Asphalt Innovation Symposium 2024

Research meets industry

Dec 12, 2024, in Antwerp

Book of abstracts

Editors:

I. Kokken

W. Van den bergh

Universiteit Antwerpen

Contacts
MSc. Isabeau Kokken (Isabeau.Kokken@UAntwerpen.be)
Prof. Wim Van den bergh (Wim.Vandenbergh@UAntwerpen.be)
University of Antwerp
Faculty of Applied Engineering

SuPAR Research Group
Groenenborgerlaan 171, 2020 Antwerp, Belgium
W: https://www.uantwerpen.be/en/research-groups/supar/
T: +32 326 51 932

© 2025 University of Antwerp
All rights reserved.

DOI 10.63028/10067/2149410151162165141

Preface

Dear Attendees and Readers,

With the 2024 Asphalt Innovation Symposium now behind us, we reflect on the remarkable achievements, collaborations, and knowledge exchanged over the past months. This year has brought new perspectives, innovative solutions, and reinforced partnerships in the fields of asphalt, bitumen, and pavement technology.

The 2024 Book of Abstracts reflects our continued dedication to developing sustainable solutions and shaping the future of road infrastructure. This symposium has once again served as a active platform for discussing new ideas, unveiling new research, and encouraging engagement between academia and industry.

Building on the success of previous years, interactive sessions returned to encourage in-depth discussions on key challenges and opportunities within the field. The symposium's diverse program covered a wide range of pressing topics, including knowledge and innovation, bio-based materials as viable alternatives, pathways to carbon neutrality, advanced pavement monitoring and management techniques, and global trends in asphalt and road research.

Notable discussions this year centred on reducing the environmental footprint of road construction, using data-driven insights for improved infrastructure management, and the potential of emerging materials to enhance durability and sustainability.

The University of Antwerp, in collaboration with participants from around the world, remains committed to expanding the scope of research and technological development in road engineering. By addressing sustainability, climate resilience, and innovation in construction practices, we continue to pave the way for a smarter, more efficient, and environmentally responsible future.

This collection of abstracts and session insights reflects the hard work and commitment of everyone involved. We appreciate your contributions and look forward to another year of learning, working together, and finding new ways to improve our industry

Sincerely,

Prof. Wim Van den bergh

Organizing committee

Wim Van den bergh

Navid Hasheminejad

Karolien Couscheir

Organizational support

Engineers of Tomorrow

Scientific committee

Wim Van den bergh

David Hernando

Cedric Vuye

Ablenya Barros

Eshta Ranyal

Antonio Roberto

Christina Makoundou

Davide Lo Presti

Inge van Vilsteren

Evangelos Manthos

Katerina Varveri

Elisabete Freitas

Sponsors

DE BRUYCKER-KEMP Reesink Construction Equipment

BAG MACBEN

SWECO

Table of content

Schedule of AIS2024

9:00 – 09:45	Registration, coffee, networking & poster session	
09:45 – 11:00	**Opening ceremony – Session 1** (EN/NL): Shaping the future of asphalt pavement engineering: insights, innovations and perspectives.	Chairs: **Davide Lo Presti** (University of Palermo) **Wim Van den bergh** (University of Antwerp)

Eva Van den Bossche (BRRC), *Nieuwe structuur voor het OCW*

Ann Vanelstraete (BRRC), *Onderzoek en innovatie bij het OCW rond Asfaltproducten*

Teena Thomas (Manipal Institute of Technology), *POWERCN2050 and Joint Master SURPAVE*

Wim Van den bergh (University of Antwerp), *Our SuPAR Innovations: Working with industry to Advance asphalt pavement research.*

Ben Moins (University of Antwerp), *CO2 benchmarking of asphalt mixtures*

David Hernando (University of Antwerp), *Envision sustainability framework*

11:15 – 12:45	**Interactive session 2A** (NL): Kennis en innovatie, een uitdaging voor de sector!	Chairs: **Wim Van den bergh** (University of Antwerp) **Inge van Vilsteren** (Rijkswaterstaat)

Inge Van Vilsteren (Rijkswaterstaat) - **Wim Van den bergh** (University of Antwerp) - **Jan Folens** (BVA-ABPE)

Actieve workshop met de sector

11:15 – 12:45	**Session 2B** (EN): Alternative materials: Focus on Bio-based materials	Chairs: **Christina Makoundou** (University of Antwerp) **Evangelos Manthos** (Aristotle University of Thessaloniki)

Evangelos Manthos (Aristotle University of Thessaloniki), The way of biomaterials in Greece

Stefan Vansteenkiste (BRRC), *Bio-based binders: towards the decarbonisation of the asphalt pavement*

sector in Flanders?

