University of Antwerp

TECHNISCHE UNIVERSITÄT WIEN
Vienna | Austria

International Workshop on Research in Road Engineering at TU Wien September 17-18, 2019

Compendium of Abstracts

Research topics and projects @ Road Engineering Research Section of University of Antwerp

Prof. Wim Van den bergh, Research Manager RERS, University of Antwerp

Road Engineering Research Section (RERS) is the academic partner for asphalt and bitumen research in Belgium. Modelling, mechanical experiments and LCA-methodology are combined in order to design sustainable road pavements.
Our mission is to bring our expertise into the design and constructing processes of sustainable roads by the sector. Current research topics are:

- Bitumen & asphalt technology: ageing - healing - bitumen mechanics
- Structural design of smart roads and asphalt pavements
- Challenging recycling & green technologies such as materials management systems for reclaimed asphalt
- Development of solar asphalt constructions
- Noise reducing measures

Current project topics which will be presented for further discussion and future collaboration: a selection of Phd projects, Rejuvebit, ROAD_IT, CyPaTs and the Fibre Bragg Grating technology.

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Investigation of the effect of short-term ageing on rejuvenated reclaimed asphalt binder

Geert Jacobs, Academic Assistant - Phd researcher, University of Antwerp

Because of the deteriorated properties of aged reclaimed asphalt (RA) binder (e.g. increased brittleness), compensation steps should be implemented to achieve a certain level of durability. This compensation can be done by using recycling agents. In the presented study the effect of recycling agents is investigated by exploring their impact in the binder scale before and after applying short term ageing (STA).

Three groups of samples are investigated in this study. The first group are binder blends extracted and recovered from lab-produced asphalt mixtures. The second and third group of binder blends are reproduced in the laboratory, using the same materials and compositions as the first set, before and after rolling thin film oven test (RTFOT) ageing accordingly. Within every group of binder blends, three binders were investigated. The first binder is a virgin penetration grade binder B35/50. The second is a blend with 40% *RAb* and 60% virgin binder. The RAb is an extracted and recovered binder from a RA originating from a Belgian road and has a penetration value of 24dmm. The desired penetration value of the virgin binder B50/70 was theoretically determined, in order to obtain a final blend with a penetration value similar to that of the first blend. The third blend is a blend with 40% RAb, 60% B35/50 and a rejuvenator. The dosage of the rejuvenator was experimentally defined in order to obtain similar penetration values of the final blend.

In the first place, penetration and softening point values are reported. Besides this, rheological properties were determined using the Dynamic Shear Rheometer (DSR). The DSR was used to assess the fatigue resistance of the binders in terms of Linear Amplitude Sweep (LAS) test. The ageing indexes are also investigated in terms of sulfoxides and carbonyls increase using Fourier transform infrared (FTIR) spectroscopy.

The objectives of this study are firstly to evaluate the effect of rejuvenating 40% RA binder in terms of binder properties and fatigue performance and secondly to investigate the effect of ageing on binders derived from lab-produced mixtures by comparing them with the RTFOT-aged binder blends.

The results show that both ageing due to RTFOT and asphalt mixture production result in similar rheological properties for the studied binder. Chemically, the results of the infrared spectroscopy indicate a difference between the two ageing methods, since higher ICO values and lower ISO values are obtained after RTFOT ageing in comparison with the ageing during mixture production. Concerning the influence of the rejuvenator, the conventional (penetration and softening point) and fatigue properties do not indicate any significant changes compared to the non-rejuvenated RAb blend. Chemically, adding rejuvenator led to a decrease in ICO values among the same ageing states. On the other hand, no clear trend was observed concerning the ISO values. Furthermore, the complex modulus displays a slightly higher increase after ageing for the rejuvenated binders.

