide a fit for purpose and durable asphalt surfacing product that could withstand the high shear stress of the Australian race cars. The R&D project utilised first principles to develop a highly engineered asphalt material. The asphalt mix was formulated to handle race conditions and minimise the potential for track surfacing failures including ravelling, rutting, shoving, cracking and delamination, all of which have the potential to damage cars, cause accidents and increase vehicle wear and tear. The successful mix design, process and methodology are discussed in detail in this paper. The bitumen selection for this particular application was based on the benchmarking of the rheological properties of different bitumen types by means of the dynamic shear rheometer (DSR). The complex modulus and the phase angle of the different binders, related to race car loading frequency and sub-tropical pavement temperatures, were considered key input parameters. Production and placement of the trial mix design was first carried out on a private race track where performance was monitored under simulated race conditions. With performance parameters set and input from the race car drivers considered, monitoring of the trial section concluded that the asphalt mix was suited for the Surfers Paradise Street Circuit. This paper discusses the complex processes of mix design, trailing, production control, paving and workmanship. The outcomes of post-performance monitoring - with no distress reported after four years in service - is provided in the paper.

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STATISTICAL ANALYSIS OF THE EFFECT OF TEMPERATURE, LOAD FREQUENCY AND AIR VOID ON DYNAMIC MODULUS OF ROAD BASE ASPHALT CONCRETE

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Abstract:

Road pavements placed in cold regions are subjected to harsh changes of temperatures both seasonally and daily which in turn influences the stiffness behavior of asphalt mixes through freeze-thaw cycling. This effect plays an important role on the performance of asphalt pavements, which is not taking into consideration in current methods of pavement design. Previous studies confirmed that after 300 freeze-thaw cycles, the stiffness behavior of a base asphalt concrete with a nominal maximum aggregate size of 20 mm (GB20) can change depending on the temperatures and frequencies of the freeze-thaw cycles. However, the effect of air void on the dynamic modulus under freeze-thaw cycles is not decisive. The main objective of this research is to perform a statistical analysis in order to identify the effect of air void content on dynamic modulus of asphalt in different freeze-thaw cycles in cold regions and also to find out a suitable tool to predict dynamic modulus based on influential factors. The results of this study showed that at very cold or hot temperature, The drop in dynamic modulus after high number of freeze-thaw cycles is tangibly influenced by the increase in air void content. Also, a linear regression model can be employed as a reliable tool to predict the dynamic modulus of asphalt in high freeze-thaw cycles based on temperature, frequency and air void content.

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Evaluation of Asphalt Mixture Frost-Resistance based upon its Stiffness

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Abstract:

A number of freezing-thawing cycles for French climate were estimated to stay in a range from 500 to 1200 in 12-15 years of service life. In this regards pavements in Eastern Europe could experience even larger detrimental effect from the frost damage. As a consequence, this may potentially lead to a decreased load carrying capacity of the whole pavement. For the freezing-thawing effect on the asphalt mixture to be assessed, the stiffness modulus of the asphalt mixture was determined. The specimen under consideration was subjected to 50 freezing-thawing cycles at temperatures ranging from -10 °C to 20 °C and strain rates from 0.01 Hz to 5 Hz. To exclude any uncertainties arising from the non-linear behaviour, an effective stiffness modulus was defined, which was taken within a linear visco-elastic region of the bituminous mix before and after the freezing-thawing exposure. The method used was therefore of a non-destructive type. Based upon the results derived, frost resistance coefficients were quantified and a set of relationships between the stiffness and these coefficients was possible to be established. It was found that the frost-resistance coefficient increases as the strain rate increases and as the temperature drops. A considerable effect on the frost-resistant ability was also observed to occur immediately after the application of the first freezing-thawing cycle during the rest phase. It was noticed that as both duration of the rest phase and an ambient temperature become larger the material is more resistant to the frost damage. This indicated that the frost-related damage in the asphalt mixture might be partly healed. The variation in the stiffness modulus and the frost-resistance coefficient identified from the experiments is depended on the settings adopted in the test and should be explained by taking real conditions the pavement is exposed to into account.

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Comparison of test results of mortar-dumbbell specimen and asphalt parameter: stiffness and fatigue behavior

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Abstract:

Material fatigue is one of the most important causes for failure of asphalt pavements. The structural model of asphalt can be divided into two phases, the aggregate skeleton and the mortar. Mortar is defined as the mixture of fine aggregates, filler, bitumen and additives. As the mortar represents the weakest link in the system of the two-phase-model, it is especially susceptible to fatigue damage. The target of this research and development project is to find out a relationship between the mortar performance and asphalt parameter: stiffness and fatigue behavior, determined on drill cores by means of indirect tension test. Therefore, in this study the fatigue behavior and stiffness of bituminous mortar by means of specially designed mortar specimens (asphalt dumbbell – specimen) have been determined. With rheological measuring by means of DSR, a modern and highly effective technique is found to assess the above mentioned mortar qualities. In Germany no experiences are available with such an investigation on mortar-dumbbell by means of DSR. Due to that, a standard for this test method is not available in Europe. First, the preparation and homogeneity of specimen as well as the repeatability of test method for several type mortars with different type of bitumen have been determined and optimized. The used methods indicate good reproducibility and sufficient accuracy of testing and test evaluation. Furthermore, the gained experiences show that the fatigue behavior and stiffness can be determined in one process compared to the test methods on asphalt drill cores. In addition, the investment for preparation of specimen and the duration of fatigue tests are significantly shorter.

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Bituminous Mixtures Ultra-Thin-Layers (AUTL)

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Abstract:

During 2017, a consortium was created between the companies CAMPEZO -the leading company-, PADECASA and REPSOL, to carry out a research project on the use and characterization of new type of bituminous mixtures which are developed in a new European standard prEN 13108-9. In this work, we consider the resources available in our country and study the use of different types of materials as well as manufacturing technologies that are less polluting and more sustainable. The ASFALTHIN project, with a duration of 3 years, has been approved in December 2017 by the Industrial Technological Development Center CDTI, within the "PID research and development projects" program, with a budget of 1 million euros. The project is divided in 6 activities, including a study of art and in-depth study of European regulations, laboratory studies necessary to identify the requirements required for materials and the proposal of grading for this type of mixtures with different structure and characteristics, for layering with thicknesses between 1-2 centimetres. In the final phase of the project, several test trials were carried out with the materials studied. This communication will present all the results obtained at the laboratory level (design and properties of the mixtures) with which several mixtures of AUTL mixtures have been defined, with different content of holes and possible applications, as well as manufactured with materials at a lower temperature and results of behavior of the mixture in service of several test sections executed throughout the project. The work will be completed with the publication of a guide of suggestions to use as a reference document in the sector where the procedures and appropriate methodologies are indicated to carry out the design and quality control of the AUTL mixtures, establishing the most suitable criteria and methodologies for the climatology and traffic conditions in Spain.

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Relaxation property as a key factor for predicting the lifetime of porous asphalt mixtures

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Abstract:

Porous asphalt (PA) mixtures are very sensitive to ravelling, as a result the lifetime of PA is limited. The use of better quality materials were implemented in an effort to improve the lifetime of porous asphalt mixtures. But these were quantified empirically based on the performance of the binder/mortar as well as resistance to ravelling of the mixture. In this study, effort is made to use the relaxation property as a key factor in relation to the durability of the mixture to predict the life-time of PA mixtures. Ravelling occurs when the relaxation property of the binder, indirectly that of the mortar and/or the mixture, becomes very limited. In other words, it becomes very sensitive to damage as a result of applied strain/stress. A new semi-empirical model, named APAS model, is developed to calculate incremental damage development in PA mixtures as a result of repeated thermal-loading (day/night and winter/summer periods). A study to pavement failures with PA surfacing is the underlying perdition model for the evaluation of the mixture performances. In this study were in total 8 mixtures investigated, in which the effect of binder type, aggregate type and aggregate size are taken into account. The rheological properties of the extracted binders from fresh (virgin) and aged mixtures were studies together with the relaxation properties of the mixtures. These were used as an input in the APAS model. It is noted that damage development in the winter periods is the main cause for the deterioration or ravelling of the PA pavements. The result of the modelling show that the type of binder plays a significant role in the development of damage, which predominantly determines the life-time of the PA mixtures. The lifetime of the studied asphalt mixtures ranges between 9 to 16 years and one binder exceptionally out performs the others with a predicted lifetime of > 18 years.

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Bonding of bituminous layers: a new tool for qualifying in situ

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Abstract:

The infrastructure maintenance represents an important socio-economic issue. Its effective planning goes through the knowledge of the behavioural evolution of pavement over time and its residual life, requiring the development of relevant experimental and modelling tools (DVDC: collaborative French national research project on Roadways lifespan, introduced in 2016). So one of the essential characteristics to optimise the durability is the quality of bonding between roads layers. A draft European project 12697-48:2014 provides seven different methods with different loadings (Torque Bond Test, Shear Bond Test, and Tensile Adhesion Test, monotonic or cyclic), temperatures, loading rate but no one can be used on construction site. Within the framework of the DVDC national project and in cooperation with the French road trade association, a consortium of academic and industrial partners leads the development of a reliable tool, usable in situ and in laboratory. The objective is the proposal of a performance test (including setup and method description) that is applicable on construction site. The various technical constraints and requirements were identified leading to a first prototype (torque control with a controlled climb speed and an estimated trial limit). In addition to the technical aspects of the test, several specific points were identified such as the control of the initial core drilling (mainly not to embrittle the material in place), the gripping of the core, the need to control the test temperature, the ergonomic design, precision and quickness execution on site, the ease of transport A program test on asphalts complexes produced in lab (three types of emulsion, temperatures, loading rate) allowed validating the interest of the experimental set-up, to define the most relevant parameters but also to identify the ways of improvement. The first tests on construction site give interesting results and have completed the different analyses in situ.

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Viscoplastic modelling of asphalt concretes: application to innovative ballastless railway structural design

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Abstract:

An original concept of railways was assessed. A classical railway track is made of rails supported by sleepers and ballast. The innovative track studied here is made of rails continuously supported by an asphalt concrete layer. Neither sleepers nor ballast are used in such a structure. This concept was developed to limit the thickness of railway structures in tunnel and increase their gauge, while reducing spending for tunnel rehabilitation. This railway concept was developed inside a French project named 'REVES', funded by the French government. It aims at developing a technical solution from the pre-design to an on-site demonstrator. It should validate the railway structure concept for commercial use on the French national network. As a part of this project, a PhD thesis was funded by SNCF-Réseau and scientifically led by IFSTTAR. It aimed at studying on the behaviour of the asphalt concrete layer under peculiar loadings related to railway freight. The viscoplastic behaviour of asphalt concretes under heavy and concentrated loads was the focal point of the PhD thesis. Despite the behaviour of asphalt concretes in roads under truck traffic being relatively well understood, freight trains can lead to double the usual truck loads and concentrate these loads under the rails. A viscoplastic model was developed, based on the Perzyna model of standardized viscoplasticity, using a Drucker-Prager criterion closed by a cap. This model was set up and assessed by means of a first experimental program of triaxial tests on highly deformable asphalt concretes. A second experimental program was performed on the high performance asphalt concrete that would be used in railway infrastructures. The parameters of the viscoplastic model were identified. They validated the model used and allowed to perform some predictions of the long term behaviour of such an asphalt concrete structure related to settlement and permanent deformation.

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Advantages of polymer additives ready to be used at the asphalt mixing plant

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PR INDUSTRIE

Abstract:

In many countries, the major sources of flexible pavement distress are still cracking and rutting. The latter, caused by the repeated application of traffic loads, may become an even more widespread phenomenon as significant global warming is apparently already taking place now. Cracking can have several origins, mechanical (traffic), thermal and solar radiation. A number of polymer brands are used in Polymer Modified Bitumen to mitigate these issues. For the same purpose, it is also possible to use polymer compounds such as PR FLEX 20® which has been formulated to allow a direct introduction into the drum or pug mill of the mixing plant. This approach known as the “dry process” brings a number of advantages when compared with the more classical PMB approach. The paper shows how quickly the ready-to-use compounds are dispersed in the base bitumen. It also describes the improvement of the binder properties (mainly softening point, elastic recovery and dynamic shear rheometry properties) obtained when polymers and ready-to-use additives are used. Fluorescent microscopy was useful for the interpretation of the measured properties. The paper also shows the influence of the bitumen nature on the binder properties.

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Towards 100% recycled high-modulus asphalt concrete

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Abstract:

Re-use of milled asphalt for production of new asphalt mixtures is continuing to increase. Unfortunately, the efforts are still not sufficient as in many locations piles of Reclaimed Asphalt Pavement (RAP) are accumulating or the material is downgraded for lower value applications. New ways to use RAP should be explored to further increase its consumption in hot mix asphalt. We explore the potential to design 100% recycled High Modulus Asphalt (HMAC). The high resistance to rutting and fatigue of HMAC mixtures is achieved through use of high content of hard binder grade. This is presumably well matched with the properties of RAP – the bitumen in RAP is hard because of aging. Another reason to consider RAP use in HMAC is the requirement to use performance-based test methods for designing this mix type. Performance-based design is recommended for RAP mixtures, since it reduces risks compared to relying on volumetric properties as done in traditional asphalt concrete mix design. Here we designed three different iterations of 100% RAP HMAC mixture in laboratory, but none of them achieved the performance required for a HMAC for stiffness modulus, fatigue and rutting resistance. The reason for the poor performance of 100% RAP HMAC was likely the lacking angularity of RAP aggregates. We thus conclude that a proper RAP management procedure has to be implemented before considering use of high RAP content for design of HMAC mixtures. We intended using the Mobile Load Simulator (MMLS3) to validate if the laboratory fatigue tests can be relied on for design of totally recycled mixtures. Unfortunately, the test setup did not allow making such conclusion because RAP mixtures broke before experiencing fatigue. This indicates that the RAP was more brittle compared to the virgin mix, but does not allow to conclusively comment on the fatigue performance.

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Performance test method for evaluating the resistance to freezing and thawing of asphalt

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Abstract:

In winter, asphalt roadways are exposed to extreme loads due to frost-thaw changes and the use of de-icing agents. These stresses can lead to severe damage of the surface. The currently applicable requirements for aggregates with regard to resistance to freezing and thawing with de-icing agents (salt) are empirically based. The changes in the road surface that occur in practice - above all due to the effects of freeze-thaw cycles in conjunction with de-icing agents - cannot be simulated in the laboratory due to the lack of a test procedure. The CDF method developed for concrete was adapted for testing asphalt surfaces in the laboratory. The freeze-thaw de-icing salt resistance is assessed by determining the mass of the material weathered from a sample after a certain number of freeze-thaw cycles. Based on the findings of the investigations, a draft "Test specification for the CDF Asphalt Test" was developed. Three different asphalts (AC, SMA, PA) with a total of six different aggregates were tested. The aggregates showed weathering values in the freeze-thaw test with de-icing agent (salt) between 0.3 wt.% and 45.1 wt.%. The test results obtained confirm the applicable requirements for the aggregates; aggregates with properties in accordance with requirements in the freeze-thaw salt test also lead to low surface weathering in the asphalt test. It has also been shown that asphalts with a high proportion of coarse aggregates (SMA, PA) react more strongly to the test than asphalt concretes; the same applies to water-saturated samples. The CDF Asphalt Test can also be used to evaluate asphalts that have already been used. For the CDF Asphalt Test, an orientation value for weathering of 200 g/m² can be assumed. The precision data of the test still have to be determined and an evaluation background has to be created.

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Possibilities of optimizing the Wehner/Schulze method (FAP) for skid resistance prognosis of asphalts

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Abstract:

Every road user expects a skid resistance road surface, even in wet conditions. To achieve this, it is necessary to ensure that the specified requirements for skid resistance are met throughout the entire service life of a road surface. The "Determination of friction after polishing (FAP)" (EN 12697-49) is provided in the currently valid versions of EN 13108: "Bituminous mixtures — Material specifications", categories FAPmin for the "minimum friction after polishing", which are based on experience in various countries, are listed. In a research project, the skid resistance of 21 asphalt surfaces was investigated. A further test was then carried out on individual sections after a service life of three years. It was demonstrated that the application of an additional mechanical load in excess of the 90.000 passes specified in EN 12697-49 resulted in a further reduction in skid resistance. The investigations confirm that a "final FAP" can only be determined unerringly after at least 270.000 passes. The investigations also show that the sample preparation to be carried out in accordance with EN 12697-49 is not sufficient for the Wehner/Schulze method. For this reason, a specific sample preparation was developed, which can be applied to every test specimens. The developed test system provides practical and reproducible results that allow a skid resistance prognosis of asphalts before a construction project starts. In order to be able to reliably guarantee the requirements for skid resistance at the end of the service life, it is recommended to require a final FAP of more than 0.25 after 270.000 passes. The minimum categories specified in the European asphalt standards are not sufficient here. With the proposed system, the construction and asphalt industry can integrate the friction after polishing into the asphalt design and thus offer the road construction administration unerringly skid resistance asphalts.

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Evaluating the Activation of Asphalt Binder from Recycled Asphalt Shingles in Asphalt Concrete

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Abstract:

The use of recycled asphalt shingles (RAS) to replace a portion of the virgin asphalt binder in asphalt mixtures has been increasing over the past several years due to environmental and economic motivations. Yet, since shingle asphalts are much stiffer than paving asphalts, there are concerns that the shingle asphalt may not be completely activated as a binding material. This could result in under-asphalted mixtures; also, the composite binder created by the blended shingle asphalt and virgin asphalt may not have suitable characteristics to resist cracking under load and environmental conditions in pavements. In this study, the activation of shingle asphalt was investigated and estimated using several different methods. The first investigation involved mixing aggregate and RAS without any additional asphalt. The second approach evaluated laboratory prepared mixtures containing 5% RAS at mixing and compaction temperatures ranging from 250°F to 350°F. A third method involved laboratory performance tests to evaluate the effect of mixing and compaction temperatures on mixture properties and provide an indication of the degree of RAS binder activation. The results of this study indicated that shingle asphalt might increase the stiffness and lower the cracking resistance of mixtures containing RAS. In addition, increasing the mixing temperature increases the stiffness of the mixtures. This increased stiffness may be caused by increased activation of shingle asphalt, and increasing the mixing time and/or storage time may additionally increase the percentage of activated shingle asphalt. Finally, further aging or increased mixing temperatures of laboratory-produced mixtures containing RAS may be needed to better match plant-produced properties.

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Fatigue Performance and Pavement Design Studies of Hot Mix Asphalt modified with Hydrated Lime

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Abstract:

Among other advantages, hydrated lime as filler substitute in hot mix asphalt (HMA) is supposed to increase fatigue resistance and thus, the design life of pavement structures. In this study, the stiffness and fatigue resistance of four reference mixtures without hydrated lime were compared to mixtures with comparable volumetric composition and addition of hydrated lime as partial filler substitute. The mixtures consisted of two surface layers, namely SMA 11 and SMA 16, one binder layer, AC 22 and one base layer, AC 32. 4-point-bending (4PB) tests according to EN 12697-26 and EN 12697-24 were carried out to determine stiffness and fatigue resistance. In addition, a recently developed test method for the assessment of the fatigue resistance on the mastic level was also employed in this study to compare mastic from all mixtures. The data from stiffness and fatigue testing on mix level were used as input data for pavement design studies in which pavement structures with reference and hydrated lime modified mixtures were compared. The results show that a balanced mix designed keeps stiffness levels of reference and hydrated lime modified mixtures within the same range and that hydrated lime does have the potential to increase fatigue performance. These findings are also reflected by the outcome of the pavement design studies, where an increased design life could be realized with the addition of hydrated lime modified mixtures. Mastic fatigue testing showed similar trends as asphalt mix fatigue testing.

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Investigation of Interlayer Bond Strength Using Tensile and Shear Tests

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Abstract:

Bond between asphalt layers is an important factor for performance of asphalt pavements. The interlayer bond strength depends on many factors including type of tack coat, application rate, type of surface, and temperature. This paper reports on an investigation conducted using modified emulsions on two paving projects. Each project was divided into three test sections. Three levels of application rates were used on one of the paving projects while two application rates were used on the other resulting in five test sections. Core specimens were taken from each of the sections and tested using tensile and shear bond strength testing methods. Results from these tests were analysed to investigate the effects of application rate on bond strength. Results of an earlier study, which was based on unmodified emulsions and shear bond testing, were reanalysed and used in addition to data obtained from the current study to investigate the relationship between shear bond strength and application rate for different surface types. The result of this analysis showed that there is no correlation between application rate and interlayer bond strength within the ranges of application rates considered in this study.