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https://www.uantwerpen.be/en/research-groups/emib/rejuvebit/ (in Dutch)

ATR-FTIR Microscopy: a novel technique to evaluate the blending on the bituminous coating of Reclaimed Asphalt

Alexandros Margaritis, PhD-researcher, University of Antwerp

The utilization of Reclaimed Asphalt (RA) in the road construction sector induces considerable economic and ecological benefits. The blending of the recycled material with new components is believed to be of great importance for the mixture's properties. An extensive knowledge of the blending of the materials is crucial in optimizing the use of RA, especially at higher recycling rates. In this presentation, the applicability of Fourier Transform Infrared (FTIR) microscopy in Attenuated Total Reflectance (ATR) mode to study the bituminous coating of RA granulates is demonstrated. This method is a promising alternative to trace heterogeneous areas within the coating compared to methods that require extraction and recovery of bitumen. In this study, actual RA granulates were used without the addition of foreign tracers and provided the opportunity to study the spatial distribution of neat bitumen within the mortar scale by means of ATR-FTIR microscopic measurements. This research aims firstly to assess the application of FTIR microscopy directly on actual RA granulates, secondly to fingerprint the different zones of components, and thirdly to trace rejuvenating agents and mobilization of neat bitumen within the coating of the granulates. For the utilization of the FTIR microscope (Lumos by Bruker, Billerica, MA, USA) a certain method for sample preparation and FTIR spectra analysis is proposed, in order to acquire a flat and even sample surface. In order to fulfil this requirement, the RA granulates were embedded in epoxy resin and afterwards the bottom side of the stone-resin sample was polished, at low temperature, until exposure of the sample's cross section. Four different samples were analyzed: a reference RA granulate, two types of RA granulates mixed with neat bitumen, and a RA granulate with rejuvenator. For the investigation of the RA granulates' coating, a procedure was set. First, the area to be measured is selected. Second, the grid of the points to be measured is defined. Third, the measured spectra are preprocessed. Fourth, the integrated typical bands are visualized. The intensity visualization of the bands on the microscopic image is defined as chemical imaging. The processing of the spectra and evaluation of the derived data was done using the Bruker OPUS™ software (v. 7.5). Each sample was analyzed following the proposed steps. The results show that the use of ATR-FTIR microscope allows the tracing of different components, indications of blending, as well as proof of rejuvenation of the aged bituminous area.

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Oxidative ageing of bitumen: behind the scenes

Georgios Pipintakos, Academic Assistant - Phd researcher, University of Antwerp

Among other distress types that affect the service life of bitumen, especially in road applications, oxidation is considered one of the most complex phenomena. The complexity lies in its multi-scale and multi-physics nature.
For the oxidative ageing process two reactions have been proposed. The first, fast-spurt reaction is related to the short-term ageing during bitumen production, whereas the second slow reaction path is responsible for the long-term ageing during the service life of road infrastructure.
Recently, a reaction-diffusion model has been derived in the framework of thermodynamics of irreversible processes (TIP). It manages to bridge between continuum theory and molecular scale. The model is able to account for oxidation mechanisms at molecular scale, with the assistance of activity models. In addition it can distinguish between different bitumen compositions.
An inspection of the potential of the existing model will be presented in short. More specifically, certain aspects of modeling will be discussed using physically meaningful parameters such as molar fractions, molar volumes and solubilties. These fundamental information are obtained via corresponding chemical analysis, e.g., SARA fractionation, FTIR spectrometry. This study finally addresses the effects of oxidation on diffusivity, as well as the results of a sensitivity analysis with regards to the different parameters of the model