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ASSESSMENT OF RECYCLED ASPHALT CONCRETE FLEXIBILITY UNDER FLEXURAL STRESS

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Abstract:

Fatigue life of asphalt concrete is affected by the growth and accumulation of cracks under the action of repeated vehicular loading, aging and effect of the environment. The flexural behavior of asphalt concrete depends mainly on the flexibility of the pavement mixture which deteriorate gradually with time. Recycling could be a suitable action to reserve such properties. In this investigation, beam specimens of (400 mm) length, a width of (80 mm), and a height of (50 mm) have been prepared from reclaimed asphalt pavement RAP as well as recycled asphalt concrete with cutback and emulsion rejuvenators. Beam specimens were subjected to repeated flexural stresses in a four-point loading system under 600 load cycles at 20°C. Repeated Loading of 138 kPa was applied in the form of rectangular wave with a constant loading frequency of 60 cycles per minute and loading sequence for each cycle is 0.1 sec load duration and 0.9 sec. The vertical deflection during the test of the beam at the mid span was measured with LVDT, which was connected to data acquisition system where the deflection at various time intervals was stored and analyzed for finding strain at any number of cycles desired for every test. The resilient modulus was calculated and compared for various mixtures. It was concluded that the tensile strain for recycled mixtures decreased by (16.5 and 22.2) % for recycled mixture with cutback and emulsion respectively as compared with reclaimed mixture at 20°C. The reduction in Resilient Modulus under repeated flexural stress was (10.4 and 19.4) % for recycled mixtures with (cutback and emulsion) as compared of the aged mixture respectively. The percent of reduction in Resilient Modulus under repeated flexural stress was (10.4 and 19.4) % for recycled mixtures with (cutback and emulsion) respectively as compared to that of the aged mixture.

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Development of a protocol for the initial type testing of asphalt mixtures with the use of rejuvenators

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Abstract:

In Europe, the approval and CE marking of asphalt mixtures is preceded by a mandatory initial type testing (ITT) study according to EN13108-20. Moreover, according to the product standards for asphalt mixtures (EN 13108 series), the application of additives such as rejuvenators are allowed, given a proof of suitability is demonstrated. However, in case of rejuvenators while using high amounts of reclaimed asphalt (RA) (> 60% for AC base courses), no further detailed information is provided in the procedures. Therefore, there is a need for a standard approach or protocol in order to carry out an ITT-study while using rejuvenators in the laboratory. This paper describes the results obtained within the framework of the research project 'Re-RACE' (Rejuvenation of Reclaimed Asphalt in a Circular Economy), specifically on the part of ITT testing procedure while using rejuvenators in combination with RA. The overall aim was to set up a standard procedure for the screening of the efficiency of rejuvenators by means of asphalt performance tests. Latter procedure should also be adequate in terms of representing how a rejuvenator is applied during real production in an asphalt plant and reflect the behavior of the asphalt mixture on the road. In this study, a series of parameters effecting the impact of the rejuvenator on the performance of the asphalt mixture such as the way the rejuvenator is added, the mixing and exposure time (time between mixing and compaction) and different concentrations of the rejuvenator were investigated for different rejuvenators. As current practice includes the use of soft binders, latter were also included in the research program for comparison. This paper discusses and draws conclusions from test results for compactibility, water sensitivity, resistance to rutting, stiffness and fatigue behaviour. Moreover, results are compared to field data as obtained from test sections constructed previously.

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Can be compactability, determined by impact and gyratory compactor, described with one single model?

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Abstract:

This paper presents new uniform model for compaction propagation generated by impact and gyratory compactor. Currently European standard EN 12697-10 defines two different models, independently for an impact compactor and for a gyratory compactor. There is no correlation between those two standardised models. In our previous studies it has already been established that the model defined in EN 12697-10 for impact compactor does not appropriately describe the compaction process. The prediction of the compaction, especially at the end of the compaction process, differs from the experimental results of the compaction tests, which was confirmed on several different asphalt mixtures. In order to achieve improved predictions, new research was performed on AC asphalt mixture of different gradations. Comparative compaction was performed on gyratory compaction device according to EN 12697-31 and impact compaction device (Marshal Compactor) according to EN 12697-30. Based on the results of these tests an improved model for the compaction propagation is proposed. It consists of two parts and results in good fitting of experimental data for either compaction process. The improved new model may be universal for both methods of compaction and may offer a supplementary solution to the one currently standardised and specified in EN 12697-10.

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Precision of complex moduli of asphalt concrete determined by modal analysis

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Abstract:

Modal analysis is an economic and repeatable test method to characterize the complex modulus of asphalt concrete specimens. The method have shown good agreement to conventional tension-compression cyclic loading and to non-destructive in-situ stiffness measurements of pavements. The testing is performed by applying impacts to a specimen using a small hammer. The frequency content of the input load and the frequency response of the specimen are measured to determine the complex modulus. This paper presents an evaluation of the complex modulus reproducibility by performing modal analysis on asphalt concrete specimens at several laboratories. The testing is repeated at a number of temperatures to evaluate the precision of the method over a wide range of the frequency and temperature dependent master curve. The simple practical test set-up and truly non-destructive nature of the modal analysis testing are some of the advantages that contribute to the good precision of the complex modulus characterization of asphalt concrete. In addition, practical aspects that are of importance for accurate testing are highlighted.

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Verifying potentials of using stone mastic asphalt for binder layers containing up to 50 % reclaimed asphalt – lab and field experience

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Abstract:

Asphalt pavements raise presently several challenges which force seeking for improved or even new solutions. For this reason in the Czech Republic it was started to think more seriously about the long-life pavement concepts, which we call in present stage as low-maintenance surfacing, i.e. focus is oriented on surface and binder layers where alternatives are sought. In case of surface layers asphalt mixtures which allow paving layers with max. thickness of 30 mm are under consideration looking at French concepts like BBTM 0/8 mm or on German concepts of noise reducing SMA 0/8 mm. Both types of mixtures have been repeatedly used for several years to proof their applicability. In case of binder courses the focus during last two years was oriented on analysing the concept of SMA mixtures which are applicable to these layers, i.e. their maximum particle size reaches 16 mm or even 22 mm. Additionally this was combined with use of RA to touch the first challenge as stated above. Mix designs of a SMA 0/22 mm mixture as well as of a BBTM 0/8 mm and SMA 0/8 mm following the national requirements on noise reducing surface layers were defined and experimentally verified. Based on that 2 km trial section was realized paving 3 options of SMA 0/22 mm with 0 % to 50 % RA and overlaid by either BBTM 0/8 mm or SMA 0/8 mm containing between 0 % and 30 % RA. Additionally for these mixtures it was required to have a voids content in the range 9-12 %-vol. Plant produced mixtures were collected during the paving and tested in laboratory. Visual control has been done after two winters to get feedback about the in-situ performance. Laboratory tests included moisture susceptibility, rutting, stiffness, frost cracking testing and for some mixtures even fatigue testing.

Porous asphalt layers as noise reducing and drainable pavements

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Abstract:

The use of porous asphalt (PA) provides various advantages due to the high air voids content and the large permeability; however, PA can also pose some disadvantages, such as reduced performance, maintenance problems and limited structural contribution. Reduced performance of PA mixtures is associated with reduced durability and functionality (i.e., drainability and noise reduction effectiveness), due to raveling and clogging, respectively. In addition, for pavement structure design, PA mixtures are typically considered to have limited structural contribution. Three types of bitumen were used in this study to construct porous asphalt pavements to evaluate their long-term performance as follows: non-modified bitumen (NM), polymer-modified bitumen (PM), and highly-modified bitumen (HM). Test results indicated that a reduction in air voids inside the pavement resulted from clogging and densification. Decreases in air voids were primarily caused by traffic compaction for the NM section, while less in amount for the HM and PM sections. The reduction in noise levels was found to be positively related to the air voids inside PA. PA layers maintained adequate functional characteristics even after they were partially clogged and condensed. The long-term functionality of PA surfaces could be properly maintained. Satisfactory performance on drainability has been observed on the three test sections since they opened to traffic in 2009. PA pavements are shown to be a durable surface on high-speed, heavy-trafficked highways since they could reduce tire–pavement noise and avoid hydroplaning in the long run.

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Development of High-Performance Asphalt Mixes

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Colas Hungaria Zrt.

Abstract:

The purpose of our research is to develop a high-performance, long-life asphalt mix by adding hydrated lime. Nowadays the average lifetime of asphalt surfaces varies between 10 to 15 years, which can be extended if the asphalt contains hydrated lime. During our research process we designed 10 different asphalt mixes, each with different hydrated lime doses (0-10-15-20-25-30% hydrated lime/limestone filler) and tested the following properties: • Water sensitivity according to EN 12697-12 • Wheel tracking resistance according to EN 12697-22 with small wheel equipment in air • Fatigue resistance according to EN 12697-24, two-point bending test with trapezoidal specimens • Stiffness modulus according to EN 12697-26, IT-CY test • Low temperature cracking properties according to EN12697-46, TSRST test After evaluating the laboratory tests, we selected the best properties and the respective hydrated lime dosage ratio for the each mix type. With ALIZE software we modelled different pavement solutions focusing on mechanical parameters and could detect the beneficial effect of hydrated lime on the mixtures compared to reference (without hydrated lime). Finally, we chose an SMA 11 mF 25-55 / 65 and an AC 22 binding mNM 10-40 / 65 mix to construct a trial section on an internal roadway of an asphalt-mixing plant, so that we could monitor the exact traffic load on the pavement structure. The trial section is divided into two parts: one built with a hydrated lime mix and one without. Dynamic sensors (strain gages) are inserted into and between the asphalt layers and linked by data logger units to test the pavement structure's longitudinal behaviour. Our research, started in 2017, finishes with building the trial section in 2018. Our presentation shows the related laboratory test results, the layout of the pavement structure, the construction of the trial section and the first results of its behaviour.

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Chemically functionalized graphene as an additive in bituminous mixtures

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BECSA

Abstract:

Graphene is currently the epicenter of several researches and studies in various development fields due to its mechanical capabilities specifically its high hardness and strength, tenacity, its specific surface and resilience that it possesses. Thereby, in addition with its increasingly lower cost, it has been elevated to the category of material of the future. These characteristics, and the chemical parallelisms that it presents with some molecular structures present in asphalt bitumen, make it a susceptible material to be integrated into bituminous mixtures in the search for new interactions that improve the physical-mechanical properties. The aim of this research is to be able to translate some of graphene's mechanical properties to asphalt mixtures through chemical functionalization. Numerous graphene formulations have been studied and optimized for integration into asphalts, measuring their compatibility and variations in mechanical behaviours. Resilience, tenacity and ductility were tested with a particular traction test developed by UPC (Universidad Politècnica Cataluña) before and after aging processes. Finally, one of the tested solutions has been applied to improve the characteristics of warm mix asphalt manufactured with bitumen foam, taking advantage of its benefits regarding to enhance the resistance to residual moisture effects.

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Full (100%) use of RAP in new HMA - possibilities and innovative evaluation process of rejuvenation effectiveness

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Abstract:

Nowadays, use of RAP (reclaimed asphalt pavement) in new HMA (hot mix asphalt) is the most important kind of its use. According to current knowledge the content of RAP in HMA depends on the properties of asphalt binder in RAP. The paper contains laboratory tests results of efficiency of RAP rejuvenation with chosen chemical substances focused on required properties of HMA. The results show that restoration of properties of aged asphalt binder may lead to full (100%) use of RAP in new HMA. The paper also contains proposal of rejuvenation effectiveness based on stiffness results analyzes.

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Thermomechanical behaviour of interfaces between pavement layers made in bituminous mixtures

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Abstract:

The strain and stress fields within the pavement depend strongly on interfaces behaviour. Therefore, the properties of interfaces between bituminous mixtures layers should be a major concern when designing pavements. The usual but inaccurate assumptions of layers being perfectly bonded or completely unbonded can lead to premature degradation of the pavement. A better knowledge of interfaces behaviour is a first step towards more efficient design methods. In this paper, the thermomechanical behaviour of different interfaces was studied using the new and innovative 2T3C Hollow Cylinder Apparatus (2T3C HCA). The samples (13 cm height, 17.2 cm external diameter and 12.2 cm internal diameter) are composed of two bituminous mixtures layers bonded at the interface with a tack coat. They can be cored in situ or from laboratory prepared slabs. Shear and tension/compression can be applied independently on the samples. Strain in the bituminous mixtures and displacement gap at the interface are obtained using 3D Digital Image Correlation. The linear viscoelastic behaviour of bituminous mixtures as well as the one of the interface could be determined. They have been studied from small strain cyclic tests at multiple frequencies and temperatures. The complex modulus of the two bituminous mixtures and the complex interface modulus are obtained in tension/compression and shear modes. The monotonic shear failure of interfaces has also been studied with different normal pressures.

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Testing of a porous asphalt with a modified composition

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Federal Highway Research Institute (BASt)

Abstract:

Within the framework of the project, a modified mixture of Porous Asphalt (PA) was to be tested on the new Demonstration, Investigation and Reference Area (duraBASt) of the German Federal Highway Research Institute. The modified asphalt mix concept with a deliberate dosage of 5 % fine aggregates ($\leq 2\text{mm}$, hereinafter referred to as "sand") could probably reduce problems such as insufficient structural service life and process safety. The aim of the project was to test the targeted production (dosage of sand) and the behaviour of the optimised asphalt mix during paving and to record and analyse the resulting properties of the finished layer. Two different asphalt mix compositions, reference mix according to technical regulations and mix with modification, with a maximum aggregate size of 8 mm were applied under industrial conditions in two layer thicknesses (4.5 cm and 5.5 cm) each. After installation in October 2017, a relatively extensive test programme was carried out, the results of which can be summarised as follows: - The PA variant optimised by sand addition can be produced on an industrial scale. - The properties of the finished layer show that the void content of the sand variant is about 2 % lower by volume. - The resistance to scuffing on laboratory samples, as well as the particle loss show a more favourable behaviour of the variant with sand addition. - An assessment of the acoustic properties leads to the conclusion that a good level of noise reduction would be achieved in the new condition of the porous layer. In conclusion a higher structural service life can be predicted for porous asphalt wearing courses with a defined dosage of sand. These findings are supplemented by good acoustic properties when new. The acoustic service life could not be predicted within the period under investigation.

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Test methods for bituminous mixtures – Challenges and the way to success in standardization work

Kenneth Lind

Swedish Transport Administration

Abstract:

The purpose with the presentation is to provide information of the ongoing standardization work on test methods for Bituminous mixtures within CEN/TC 227 and to increase the understanding of the factors that affect progress and final quality of developed test methods. Summary of the intended presentation: - Initial description of the comprehensive work on revision and development of test methods within TG2 Test Methods in CEN/TC227-WG1 - The importance of synchronizing with other testmethods and product standards in order to avoid conflicts - The importance of liason with manufacturers of equipment in order to set relevant requirements on accuracy etc - Pro-active work with Round robins in Europe in order to update precision data for increased reliability of test results - The way from TR-TS to a perfect EN-standard - The way to correction of a test method when it went wrong - How to keep track on standards to avoid stalled operation - Tips from the coach on how to write comments and suggestions with proper justification to gain support and enable efficient handling of comments - Conclusion and future challenges

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Determining the effect of additives on hot mix asphalt performance through the testing of recovered composite mastic

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Abstract:

As more and more recycled materials and additives are used in the manufacturing of hot mix asphalt (HMA), it has become rather meaningless to test bitumen sampled from the supply tank in the asphalt plant. Reclaimed Asphalt Pavement (RAP), Re-refined Engine Oil Bottoms (REOB), Ground Tire Rubber (GTR), Styrene-Butadiene (SB, SBS) polymer, and Polyphosphoric Acid (PPA) are materials commonly added to the HMA at various points during production. A standard method to determine their effect on HMA performance has been to extract and recover the binder for testing. This involves the use of solvents that may be hazardous to health and safety, and the process is generally speaking time consuming and laborious. The quality of extracted binder is also not guaranteed since solvent or filler may be left at the end of the process, or material such as polymer gel or rubber particulates may not pass through the filter feeding the rotary evaporator. Such issues have prevented the widespread use of extraction and recovery. A new method to determine the effects of additives on asphalt performance is proposed in this paper. A small quantity of mastic is separated from the mixture using a safe, fast and reliable physical process, without the use of any solvent. The material is called a composite mastic since it is comprised of all the components of the HMA except for the fine and coarse aggregates. Three tests are developed on a Dynamic Shear Rheometer (DSR) to test the composite mastic specimen to determine high, intermediate and low temperature properties. The high and low temperature properties provide the Performance Grade (PG) of the mixture and the intermediate temperature property is a newly developed fatigue index. It is shown that the method can determine the effect of additives on high and low temperature PG, and fatigue performance.

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Study of the water sensibility of asphalt mixtures

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Abstract:

Currently there are two European test methods for water sensitivity of asphalt mixtures at medium and high temperatures, but a respective correlation between them has not been established yet. There is not test method for water resistance of asphalt mixtures at low temperature. There are some evidences in scientific publications that both the chemical composition and low temperature properties of the binder are very important for the water resistance of asphalt mixtures. The low service temperatures are critical for the water resistance performance of the asphalt mixtures. Bitumen with different acid numbers and bitumen modified with organic and inorganic additives have been studied. The low temperature properties have been examined according to Fraass breaking point and BBR test methods. The binders were aged both short term according EN 12607-1 and long term according EN 14771. The acid number of all binders has been tested before and after short and long term aging according to CEN TC336, Working Group 2 Doc Number: N107-A1e. The water sensitivity of asphalt mixtures prepared with the above described bitumen, has been tested according to EN 12697-12, both at medium and low temperatures, before and after exposure at short and long term aging according to procedures, proposed in "Selection of Laboratory Aging Procedures for Asphalt – Aggregate Mixtures" by C. A. Bell, Y. AbWahab, M.E.Cristi, D. Sosnovske from Oregon State University. It was made an attempt to be defined the water sensitivity of asphalt mixtures prepared with bitumen with different acid numbers and different low temperature properties.

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New perspectives for mastic asphalt with paraffinic bitumen

DECAMPS Jacques-Antoine, LEBARBE Thomas, GIANETTI Thomas, DELFOSSE Frédéric
EUROVIA Management

Abstract:

Mastic asphalt is a dense mixture consisting of coarse aggregate, sand, and high amounts of fillers (generally limestone) and bitumen. The binder content is so adjusted that the voids are completely filled and that even a slight excess of binder may occur. The specific mix design of mastic asphalt makes it suitable for numerous fields of application (buildings, bridges, pavements, paths, railway platforms ...). Mastic asphalt is pourable and able to be laid, normally in one coat, at a temperature between 175°C and 230°C with no compaction required on site. Since the application of REACH regulation to bitumen on the 1st of December 2010, European companies had to move to industrial solutions allowing the production and the laying of mastic asphalts under the temperature of 200°C. In this context, companies developed a range of mastic asphalt products in accordance to these new specifications. However, in order to satisfy laying temperature specifications, most of mastic asphalt production in France and in Europe is dependent on naphthenic bitumen because of its particular chemical composition. The consequences of this dependency are multiple for mastic asphalt producers: higher price of naphthenic bitumen in Western Europe, limited choice in source of supply, high environmental impact due to bitumen transport, ... The aim of the presentation is to detail a new additive which allows all paraffinic bitumen to be used in mastic asphalt applications without any compromise in cost, health/safety profile, performances and production methods compared to the reference solution with naphthenic bitumen. By using this additive, mastic asphalt application can be performed at temperature lower than 200°C whatever the bitumen origin due to the great workability that brings this new additive to the formulated mastic asphalt. The technical performances and the implementation of this additive in France will be detailed in this presentation.