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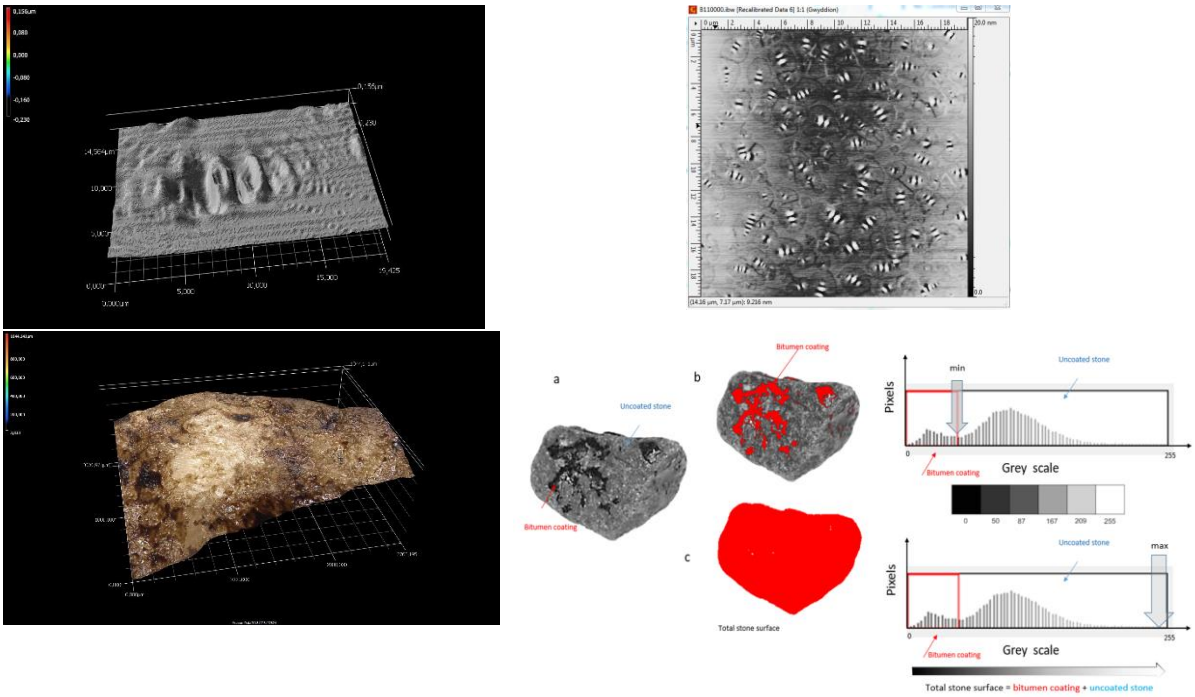
Mining the microscale for macroscale ideas

Dr. Johan Blom, Doctor Assistant – postdoctoral researcher, University of Antwerp

Johan Blom, post-doc at the University of Antwerp, is looking for answers for the behaviour of bitumen in the material's microscale structure and composition.We have to study the microscale in order to solve problems in the macroscale. Our aim is to find the innermost secrets of bitumen. Current methods, involving the titration of bitumen residues found on stones in recycled asphalt, are more limited in scope and detail than the novel alternatives based on optical recognition. An example is the new optical detection method developed for studying the affinity of bitumen on asphalt stones. This will allow us to build a better picture of how and why bitumen binds to the stones, which in the end will help us to improve the performance of bitumen and asphalt. At the moment, the influence on bitumen of oxidation, UV and water is like a 'black box' area, but the latest analysis methods for, for instance, AFM and TOF-SIMS are now providing nanoscale information for several important research areas. One such hot research topic concerns the propagation of wax in so called bee structures, and the effects these have on the overall performance of the bitumen, and I believe this might hold the key to a better understanding of fatigue in bitumen with implications for improved future recycling methods.



Investigation of the bulk and surface microstructure of bitumen by atomic force microscopy
Blom Johan, Soenen Hilde, Katsiki Antigoni, Van den Brande Niko, Rahier Hubert, Van den bergh Wim, Construction and building materials - ISSN 0950-0618 - 177(2018), p. 158-169 ,Full text (DOI uitgever): https://doi.org/10.1016/J.CONBUILDMAT.2018.05.062

Determination of bitumen stone coverage by digital image processing
Blom Johan, Soenen Hilde, De Boeck B.,Bituminous Mixtures and Pavements VII: Proceedings of the 7th International Conference 'Bituminous Mixtures and Pavements' (7ICONFBMP), June 12-14, 2019, Thessaloniki, Greece / Nikolaides, A.F. [edit.] - ISBN 978-1-138-48028-5 - CRC Press, 2019, p. 172-177

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Current Research Topics in the Lab of Road Materials, TU Wien

Prof. Bernhard Hofko, Head of the Lab for Road Materials, TU Wien

The presentation gives an overview of the approach taken to increase our understanding of bitumen and asphalt mixtures from the micro- to the macro-level. A multi-disciplinary and multi-scale view is taken including expertise from material chemistry, mechanical modelling and mechanical analysis of the materials. Based on a fundamental understanding of the links between chemical composition, microstructural setup and mechanical performance including evolution over time (ageing) of bitumen, various questions are worked on in the team of the lab. The research questions range from basic understanding of ageing and separation of thermal and oxidative ageing effects to developments of efficient and realistic ageing simulation, fatigue resistance testing of asphalt mastic and very applied topics like optimization of road winter maintenance and prediction models for skid resistance evolution of road surface layers.