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Advantages of non-destructive method in stripping evaluation

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Abstract:

Moisture damage, cracking, and deformation are the three chief distresses caused by traffic and climate during the service life of an asphalt pavement. Stripping phenomenon is one of the moisture damage mechanism, defined as the loss of bond between bitumen and aggregate. A time-lapse image analysis method was used to characterize the dynamic stripping of bitumen droplets on the surface of highly polished mineral aggregates. In a framework of a partnership between IFSTTAR, EUROVIA and INGEVITY, this study examines the influence of aggregates mineralogy on stripping resistance. In another hand, the loss of dynamic modulus with immersion time is evaluated using lab-made, lab-compacted, dense-graded paving mixtures. The results of the dynamic wetting analyses are compared to the results from modulus evolution in time and AASHTO T-283 results. Loss of performances are observed in both destructive and non-destructive test, but mechanism degradation are identified as different. Keywords: Bitumen, stripping resistance, asphalt mixture Preference for an oral presentation

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Comparative test on the new uniaxial cyclic compression test for mastic asphalt

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Abstract:

A new version of the test method for the determination of the resistance of bituminous mixtures to permanent deformation by cyclic compression tests was published by the European Committee for Standardization in 2016. The standard EN 12697-25:2016 contains a new variant of the uniaxial cyclic compression test with confinement specifically developed for mastic asphalt. The new test method provides a cyclic haversine pulse loading with rest period and is required in addition to the indentation test for all mastic asphalts with maximum indentation values equal to or less than 2,5 mm if measured by EN 12697-20. Although there exists already experience with not standardized predecessor methods of the uniaxial cyclic compression test for mastic asphalt, there is still need for analyzing the new standardized method in an interlaboratory test. For this reason, the Belgian Road Research Centre organized a comparative test in order to gain a better understanding of the new test method. Three representative mastic asphalts of different composition were tested according to the new uniaxial cyclic compression method. The tests were carried out in two laboratories, one in Belgium and one in Switzerland. In connection with the comparison of the results, the study gives a good indication of the repeatability of the new test method determined during the comparative test. The study also pursues the question whether it is possible to distinguish mastic asphalts of different composition from each other and if a detection of aberrant test specimens is possible. The comparative test looks as well at the question of whether different sizes of mastic asphalt slabs used for the preparation of the test specimens have an impact on the test results.

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The impact of VAPro ageing on material characteristics and calculated life time of a surface course asphalt mixture

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Abstract:

Ageing of bitumen leads to increased stiffness and brittleness. Thus, the ageing behavior of bitumen has a large impact on the fatigue behavior and the durability of asphalt pavements. To assess ageing of bitumen in the laboratory RTFOT is the standard for short-term-ageing and with additional PAV for long-term-ageing. In the last decades more and more methods have been developed to study the ageing of asphalt mixtures. The paper presents the results of a joint research project using the Viennese Ageing Procedure (VAPro) for ageing a surface course asphalt mix. Aim of the project is to validate the VAPro with regard to the in-situ ageing. Studying a 19 years old test track and the samples taken there after different exposure time, offers the possibility to validate the VAPro ageing. Additionally, it was determined that only the top 1 cm of the surface course suffers considerably ageing. All these findings are combined with the results of the laboratory tests. This paper focuses on the impact of VAPro on the fatigue and stiffness performance determined using the CY-IT at three different stages – (1) unaged test specimen (2) 72 hours VAPro aged and (3) 144 hours VAPro aged. It is a well-known fact that fatigue and stiffness characteristics have a major influence on the pavement performance. Thus, the described investigations concerning the material characteristics are completed with pavement design life calculations concerning top down cracking due to fatigue of the asphalt surface course mixture. The calculations cover different settings concerning the layer bond and the fact that only the upper part of the surface course layer will sustain changes of the material characteristics due to ageing.

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Asphalt concrete stiffness prediction model

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Abstract:

Boskalis Nederland is currently taking the first steps in the introduction of end result (functional) verification of asphalt pavements in The Netherlands. Nowadays the quality control of delivered works is based on non-functional properties, like aggregate gradation, void content and level of compaction. However, fundamental properties are the basis for pavement design. Fundamental tests are more time-consuming and due to the fact that asphalt properties develop over time, the tests can only be performed five to eight weeks after production. A model for estimating the fundamental properties is required for a quick first evaluation of the quality of a constructed pavement. Fundamental tests, the second phase, will only be performed if the model rejects the work in the first phase. In this research only the prediction of asphalt stiffness is considered. Eight existing asphalt concrete stiffness prediction models are investigated and a new database was set up. This database consists of data of seven asphalt concrete mixes including mixes with RAP and polymer modified binders. In total 46 candidate predictive parameters are determined. It can be concluded that the binder stiffness, the penetration value, the volume fractions, coefficient of uniformity and the maximum aggregate size are preferred in a new model. Subsequently, the existing models are all applied on the Boskalis database. A new model has been created which is preferred for its accuracy, simplicity and the significance and theoretical value of the predictive parameters. The relevant predictive parameters are the binder stiffness, and the void and aggregates fractions. 90% of the predictions deviate less than 10% from the measurements. The conclusion can be drawn that a multiple linear regression model is simple and accurate compared to existing (un)fitted models. Key words: prediction model, stiffness modulus, mechanical properties, asphalt, end result verification, quality control

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Impact of Asphalt Plant Silo Storage to Enhance Blending between RAP & Virgin Binders in Hot Mix Asphalt

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Abstract:

Recycled Asphalt Pavement (RAP) is used in manufacturing of new asphalt mix due to economic and sustainability incentives. A 2016 industry survey indicated an average increase in RAP content of new asphalt mixes from 15 to 20% in North America. The RAP content in newly manufactured mix depends on the mix design and asphalt mix plant capability. Increased RAP content necessitates better understanding of blending between aged and virgin binder. This understanding helps to develop and implement best practices in asphalt plant to ensure maximum blending between binders is achieved. Proper blending between binders impacts cohesion of binder and adhesion to aggregates. The quality of blending ultimately is reflected in hot mix asphalt (HMA) performance in the field. Plant produced HMA samples containing RAP between 15 and 40%, were sampled from storage silo at different storage times ranging between 0-24 hours. Data indicate that silo storage can help diffusion between binders to progress faster towards completion. It was demonstrated that improved binder blending in plant-produced lab-compacted HMA samples results in reduced rutting depths, improved binder-aggregate adhesion, and resistance to fatigue and low temperature cracking. Trends in evolution of asphalt mix dynamic modulus mastercurves also indicate that there is an optimum time during which diffusion is the dominant process helping to maximize blending and thus improving HMA properties. Beyond this optimum time, binder oxidative aging becomes a dominant process and mix properties start to deteriorate.

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End result verification for performance based project delivery

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Abstract:

With the introduction of the European Standards for asphalt in 2008 the Netherlands has chosen the fundamental approach for the specification of properties of asphalt concrete. In this approach the mechanical properties of the asphalt are determined by laboratory type testing; a standard set of fundamental asphalt tests. The results are declared on the Declaration of Performance of the asphalt and are direct input for pavement design calculations. A major disadvantage of the fundamental approach, however, is that the responsibility of the asphalt producer for the specified mechanical properties ends at the gate of the asphalt plant. This is in full contradiction with the common knowledge that asphalt concrete only develops its mechanical properties in practice after transport, application and compaction. Nowadays quality control of a finished asphalt pavement is still based on the evaluation of only empirical properties which might have worked in the past for the very limited types of asphalt composed of straight run bitumen, but do not suffice any more in the current practice with different types of bitumen production, polymer modifications and the large scale introduction of additives and bioproducts. Since 2014 the Dutch contractor Boskalis started working on a new framework for performance based evaluation of constructed pavements. This framework is based on the use of fundamental asphalt tests as is done for the determination of the performance based mix specifications for CE marking. One of the most important boundary conditions is that all tests within this framework can be performed on asphalt cores and a direct comparison of the mechanical properties of the type test and the constructed asphalt can be done. For the comparison of the fatigue behavior a dissipated energy based analysis method was developed. The first results of the practical use of this framework are presented in this paper.

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Life optimisation tool for porous asphalt using multiscale modelling

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Abstract:

With the objective of extending the service life of an porous asphalt mixture, an FE modelling approach was developed to predict the mechanical response of the mixture at the mesoscale, the scale of the aggregates, calculate the homogenous properties then evaluate the performance of the asphalt under a cyclic loading. This project is divided into 3 phases and this paper presents the results of the second phase. In the first phase, samples of asphalt mixture were scanned and a 3D realistic model was created. The model accounts for the visco-elastic response of the mortar, the adhesive zone between the aggregates and the mortar and the detailed geometry of the aggregates. The realistic model was used to characterise the asphalt mixture and identify the relevant parameters to include in the predictive model. In the second phase, a new model based on a representative volume element (RVE) has been developed. The model idealises the asphalt mixture but still accounts for the geometrical characteristics of the aggregates and the mortar. A Python script was written to automatically create the geometry and generate the mesh. The FE-RVE plug-in can then be used to calculate the homogenised properties. This allows for multiple iterations over various types of mixture in order to design a specific asphalt for each application. Finally, in the last phase of the project, a macromodel of the asphalt with multiple layers will be created using the properties obtained from the RVE model. The life of the asphalt under a representative cyclic load will be estimated using an energy based approach.

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EVALUATION OF COLD MIX ASPHALTS AND ADDITIVES, APPLIED IN TURKEY, DEVELOPING OF THE SPECIFICATIONS THAT CONCERN MANUFACTURING, USAGE AND QUALITY CONTROL

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Abstract:

The choice of materials used in bituminous layer significantly affects road construction and usage that is service ability. Despite the improvements in construction techniques and material properties, because of increasing number of vehicles and environmental impacts, structural or non structural deterioration or local collapse and pits may occur on the highways. We can sort reason of occurring pits in generally due to wrong construction techniques, missing quality controls, not enough quality of materials used, excess moisture in the pavements granular layers, freeze dissolution effect, insufficiency of traffic and pavement layers. Generally, small amounts of hot mix asphalt (HMA) are needed for the repair of this type of deterioration that occurs locally. Production after deterioration may not be economically or not always technically applicable. It is also impossible to produce and store HMA before the deterioration. For this reason, it is preferred cold mix asphalt which allows production and pre-storable and can be used if needed. But in Turkey there is no standard or sufficient technical specification for the composition and properties of these materials and the performance expected from the mixtures except for user catalogs and specifications of the companies that produce or market the cold asphalt mix and additives. In this study, it is aimed to determine components, definition of physical properties (bitumen, aggregate, additive properties, etc.), determination of storing lifetime, classification, performance measurements, technical and administrative specifications applicable to Turkey and specifications for implementation of cold asphalt mixtures that used for patch in HMA. For this reason, firstly, chemical analyzes of the cold patch additives were made and after this development of the application specification will be made and the necessary tests will be carried out in order to determine performances of the cold mix.

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Evaluation of test methods for measuring adhesion between asphalt pavement layers according to NLT-382 (EN 12697-48)

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Abstract:

Within the context of Spanish and European specifications, the need to perform the adhesion test between asphalt pavement layers according to NLT-382 standard is established, to verify that the shear strength exceeds the minimum values of said specifications. It is therefore of great importance to deepen the knowledge of this test, which allows the use of two different devices (A and B). In addition, the European standard EN 12697-48 is being revised to evaluate the adhesion between layers, in which different alternative methods are proposed to evaluate this parameter, among which are the equivalent to NLT-382 with device A, and the inclusion of device B is being evaluated. The objectives of this work are, evaluate the differences between the results obtained with the devices included in the NLT-382 standard, estimate the accuracy of the test and analyze, with cores extracted from recently constructed pavements, how the different tack coat dosages and mixture types used influence the adhesion values. In this paper, it is showed the results (on 2000 testing specimens) of the intercomparing exercise with the device B to obtain accurate data for this test. The results obtained with both devices have been compared on laboratory manufactured specimens and cores extracted from constructed pavements, obtaining higher results when tested with the device A. An evaluation of the accuracy of both methods has been made, obtaining smaller dispersions with the device B than the device A. The precision in the determination of other parameters of the test, deformation at maximum load and energy of deformation, presents worse values (greater dispersions) than the resistance to permanent deformation shear stress, with both devices. Likewise, with all the results obtained, we intend to model, by means of the finite elements method, the adhesion values between different layers of asphalt pavements.

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Optimization of bitumen emulsions to achieve the best possible bond of layers

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Abstract:

Generally, an asphalt pavement consists of different asphalt and unbound layers. The bond between two superposed asphalt layers is realized by a wide range of varied types of bitumen emulsions, which are applied over the entire layer surface. However, only little information is available on bitumen emulsions, which guarantee particularly good long-term behavior of the layer bond. The paper presents selected results of a research focused on the increase of the shear stiffness respectively on the permanent layer bond through the use of specially developed bitumen emulsions / mortar in the interface of two asphalt layers. The main objective of the project is the development of a particularly durable bitumen emulsion. This emulsion is intended to ensure an improved bonding effect in the context of road maintenance between already existing asphalt base layers and new asphalt binder layers to be realized, especially on critical surfaces (e.g. milled surfaces). To achieve this goal dynamic shear tests were conducted on asphalt specimens bonded with different emulsions by using a newly developed testing device. Therefore, in particular a temperature range as wide as possible was considered, combined with varying the test frequencies and normal stresses applied to the test specimens. Based on the results of the dynamic shear tests bitumen emulsions especially suitable for an application in practice were selected. The investigation and comparison of these selected materials are presented and discussed in the corresponding contribution. The discussion includes design life calculations involving a special developed model describing the tested layer bond.

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Long lasting asphalt pavements with polymer modified bitumens

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Abstract:

Over the years there has been increased interest in using polymer modified bitumens (PMBs) to ensure asphalt functional performance and long-term durability or to meet high requirements for certain special applications. To gain knowledge about various aspects of using PMBs (e.g. durability, relevance of lab tests, cost-effectiveness, etc.), between 2003 and 2006, a test road of several sections with PMBs was constructed along with reference conventional sections on the motorway E6 in Sweden. Performance follow up has been carried out regularly since then, and recent field measurements and inspections were made in October 2017. All the test sections were still in a good condition. Field asphalt cores were taken to study long-term performance differences between the different test sections, and the fatigue life of each section was predicted with regards to fatigue damage (bottom-up cracking) caused by traffic loading. It was found that the road base mix with the SBS modified bitumen produced significantly better fatigue cracking resistance. While the conventional reference sections were optimized with a design life of approximately 20 years, the sections with the SBS modified bitumen in the base mixes demonstrated more than 30 years' longer fatigue life, implying that they are long lasting asphalt pavements. Test results indicate that the SBS modified binders perform excellently in terms of rheology and resistance to aging. The high aging resistance of the SBS modified binders was further demonstrated by the stiffness measurement made on asphalt field samples. Furthermore, the different binders were evaluated by delta T_c (LST-LmT, measured by BBR and/or 4 mm DSR), a binder durability parameter which was reported to be associated with the aging-induced surface cracking of an asphalt pavement.

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High-quality reuse of polymer modified Asphalt

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Abstract:

With the increase in the use of polymer modified bitumen (PmB) in new asphalt, the flow of old asphalt which PmB when replacing or renewing this asphalt, also increases. This stream of old asphalt with PmB is usually seen as a permissible "pollution" of the total flow of old asphalt, which is reused in new asphalt mixtures in the usual way. With the increasing amounts of old asphalt with PmB, there is also the possibility of collecting this asphalt granulate in a separate manner. This creates the possibility to reuse this material at the production of new asphalt with PmB. The old PmB then delivers added value in the new PmB modified asphalt, so that a higher-quality reuse is achieved. However, a number of technological challenges arise: Will it be possible to rejuvenated old PmB and bring it to the quality level of a new PmB? Will the mixing action cause a homogeneous blend of the old and the new binder? Does this affect the way of mixing and mixing time? Are outdated PmBs of a different origin and polymer family compatible with new PmBs? Questions that cause technologists all over the world to hesitate to enter this field. Heijmans Infra BV has taken up this challenge together with the Dutch Ministry of Infrastructure and Water Management (Rijkswaterstaat) and TNO, the Netherlands Organisation for applied scientific research. Earlier developed reuse and rejuvenating techniques for Porous Asphalt mixtures with normal bitumen are upgraded for the use of PmB Asphalt. The developed technique was applied at milling material from an old top layer of two-layer Porous Asphalt for use at 40% level in a new top layer. Relevant bitumen and asphalt properties have been intensively studied both fundamentally and functionally. The result gave reason to take serious steps on a practical scale.

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Introduction of epoxy modified bitumen in The Netherlands

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Abstract:

Epoxy modification of bitumen leads to improved binder properties e.g. good fatigue performance, improved adhesion to mineral aggregates and excellent aging resistance. It already exists over 50 years and since then it has successfully been applied on many orthotropic steel bridge decks around the world. After an OECD research program on long life pavements, New Zealand decided to modify their open graded porous asphalt mixtures. Since the first field trial in 2007, more than 700.000 square meters in New Zealand have been paved with porous asphalt containing epoxy modified bitumen. In 2017, Delft University of Technology, province of Noord-Holland and Dura Vermeer started a joint fundamental research program to investigate the possibilities of epoxy modified bitumen in The Netherlands. During this program, extensive laboratory testing on various scales of epoxy modified bituminous materials (i.e., binder, mortar and mixture) has been performed using sophisticated testing tools. In addition, to explore the practical aspects of epoxy modification, Dura Vermeer formed a joint proof-of-concept program with six innovative municipalities to build and monitor trial pavement sections. Experiences are continuously exchanged between the two programs. This paper briefly describes the outcome of the laboratory research and focuses on the trial pavement sections. It reports on the implementation of epoxy modified bitumen from research to its introduction in The Netherlands.

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Filler effects on durability properties of asphalt mortar

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Abstract:

Within asphalt mixtures, the fine and coarse aggregates are bond in asphalt mastic composed of bitumen and aggregate filler. Despite its usually small proportion within the aggregate mixture, the filler takes an important role within the overall asphalt mix performance. Reason for this is the high specific surface of the filler which results in strong effects of bitumen-aggregate interaction onto the overall durability properties of asphalt mixture. As aggregate fillers, usually limestone fillers are used as added fillers. As there are little economic viable applications for mineral fillers, asphalt industry as well as recycling industry is interested in using mineral dust also in asphalt mixtures. Within a research study about the recyclability of mineral fillers reclaimed from sand-lime stone masonry, the applicability in asphalt mixtures was researched. In a first stage, the conventional filler characteristics were assessed. In order to evaluate durability effects of the applied filler, shaking abrasion tests were conducted. The results obtained from filler tests showed, that most of the recycling fillers reach the requirements for mineral fillers for application in asphalt mixtures. However, within shaking abrasion tests, only a few of the tested fillers were found suitable for possible use in asphalt. Whereas the standard filler characteristics are predominately affected by the grading of the fines, the durability property is linked to the individual combination of filler and bitumen. On basis of the results, fillers could be selected for further asphalt mix performance tests.

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Suitability of European ravelling tests to assess the performance of UK thin asphalt surface course systems

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Abstract:

Material loss at the road surface caused by the scuffing action of tyres - commonly termed 'fretting' or 'ravelling' - is a potential cause of defectiveness in surface course materials. Simulations in the laboratory, when used effectively, can lead to more accurate predictions of how materials will perform on the network. This paper presents findings from research designed to assess the suitability of a range of simulative laboratory test methods to predict surface course material loss from Thin Surface Course Systems (TSCS), the predominant bituminous surface course material used in the UK. The research included a critical evaluation of past research conducted in relation to PD 12697-50 Resistance to scuffing, simulative tests on samples of TSCS in the laboratory, and development of a pathway to adoption of this standardised test method for use in relation to materials laid on the Strategic Road Network in England.

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Moisture and frost susceptibility of asphalt mixtures including freeze-thaw cycles in NaCl solution

Tereza Valentová, Jan Valentin, Pavla Vacková

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Abstract:

Durability of asphalt mixtures which is closely connected to their resistance to water immersion is long-termly tested according to ČSN EN 12697-12 by using the qualitative ratio ITSr. To get this ratio part of the test specimen is saturated by water and subsequently stored for 72 hours in water bath at 40 °C. Beside this procedure CTU in Prague collects for many years data with similar water saturation, where the test specimens are subjected to one freezing cycle and subsequently for 24 hours stored in a water bath at 60 °C. At the same time for several years the attention is paid also to the aspect of long-term laboratory ageing of asphalt mixtures. In this case the test specimens before water saturation, freezing and elevated temperature of water bath subjected to thermo-oxidative impacts, which degrades the bituminous binder. To secure the complex study of effects which act in a pavement structure a more extensive runs of cycling test specimens in water-NaCl dilution were executed recently combining the effect of freezing and thawing in such dilution. For this reason a modified procedure of the test described in the annex of ČSN 73 6161 was used, whereas for the overall comparability of different impacts or effects the test specimens in this case were compacted by 2x25 blows like for the tradition water immersion test. Further cycles of different duration were selected in a range of 5 to 25 cycles and the impacts were assessed for asphalt mixtures of various types not only for wearing course, where the simulated impact of freeze-thaw cycles is probably most critical.