B. Hofko, F. Handle, L. Eberhardsteiner, M. Hospodka, R. Blab, J. Füssl, H. Grothe: "*Alternative Approach Toward the Aging of Asphalt Binder*"; Transportation Research Record (invited), **2505** (2015), 2505; 24 - 31.

B. Hofko, Z. Alavi, H. Grothe, D. Jones, J. Harvey: "*Repeatability and sensitivity of FTIR ATR spectral analysis methods for bituminous binders*"; Materials and Structures, **50** (2017), 187; 1 - 15.

B. Hofko, H. Kugler, G. Chankov, R. Spielhofer: "*A laboratory procedure for predicting skid and polishing resistance of road surfaces*"; International Journal of pavement engineering, **1** (2017), 1 - 9.

Impact of thermal and oxidative aging on the durability of asphalt binders

Ingrid Camargo, PhD Researcher, TU Wien

The durability of asphalt pavements is correlated to the increment of the asphalt mixture stiffness during its lifespan, once the evolution of the material fosters the early development of fatigue and thermal cracking. The modification of the asphalt binder characteristics is mainly related to its aging. The aging can be assessed through physical, rheological and chemical analysis. The rheological characterization of asphalt binders usually correlates the aging with the increase of the dynamic modulus and the decrease of the phase lag. The physicochemical characterization can assess the aging level of the asphalt binder by the evaluation of change in the percentages of saturates, aromatics, resin, and asphaltenes (SARA) fractions and by the assessment of the formation of sulfoxide and carbonyl structures.

The aging of asphalt pavements is usually subdivided in short-term and long-term aging. The first phase is related to the production of the asphalt mixtures where the high temperatures result in the loss of volatiles and fast oxidation of asphalt binder. The second phase of aging is related to the oxidation of the binder due to the interaction between the asphalt binder and reactive gases in the atmosphere. The short-term and long-term phases are usually simulated by conventional aging procedures know as Rolling Thin film Oven Test (RTFOT) and Pressure aging vessel (PAV), respectively. Those laboratory aging procedures consider, simultaneously, high temperatures and pressure to reduce significantly the time needed to age the asphalt binder to a similar aging level that material would undergo in the field.

Nevertheless, the setup of the conventional aging procedures is not suitable to evaluate and distinguish the effect of temperature and oxidation on the increment of asphalt binder stiffness during the asphalt mixture production. In this way, the present study aims to distinguish the effect of temperature and oxygen on the aging of asphalt pavements. Therefore, an aging procedure that conditions the asphalt binder considering an inert atmosphere is presented. The concept is based on the principle that the inert gas may minimize the oxidative process and allow the assessment of the effect of the high mixing temperatures and oxidation on the increment of asphalt binder stiffness.

VAPro – Efficient and realistic long-term ageing simulation of asphalt mix specimens

Daniel Maschauer, PhD Researcher, TU Wien

As for all organic material, bitumen ages due to anthropogenic and natural influences. The aging process alters the properties of the material. Mechanically speaking, it becomes stiffer and more brittle. This leads to a deterioration of low-temperature and fatigue performance and limits the life span of road pavements. For this reason, it is important to simulate the aging of bituminous material in the laboratory in an accelerated way to study the change in material behavior to design more durable roads. A distinction is made between short-term aging (STA) during production and long-term aging (LTA) during service-life. For simulating aging in the laboratory on bitumen scale, the standardized Rolling Thin Film Oven Test (RTFOT) for STA and Pressure Aging Vessel (PAV) for LTA are used. On asphalt mix scale, various methods have been developed in the past for either loose material or compacted specimens. Many of these methods use high temperature and/or high pressure, which do not occur in the field.
The Viennese Ageing Procedure (VAPro) works at temperatures and pressures that occur in the field on pavement surfaces regularly. To achieve aging in a short time, VAPro perfuses specimens with a highly oxidant gas mixture consisting of ozone and nitrogen oxides. It is expected that the chemical reactions triggered by the oxidant are similar to field aging. With the initial layout of VAPro, cylindrical specimens can be conditioned. However, for investigating the effects of long-term aging on the low-temperature performance of asphalt mixtures, prismatic specimens are needed for low-temperature tests like the Thermal Stress Restrained Specimen Test (TSRST) or the Uniaxial Tensile Strength Test (USTS). Therefore, a new aging cell has been developed. First preliminary results are promising. With the VAPro method at hand, asphalt mixture can be optimized not only regarding their short-term performance but also their long-term performance including relevant impacts of aging.