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Role of binder-aggregate adhesion and SBS modification on thermomechanical performance of bituminous mixtures

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Abstract:

Bitumen properties strongly influence bituminous mixtures performance. Modifying bitumen with Styrene-Butadiene-Styrene (SBS) polymer is known to alter mixture properties. Adhesion between binder and aggregate probably plays a crucial, yet not fully understood role in bituminous mixtures performance. This work introduces a new method to isolate and understand the role of binder-aggregate adhesion based on molecular silane coating, then compares the influence of SBS binder modification and of binder-aggregate adhesion regarding key performances of bituminous mixtures.

Hot-Mix Asphalts with pure or SBS-modified bitumen were studied, with same aggregate and grading curve. Concerning the mixture with pure bitumen, a copy is made with aggregates submitted to anti-stripping surface treatment prior to mix design. A carbon-chain silane was chosen to enhance aggregate adhesiveness. Surface modification was verified with contact angle method.

Thermomechanical performance of all mixtures were then tested with French Testing Method: Stiffness (2-PB apparatus), Fatigue resistance (2-PB), Water sensitivity (Indirect Tensile Stress Ratio). The surface analysis with contact angle method confirmed a proper molecular coating with silanes. 3% SBS modification of bitumen improved fatigue resistance with only little effects on modulus. Promoting only binder-aggregate adhesion with silane slightly decreased the complex modulus and increased ITSR significantly. Most importantly, it increased the resistance to fatigue of the same level (ϵ_6 increase $\approx 20\mu\text{m/m}$) as 3% SBS modification did.

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The effect of hydrated lime on asphalt mixtures with highly polymer modified bituminous bitumen (HiMA)

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Abstract:

The paper presents the results of research conducted to investigate the effect of hydrated lime on the properties of asphalt mixtures containing highly polymer modified bitumen (HiMA). HiMA is a new type of polymer modified binder and is characterized by reversed-phase of polymer-bitumen blend i.e. polymer phase in the polymer-modified binder becomes continuous phase. The influence of the hydrated lime addition on the functional properties of asphalt mixtures has been known on the basis of literature and field performance, however the combination of hydrated lime with highly modified bitumen does not result such obvious and expected effects. As part of the research project, the following types of asphalt mixtures were tested: SMA 8 (surf), asphalt concrete AC 16 (bin) for binder courses, asphalt concrete AC 22 (base) for base courses. Each of the mixtures was prepared with highly polymer modified bitumen (PMB HiMA). Asphalt mixtures were prepared in two variants. First one was produced with limestone filler, second in which a part of the limestone filler was replaced with hydrated lime. The research program included determination of functional parameters of asphalt mixtures (rutting resistance at 60°C, water and frost resistance ITSR, low-temperature test). On the basis of the analysis of the obtained results, several conclusions concerning optimum binder content, rutting resistance, failure stress in the indirect tensile method, ITSR parameter and TSRST test were created.

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Effects of hydrated lime on the mechanical properties and moisture susceptibility of foamed half-warm mix AC 16 asphalt concrete

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Kielce University of Technology

Abstract:

The article describes laboratory investigations regarding production and performance of half-warm mix (HWMA) AC 16 asphalt concrete mixes with produced with foamed bitumen and incorporating hydrated lime. The experiments were designed to evaluate the influence of the hydrated lime added in partial substitution of limestone dust in the filler on the properties of the asphalt mixes produced at decreased temperatures. The performed laboratory tests included assessment of two reference asphalt mixtures (HMA and HWMA produced at ca. 120°C and compacted at ca. 100°C) and four HWMA mixes with 10% and 30% of limestone dust substituted for hydrated lime and with typical and increased (+0.3%) bitumen content. The mixtures were evaluated based on the air void content in Marshall samples (V_m) indirect tensile strength of dry and freeze-thawed Marshall samples (ITS_{dry}, ITS_{freeze-thaw}), resistance to moisture and frost damage (ITSR) and wheel tracking performance (PRD_{air}, WTS_{air}). Additionally, a multivariate optimization of these properties was utilized to distinguish the best performing mixtures and showcase their features. The adopted methodology allowed to evaluate relationships between the investigated properties of the half-warm mix asphalt concrete and its composition in scope of the mix performance and its projected durability.

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Design of the asphalt mixture using Friction After Polishing parameter

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Abstract:

The paper presents results of the research project which aims to design and test wearing courses containing mixtures of aggregates with different resistance to polishing and improve quality and lifespan of skid resistance properties of pavements built in areas where aggregate resistant against polishing is not available. Within the research project, five different SMA mixtures were produced, each containing a different ratio of aggregate from various sources (basalt and greywacke). The test specimens made of these asphalt mixtures were tested according to EN 12697-49: the laboratory equipment simulates the traffic load and thus allows the prediction of the development of the friction coefficient with time. Based on the results of the laboratory measurements, asphalt mixtures were selected for the production of three test sections in the area of the asphalt plant and one test section on the trafficked road. The paper compares the results of FAP (Friction After Polishing) measured in the laboratory and longitudinal friction coefficient measured on site by the dynamic measuring device. The article also summarizes the possibility of using the aggregate less resistant to polishing, even from recycled material, while keeping required skid resistance, might improve road safety and effectivity of the production of asphalt mixtures for wearing courses.

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Design and Performance Evaluation of Highly-modified Asphalt Concrete

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Abstract:

The use of porous asphalt as surface course is a solution to help address the built environmental issues of both heat island and stormwater management in tropical countries. However, another form of moisture damage has been noted. Water enters the porous pavement and can become trapped between two layers. The asphalt pavements would fail as a consequence of traffic loading creating high hydraulic pressure gradients and movement of trapped water. A suitable binder course material is the highly-modified asphalt mixture conforming to the Taiwanese specification. The highly-modified asphalt concrete is being developed and is designed in terms of the pavement performance-related requirements. The objective of this study is to investigate the rheological properties of the polymer modified and conventional petroleum asphalt binders, and to assess the performance characteristics of the corresponding asphalt mixtures. The laboratory results show that the highly-modified bitumen (HMB) was less susceptible to temperature due to the highly polymeric modification effect in terms of the G^* master curve. The HMB also possessed better delayed elastic response and had better rutting characteristic based on the MSCR test results. The performance-related characteristics of the asphalt mixtures could be well interpreted by means of the DSR master curves of the bituminous binders over a wide range of the temperatures. With regard to the wheel track testing, the highly-modified asphalt mixture with gap gradation generally had better resistance to rutting compared to the other asphalt concrete types based on the rut depth and mixture viscosity. In addition, the Burgers model was used to fit the rutting data and satisfactorily explained the durability of the asphalt mixtures. The asphalt mixture containing steel slag appeared to have better long-term rutting resistance in terms of the prediction obtained from the model.

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Use of PmB's for road recycling: a case study in France highways

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Abstract:

Due to economic and environmental considerations, the use of Reclaimed Asphalt Pavement (RAP) is growing more and more in developed countries. In France, traditional percentage of RAP is around 20% with an increasing tendency. Depending on RAP characteristics and asphalt mix formulation, high RAP content formulation can present poor performance of the mix at low temperature/winter conditions. One challenge is to add the appropriate binder in order to maintain performance of the asphalt mix at low temperature. There are different approaches to recycling, in the present work, the impact of binder's nature is studied in the case of 50% RAP content mixtures. Four types of mixes have been studied, two with standard bitumen (35/50 and 50/70 grade) and two with polymer modified binders. All binders and mixes properties have been characterized at initial state and after ageing steps both in the lab and in field. Binder characterization included empirical testing such as penetration, Ring & Ball, FRAASS breaking point and rheological properties obtained with DSR and BBR. Then, those results are correlated to TSRST results obtained on asphalt mixes. This study demonstrates that simple consideration such as penetration, Ring & Ball and FRAASS are not sufficient to select the right solution with high RAP content mixes. It also shows the benefits of using PmB's instead of soft base binder to maintain a high level of performances.

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Superpave5: Enhanced pavement durability achieved by changes to design and construction

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Abstract:

Throughout most of the world the Marshall method is used to design asphalt mixes. Since the method was developed in the early 1940s, design air voids have been set around four percent (three to five percent). After compaction on the roadway, in-place air voids have been most often targeted to be seven to eight percent. When Superpave was developed in the early 1990s this practice was carried forward. AASHTO specifications for Superpave design call for four percent air voids. Most state DOT specifications target seven to nine percent air voids after compaction on the road. Superpave5 is an adjustment to the mix design system in which the design air void level is five percent. Asphalt content and aggregate requirements remain the same. To develop Superpave5 laboratory design compaction was changed based on engineering properties of in-place Superpave asphalt mixtures. In Superpave5 roadway compaction calls for air voids to be five percent. The main benefit is believed to be a reduced rate of asphalt binder aging that forestalls the occurrence of cracking and extends pavement life. This paper summarizes research that led to changes to the Superpave system. Results of three trial sections are presented and a performance evaluation of the first section at age five years is included. The trials show that Superpave5 mixtures can be compacted to five percent air voids on the road. The performance review shows the effect of lower in-place air voids on aging of the asphalt binder after five years in service and the reduction in crack formation. As well, other performance indicators (ride, rutting) show similar performance to regular Superpave.

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Determining the moisture susceptibility of asphalt reinforced using banana fibre

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Abstract:

The aim of the study is to evaluate the performance of asphalt against moisture with banana fibre addition. Superpave gyratory compactor is used for compaction of samples. Banana fibre was added to the asphalt at 0.25%, 0.5% and 0.75% ratios by wt. The optimum bitumen content was determined for each ratio in accordance with Superpave volumetric design. Indirect tensile strength test was conducted. Moisture sensitivity was evaluated according to Modified Lottman test procedure. According to the results, the asphalt containing 0.25% banana fibre has ensured the limit values and can be used.

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EVALUATION OF PERFORMANCE PROPERTIES OF ASPHALT MIXTURES USING NANO-ORGANOSILANE ADDITIVE

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Abstract:

In this study, the performance of zycotherm- a liquid, nano-organosilane anti stripping additive- on the tensile strength and rutting resistance of asphalt concrete was investigated. To carry out the study, a detailed experimental program was scheduled including, indirect tensile strength test and Hamburg wheel-track test, to evaluate the tensile strength and rutting resistance of the mixtures respectively. The mixture designs were performed using the standard Marshall mixture design methodology for two types of aggregate and with/without chemical additive. Optimum bitumen contents for four different mixture types were determined for the design air void of 4%. The test results showed that, the use of anti-stripping additive, increased the IDT strength of the mixtures by up to 24.7%. In terms of rutting performance, the specimens having nano-organosilane additive, yielded smaller rutting than their control mixtures up to 11.6%.