D. Steiner, B. Hofko, M. Hospodka, F. Handle, H. Grothe, J. Füssl, L. Eberhardsteiner, R. Blab: "*Towards an optimised lab procedure for long-term oxidative ageing of asphalt mix specimen*"; International Journal of pavement engineering, **17** (2016), 471 - 477.

Frigio, F., Raschia, S., Steiner, D., Hofko, B. & Canestrari, F. 2016. *Aging effects on recycled WMA porous asphalt mixtures*. Construction and Building Materials, 123, 712-718.

Maschauer, D., Steiner, D., Mirwald, J., Hofko, B. & Grothe, H. (2018) *Viennese Aging Procedure – Behavior of various bitumen provenances*, RILEM 252 CMB Symposium. Braunschweig, Germany.

Fatigue Resistance of Asphalt Mastic and Correlation to the Asphalt Mix Level

Michael Steineder, PhD Researcher, TU Wien

The primary reasons for deterioration of asphalt pavement surface layers are thermal cracking, rutting and fatigue cracking. Bitumen ageing increases the risk for cracking. In recent years, premature deterioration of bituminous bound surface layers, e.g. ravelling, occurs on surface layers on the Austrian road network. This deterioration cannot be correlated to climactic or traffic loading. The current thesis is that it is linked either to inferior durability of the asphalt mastic (bitumen + fines) or poor aggregate adhesion.

Asphalt mastic consist of bitumen and fines. Fines are mineral aggregates with a maximum aggregate size smaller than 125 µm. Current regulations contain specifications for bitumen and fines, but no performance based testing of the mastic. Currently, the European testing standards EN 12697-xx contain only performance based test methods for asphalt mixtures. These test methods address low temperature performance, stiffness and fatigue resistance as well as resistance to permanent deformation at high temperatures. However, the methods demand high amounts of material and time for specimen preparation and testing.

At this time, there are no specifications for durability or fatigue resistance of asphalt mastic in product standards or regulations. To prevent premature failure in the future, it is of interest to study, analyse and understand impacts of filler quality on the durability of asphalt mastic by laboratory testing. This will ensure long-lasting road infrastructure, efficient and sustainable use of natural re-sources and public money.

Therefore, it is the main goal of an ongoing research project to assess fatigue resistance on the mastic level by Dynamic Shear Rheometer (DSR), since mastic is the relevant binding component in asphalt mixtures. There are several international studies that deal with this topic. However, these studies look mostly into correlation between fatigue on mastic and asphalt mix level. Within this project, the reasons for differences in the fatigue behaviour of mastic with different bitumen/filler combination will be investigated. Impacts of grain shape, moisture susceptibility and ageing effects will be analysed in detail. The results will be the basis for specifications regarding durability/fatigue resistance of asphalt mastics. These specifications can then be implemented into existing product standards and regulations.

M. Hospodka, B. Hofko, R. Blab: "*Introducing a new specimen shape to assess the fatigue performance of asphalt mastic by dynamic shear rheometer testing*"; Materials and Structures, **51** (2018), 46; 1 - 11.