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Laboratory and site validation of a regeneration oil for recycled asphalt mixtures

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Nynas UK AB

Abstract:

The addition of Recycled Asphalt (RA) into asphalt mixtures has been common practice for many years. This can be both environmentally and commercially desirable if managed properly and care is taken to ensure the subsequent asphalt mixture remains compliant with prevailing performance specifications. With additions of up to 10% RA little is required in amendments to production procedures to ensure full compliance. However, the current trend of increased RA content mixtures requires more careful consideration of both the constituent materials and the asphalt production method. To manufacture asphalt mixtures with RA contents above 20% the addition of a soft bitumen may be sufficient to maintain performance. However, at increased RA levels or for mixtures targeting a softer penetration grade based asphalt an alternative approach of using a regeneration oil is necessary. A wide range of materials are available which may be employed as a regenerating agent for RA mixtures. However, to produce a finished asphalt with equivalent short and long term performance to a virgin asphalt mixture far fewer suitable materials are available. Nynas technical centres in Belgium, Finland, Sweden and UK, working in cooperation with their customers throughout Europe, identified a non-hazardous hydrocarbon regeneration oil and this paper details its laboratory and site verification.

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HiMA experiences in cold climate conditions

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Abstract:

Studded tires are commonly used in some countries around the world for improved traction on roads in icy conditions. While they improve traction, the metal studs cause abrasion rutting on both asphalt and concrete pavements. Standard approaches do not show sufficient improvement in heavily-trafficked areas such as the City of Anchorage, Alaska, especially on higher speed roads and highways, where the resultant rutting from studded tire wear is one of the most persistent pavement distresses. In the fall of 2014, the Alaska Department of Transportation and Public Facilities (Alaska DOT&PF) undertook a trial in the City of Anchorage using a novel approach to improved resistance to studded tire wear. The approach was to use a standard mix design with a hard aggregate along with an exceptionally soft, tough asphalt binder with an AASHTO M332 grade of PG 64E-40. In laboratory Prall testing, this new mixture gave less than half the volume loss of a typical good-performing mix. Binder design, mixture testing, construction and performance are discussed. To date, performance has been sufficiently impressive to warrant further projects. A follow up major project resurfaced 25 km of highway from 2016 – 2018 and is performing well. A trial project on the Ring Road around St. Petersburg, Russia is also meeting expectations. To date, projects are showing one third less deformation than previous solutions.

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Determination of bitumen coverage, after the rolling bottle test, by a digital image processing method.

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Abstract:

Pavement durability is often linked with water damage either through ravelling or loss of integrity. A large number of tests exists to address experimentally the water sensitivity and affinity between aggregates and asphalt binders. For example, EN 12697-11 combines three standard methods to determine the affinity between aggregates and bituminous binders. This paper focuses on the analysis of bitumen coverage after the rolling bottle test. The aim of this paper is to propose an alternative method to measure the bitumen coverage based on digital image processing techniques. These tests should result in a lower variability between samples, and also ensure a more objective and reproducible test method. In a first part, a number of rolling bottle tests were conducted, using two aggregates and one bitumen. These aggregate-bitumen combinations have been used before in a Rilem round robin test. After these tests, the coverage was measured by a visual inspection as stated in the corresponding norm, and also by a newly developed method, based on digital image processing (DIP). In a second part, photographs obtained from this Rilem SIB TG1 round robin test were used and analysed by DIP. In this part, all the samples from the round robin test were considered, three asphalt binders, two unmodified and a polymer modified binder and four aggregate types with different mineralogy. In the outcome of the round robin test, a large scatter in the absolute results was observed, which could be attributed partly to the visual inspection method. Therefore, digital image processing could provide a better solution in reading the results. In this paper the method is explained and some results obtained from rolling bottle tests are presented. These results look promising, the data show a low variability in the degree of coverage compared to the visual determination.

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Outcomes of RILEM TC 237-SIB on the affinity between aggregates and bituminous binders

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Abstract:

Water damage is one of the key aspects related to pavement durability. It leads to ravelling and loss of integrity especially for asphalt pavements. There are numerous test methods that aim to address this, either with respect to binder, aggregates or the combination of both, as loose or compacted mixture. The RILEM technical committee, TC 237-SIB, focused on testing and characterisation of Sustainable Innovative Bituminous (SIB) materials and systems. Within this TC, Task Group 1, TG1, focused on bituminous binder testing and more specifically on the affinity between aggregates and bituminous binders and test methods. One of the main purposes was to run a Round Robin Test to evaluate the reproducibility and repeatability of these test methods and to give recommendations for improvement. A total of 13 laboratories participated from Europe and North America. This paper summarises the main results comparing, amongst others, the rolling bottle test and boiling water stripping test according to EN 12697-11. Three asphalt binders were selected, two unmodified and one polymer modified binder, along with four aggregate types with different mineralogy. This paper provides the key results on the evaluation of the test methods related to test procedure, measurement and interpretation of the results. The outcomes show that, while some qualitative trends are seen, there is still a large scatter in results both within the same test method and between different test methods. Thus, it is hard to consider these methods as giving essential characteristics for defining the specifications of bituminous materials. This does not come only from visual interpretation. The overall recommendation is to relate the results to qualitative classes.

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Laboratory Investigation of Reacted and Activated Rubber Modified Gap and Dense Graded Asphalt Mixtures

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Abstract:

Various methods have been proposed to address the difficulties involved with the production of rubber modified asphalt mixtures. Reacted and Activated Rubber has been introduced to alleviate the problems associated with the production of rubber modified binders. Dry mixing method can be easily implemented for the addition of this modifier to pug-mill. Although this type of rubber modification has shown promising results with dense graded asphalt mixtures, further investigation may be required to confirm its potential advantages for gap graded asphalt mixtures. The objective of this study is to determine optimum composition of Reacted and Activated Rubber asphalt mixtures based on volumetric properties for dense and gap gradations. Response surface methodology was used in the experimental design process to investigate the simultaneous effect of variations in asphalt content and modifier amount. Furthermore, volumetric properties of asphalt mixtures were supplemented with performance-related characteristics. Permanent deformation, fatigue cracking as well as reflective cracking properties were evaluated and compared to that of unmodified and wet-process rubber modified mixtures

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Improvement of Resistance to Moisture-Induced Damage of Activated Carbon Modified Hot Mix Asphalt Using Hydrated Lime

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Abstract:

Due to the change in traffic and climatic conditions, the traditional bituminous binders are insufficient to resist various deformations in flexible pavements. For this purpose, various additives are used in bitumen or mixture modification. The materials obtained from various biomasses are tried to be used as bitumen additives because of the high cost of commercial additives and also for the utilization of waste materials. Although active carbon obtained from various biomasses have a positive effect on the various performance parameters of bituminous binders and mixtures, they generally affect the against resistance moisture-induced damage negatively. In the study, activated carbon obtained from pulp residue and vinasse was used in bitumen modification in 3 different ratios (5%, 10% and 15%). Mixtures prepared with pure bitumen and modified bitumen were subjected to resistance test against moisture-induced damage in accordance with AASHTO T 283 standard. The results of the experiments showed that the resistance to moisture-induced damage of the mixtures containing activated carbon was lower than the pure mixture. Hydrate lime was added to the mixture as filler (2% by weight of the mixture) in order to eliminate this negativity. Hydrated lime-containing mixtures were tested with the same procedures. The obtained results showed that the resistance to moisture-induced damage increased significantly with the use of hydrated lime as filler in the mixtures prepared with both pure binder and activated carbon modified bitumen.

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Procedure for the evaluation and comparison of the cracking resistance of bituminous mixtures. Characteristic curve. Fénix diagram

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Abstract:

The particularity of the bituminous materials is that their break is ductile and tough. They require a great energy to produce the break since the start (maximum load) until failure. In traditional mechanical tests, only the mechanical response of the material up to maximum load (stiffness modulus or breaking stress) is evaluated and the tenacity of the material is not considered. However, the ductility and tenacity of the mixture are very important in its behaviour and can be estimated in a simple way if the mixture is tested under tensile loading with the Fénix test. The Fénix test is basically a skewed tensile test that gives rise to a slow and controlled crack propagation. It can be carried out at different temperatures, which allows obtaining, in a diagram of stress-displacement - Fénix diagram - the characteristic curve of the mixture. This curve shows the response of a mixture in a wide range of temperatures, indicating when the response is fragile or ductile, not very resistant or very tough. The Fénix diagram makes it possible to differentiate the response of different mixtures and the effect of their composition and the quality of the materials used. It offers an easy and simple methodology for the dosing and design of bituminous mixtures. This paper presents the results obtained after testing different types of bituminous mixtures, AC and BBTM, as well as recycled mixtures with different percentages of RAP.

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Longer lifespan of Porous Asphalt due to the addition of homopolymer Polyacrylonitrile HT fibres

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Abstract:

The Dutch national roads agency Rijkswaterstaat (RWS) is constantly looking for more durable and more cost-effective noise reducing wearing courses for motorways. When more noise reduction is required than single layer Porous Asphalt 16 (PA 16) more and more two-layer Porous Asphalt (TLPA) is applied. Standard TLPA consist of a 25 mm thick PA 8 and a 45 mm PA 16. In order to extend the lifetime of the standard top-layer PA 8, which contains polymer modified bitumen (PmB), test sites were constructed with PA 8 with pen grade 70/100 bitumen and homopolymer high tenacity polyacrylonitrile fibres. From yearly monitoring it appeared that PA 8 with pen grade 70/100 bitumen performed much better than the standard PA 8 with PmB. The expected lifetime is 4 years longer. To find out why the field performance of this alternative PA 8 mixture is much better, lab test were carried out on lab prepared samples and on 6 year old material from core out of the test sites. This research consisted of microscopic investigation on thin slices, DSR (master curves and fatigue resistance) measurements on mortars and numerical calculations. In this paper the results of the lab test are discussed and the results of the monitoring of the investigated test sites are given.