Winter Maintenance: effects of anti-caking agents on pourability of salt and comparison of scraper blades

Michael Gruber, PhD Researcher, TU Wien

In modern winter road maintenance, commonly used de-icing agents in form of sodium chloride (NaCl) is used in curative and pre-wetted salt or brine in preventive measures to provide safe roads. While an increased brine content is advantageous for spreading and minimizing spreading loss, high air humidity or an unintentional moistening of the road salt is unfavorable for storage in halls and salt silos. This moistening causes the formation of lumps and decreases the flowability in the salt silos, which makes the preparation and loading of the spreading vehicles more difficult. Based on initial tests on pourability based on the device "Auslaufbox nach Sonntag" (pouring out box acc. to Sonntag), a repeatable test method was established and the effects of drying processes on solid de-icing agents quantified. With regard to the avoidance of sedimentation and the increase of the storability, further investigations on the effects of different moisture contents and anti-caking agents on the pourability are regarded as necessary. In additional tests, the question of whether these anti-caking agents have an influence on the thawing performance depending on the dosage will also be clarified.

Snow clearing is an essential point in every winter maintenance, since snow does not have to be thawed and a good snow removal pattern is therefore essential for economic winter maintenance. Many different snow plough systems are currently available for clearing snow, which can be operated with various scraper blades. Since there is little reliable data available with regard to the wear of the scraper blades under comparable conditions, corresponding surveys and experiments are part of this work.

Current Research Topics in the Research Team Mechanical Modelling

Dr. Lukas Eberhardsteiner, Head of Mechanical Modelling, TU Wien

The team “Mechanical Modeling in Pavement Engineering” works on research projects dealing with two main topics: (i) mechanistic description of pavement material behavior, and (ii) pavement design and evaluation based on mechanistic-empirical approaches.

A multiscale approach based on the framework of continuum micromechanics is used to predict the stiffness behavior of bituminous materials. Thereby, volume fractions, mechanical properties and morphology of single constituents as well as the interaction between material phases are considered. This model is extended by a microstructural model of bitumen allowing for the description of bitumen ageing effects on the basis of the volumetric composition in terms of SARA fractions. Current research deals with further extension of the existing models regarding fatigue and plastic behavior.

Additionally, mechanistic-empirical pavement design methods for bituminous and rigid pavements have been introduced in recent years, which are based on a multi-level approach for important input parameters (traffic load, material stiffness, strength and fatigue behavior). This allows for a realistic consideration of these parameters in pavement design. The developed approach is implemented into a pavement design software.

Ideas for possible future works include the introduction of multiscale modeling (stiffness, fatigue, plasticity) into pavement design, which would not only allow structural pavement design but also mix design for single (bound) layers. Additionally, multiscale models can be used to derive mechanistic state functions to predict pavement condition development and residual life time.

Mechanistic-empirical design of rigid pavements

Kristina Bayraktarova, PhD Researcher, TU Wien

New mechanistic-empirical pavement design methods for conventional rigid pavements and for white topping constructions have been recently developed in Austria in order to better consider the material characteristics, the actual traffic load, local climate conditions, the interface bonding between the concrete and asphalt and other boundary conditions. Within this work, a focus is laid on the proper characterisation of the climatic boundary conditions, on the increased dynamic wheel loads due to unevenness and on the consideration of the interface bonding conditions in the design method. Different approaches were used and developed in order to ensure proper consideration and implementation of these input parameters in the design method. In a subsequent step, a variety of design examples demonstrates their impact on the design service life of the pavement.

Remaining service life of rigids pavements

Pia Mandahus, PhD Researcher, TU Wien

In Austria, there is (still) no appropriate and reliable method for determining the remaining service life of rigid pavements. Hence, a standardized procedure should be developed in this work.

This is done by the combination of innovative experimental and computational methods, both on the material technological and structural level. The result is an overall concept for assessing the condition of a rigid pavement section.

At three test sections visual assessments, drill core sampling and measurements with the falling weight deflectometer were carried out. The results were compared with highway data (such as age and AADTT) and evaluated. The visual assessment is not uniform in Austria, which makes economic maintenance management even more difficult. This disadvantage can be improved by recording damages with a video camera on a driving car with subsequent evaluation on the PC, and a revised damage catalogue. A comprehensive literature study showed that the degree of fatigue can be represented less by strength and more by stiffness values. This assumption was also confirmed by tests in one of our research projects.

The falling weight deflectometer is used for the evaluation of the bearing capacity of the subbase. On the one hand, this test can be carried out quickly and, on the other hand, it does not damage the road pavement. While a performance-based evaluation background already exists for asphalt roads, it is still missing for concrete pavements. According to the valid standard, in Austria only the deviation from the mean of the tested slabs is used for an evaluation of the subbase and the pavement, but there is no statement on the absolute values. In the context of this work, an evaluation background for FWD tests should be developed. On the one hand by calculation with suitable models, on the other hand also by validation on actual measurement data.

The remaining service life can be estimated from the information obtained from the visual assessment, the material tests and the measurements with the falling weight deflectometer. With these results and the introduction of a dowel effectiveness number, a maximum permissible traffic load is obtained which can be compared with the traffic load, which already passed a specific road section. This results in a structural remaining service life expressed in load cycles. By extrapolating the traffic data, a statement in years is also possible.

Estimation of service life with censored condition data

Valentin Donev, PhD Researcher, TU Wien

An accurate estimation of service life is of primary interest in pavement management systems (PMS), limiting the time frame for maintenance and rehabilitation (M&R) treatments. Commonly, condition prediction models are derived using regression analysis at the road network level based on empirical data from periodic condition surveys. However, if a particular section has not failed prior to the last survey or the condition has improved (e.g. due to M&R treatment), it must be considered as censored. If censoring is neglected, the estimated performance functions, service lives and costs may show substantial bias. The authors who acknowledge this problem have used standard statistical (survival analysis) techniques accounting for censoring. However, any road section may fail due to different but dependent competing failure causes (risks), each leading to treatments. This constitutes a special type of censoring that cannot be addressed with traditional survival analysis methods relying on the assumption of independent censoring. As the number of possible failure causes usually exceeds one (e.g. fatigue, permanent deformation, thermal cracking), this case is quite common. Furthermore, the time until the first failure depends on the sign and degree of correlation between failure types. This presentation provides a critical review and comparison of common regression, Markov chain and survival analysis models with and without correlated competing risks based on computer-generated data. The results show that using performance history and distress progression models at the road section level in combination with survival analysis improves the accuracy of predictions. A more general approach is furthermore offered by copula functions, allowing for a simultaneous modelling of joint and marginal service life distributions and accounting for dependence between competing risks.

Fatigue behavior of pervious concrete

Jesus Oltra Sanchez Izquierdo, PhD Researcher, TU Wien

Due to the great advantages in terms of water evacuation and increased strength, pavements with a roadbase of pervious concrete represent a new variant for road pavement constructions. Therefore, it is useful to know the response of pavement surfaces with block pavements under traffic loads. Something that characterizes this type of pavement is the mechanical structure of the interlocking that in some way resembles a flexible material. Observations of the behavior of the pavement with pavers show that a great advantage is the durability of the concrete. On the other hand, the structural benefit consists of the interlocking capacity of the blocks, which is defined as the inability of one block to move independently (rotational, vertical and horizontal movement) with respect to the others. In order to establish an answer and analyze the different variants different models of finite elements of axial symmetry have been elaborated, supported by other researches carried out previously - all the material parameters have been defined to carry out the calculation.

Such as for all road pavements its main objective is to distribute traffic loads to the ground. Therefore, there are different layers that can absorb these stresses and deformations effectively, distributing them through the adjacent layers. Pavements of interlocking blocks are made up of different layers, as are rigid and flexible pavements. The main difference with the other two is the composition of the top course, which is made up of paving blocks interlocked by means of stone or concrete slabs or paving blocks. This composition gives the pavement a semi-flexible character. The pavement of interlocking blocks consists of pavers (or slabs), a bedding sand or mortar, a base and a subbase. The layer of pavers is situated at the very top through which the vehicles pass. As a result, this surface must be flat with a certain degree of roughness, preventing people and vehicles from slipping. Two structural types can be distinguished: the bounded (with bedding mortar) and the unbounded (with bedding sand). Although other types of sections can be used for the base layer, it has only been made with a base composed of pervious concrete, which gives this structure an improved structural response and at the same time allows the evacuation of water from the road. It needs to be emphasized that at the time of executing this type of pavement, it is necessary to avoid a great problem, which is to avoid the filtration of the bedding sand through the pores of concrete. This can be done with a draining mesh that allows water to pass through the concrete but prevents sand from seeping through the pores. Finally, the sub-base is defined as the layer of granular material located between the base and the esplanade. The materials can be natural aggregates or from the crushing of quarry stone or natural gravel, slag, selected soils or local materials, free of clay.

Physico-Chemical Research on Asphalt Binders

Prof. Hinrich Grothe, Head of Physical Chemistry of Atmosphere, TU Wien

Gas phase chemistry in urban environment is often dominated by severe air pollution (so-called photo smog). Photochemical smog depends on primary pollutants as well as the formation of secondary pollutants. These primary pollutants include nitrogen oxides, particularly nitric oxide (NO) and nitrogen dioxide (NO_2), and volatile organic compounds (VOC). An important secondary pollutant for photochemical smog is ozone, which is formed when hydrocarbons (HC) and nitrogen oxides (NOx) combine in the presence of sunlight. The result is a highly oxidative gas mixture (reactive oxygen species, ROS), which is reacting with the surfaces of the asphalt pavement. Due to the heavy NOx emission of traffic the ROS concentrations next to the road surface are high (about 500 ppb) and cause intense aging of the asphalt binder. Here we present new aging method, implementing these ROS into the aging atmosphere, simulating day and night time conditions.

Impact of Reactive Oxygen Species on Asphalt Binder Aging

Johannes Mirwald, PhD Researcher, TU Wien

Asphalt binder aging has a significant impact on the performance and durability of road pavements, since increasing stiffness and brittleness lead to an elevated risk for deterioration due to cracking. Thus, binder aging is a limiting factor to a pavements life. To predict the aging behavior of roads and its binder, realistic long-term aging simulation is necessary. Therefore a new ageing method, the Viennese Binder Aging (VBA), has been developed. The method combines atmospheric oxygen with traces of so-called reactive oxygen species (ROS) which are found near the pavement surface. These ROS are highly reactive and are responsible for aging organic matter, like bitumen. By using a variety of chemo-mechanical analysis, proper characterization and correlation between different levels of aging can be obtained.

J. Mirwald, B. Hofko, H. Grothe: „*Impact of Reactive Oxygen Species on Asphalt Binder Aging*"; Transportation Research Board (TRB) Meeting 2020 (submitted), 2020, Washington, D.C.

Aging effects on Bitumen – Field aged bitumen and laboratory simulation with microscopy and spectroscopy

Ayse Koyun, PhD Researcher, TU Wien

A comparison between various laboratory-aging methods and the natural ageing gives clues whether and how the laboratory-aging methods portray the field ageing. Main causes of bitumen oxidation are sunlight (photo-oxidation), atmosphere (reactions of bitumen with reactive oxygen species (ROS)), rain water (dissolving acids and oxygen containing species) and thermal oxidation (during treatment process in refinery, during transportation from refinery to pavement area and the embedding process itself). A comparison of bitumen which had 19 years of service on the road, and laboratory-aged bitumen samples of the same composition, gives clues whether and how realistic laboratory ageing methods are. To simulate the ageing of bitumen the standardized RTFOT (Rolling Thin Film Oven Test), PAV (Pressure Aging Vessel) and the optimized laboratory – ageing procedure VAPro (Viennese Ageing Procedure) were used. Various ageing steps were generated and then compared with each other applying microscopy and spectroscopy. Unaged, laboratory–aged and field-aged samples were analyzed with Atomic Force Microscopy (AFM), which is capable to picture the topology of bitumen at a sub-micrometer level and with cryo-Enrivonmental Scanning Electron Microscopy after a fresh surface has been generated. The chemical composition of the samples was analyzed using FTIR- Spectroscopy. Carbonyl and sulfoxide indices were determined from the absorbance FTIR spectra using an integration method considering the area below carbonyl or sulfoxide band maxima. Finally, fundamental spectroscopic and microscopic investigation of bitumen samples with various ageing steps provides deeper insides in the mechanisms of the ageing processes.