Hans Hendrikse (LATEXFALT), *The Road towards Circular Binders*

Dineke van der Brug (Rijkswaterstaat), *CIRCUROAD, evaluation, validation and implementation of bio-enriched binders* in the Dutch road industry

Maria Chiara Cavalli (KTH), *Bio-Composites for Advancing Sustainability in Pavement Engineering*

12:45 – 13:45	Networking Lunch	
13:45 – 15:15	**Interactive session 3A** (EN): The road to carbon neutrality: 2050	Chairs: **David Hernando** (University of Antwerp) **Katerina Varveri** (TU Delft)

Inge Van Vilsteren (Rijkswaterstaat) - **Martin van Stek** (Ammann Group) - **Martin Diekmann** (Wirtgen Group) - **Julien Van Rompu** (Eiffage Route) - **Rien Huurman** (AsfaltNu)

Interactive discussion

13:45 – 15:15	**Session 3B** (EN): Pavement monitoring and management	Chairs: **Cedric Vuye** **Ablenya Barros** **Eshta Ranyal** (University of Antwerp)

Ali Yeganeh (BRRC), *The Critical Role of Pavement Management System (PMS): Innovations Leading the Way*

Ali Anwar (UAntwerpen-IDLAB), *Efficient AI for road surface fault detection*

Thomas Weyn (ASAsense), *Advancements in pavement quality monitoring using sound and vibration*

Fan Gu (Changsha University of Science and Technology), *Influence of As-Constructed Asphalt Pavement Air Voids on Pavement Performance*

15:15 – 15:45	Break	
15:45 – 16:45	**Session 4** (EN): Global trends in asphalt and road research	Chairs: **Antonio Roberto** (University of Antwerp) **Elisabete Freitas** (University of Minho)

Davide Lo Presti (University of Palermo), *SMART ROADS, European visions and proposed developments*

Gabriella Buttitta (University of Palermo), *A Methodology for the Life Cycle Management of European Road Pavements*

Girish Murgod (Manipal Institute of Technology), *Geopolymer concrete - a sustainable option for OPC concrete pavement in infrastructure*

Elisabete Freitas (University of Minho), *Smart pavement Engineering at UMinho*

16:45 – 17:00	Closing ceremony

Evangelos Manthos (Aristotle University of Thessaloniki), *Collaborating for Impact: Academic Research Success*

Wim Van den bergh (University of Antwerp), Farewell

17:00 – 18:00	Final networking reception

Session 1:
Shaping the future of asphalt pavement engineering: insights, innovations and perspectives

Session 1 Shaping the future of asphalt pavement engineering: Insights, innovation and perspectives

Wim Van den bergh[1]

Davide Lo Presti[2]

[1] Sustainable Pavement and Asphalt Research (SuPAR), University of Antwerp, Belgium

[2] Dipartimento di Ingegneria, Università degli studi di Palermo, Palermo, Italy

ABSTRACT

The opening session presented the latest developments in asphalt pavement engineering and fundamental research, in an international context. The SuPAR research group invited several external partners to present their latest research output and collaborations.

Eva Van den Bossche presented the new momentum of the Belgian Road Research Center. BRRC changed its structure last year into three core activities: Innovation, Technical support and Training. Four new departments were defined: Research and Development, Materials Testing and Analyses, Technical Assistance and Infra design and Inspections. Ann Vanelstraete then explained new research and innovation on asphalt materials. BRRC focuses on sustainability and digitisatoin, as their two strategic goals. BRRC is working on recyclability and workability of bitunimous materials (RECYWOBI), Recycled Sands for asphalt mixures (RESANDAS), Fingerprinting of binder for workability and performance testing of mastic asphalt (FORECAST), porous asphalt pavements (DRAINASPAVE), biobinders (BEAM), Digitalisitaion of the infrastructure industry, Infrared linescanner methodology and their follow up on test tracks.

Prof. Teena Thomas presented a wrap-up of the POWERCN2050 – SURPAVE conference, held on 11 December 2024. The SURPAVE consortium, consisting by more than 40 associated partners and led by four universities (UAntwerp, UMinho, MAHE and UniPA) will organize a two-year master's, starting in September 2026: Sustainable and Resilient Pavement Engineering. With this two-year master's degree, the consortium aims to make a difference in future pavement engineering. At the POWERCN2050 conference, SURPAVE was explained and discussed with online and in-person attendees. The program takes a multidisciplinary approach and covers sustainable technologies such as Sustainable and Resilient Project Management, Introduction to Data Mining, Artificial Intelligence and Digitalization, Airports and Railways, Highway Environment Management Systems, Circular Life-Cycle Based Pavement Management, Sustainable Geometric Design Practices and Spatial Technology for Smart Roads.

Prof. Wim Van den bergh presented SuPAR innovations 2024, collaboration wit industry to advance asphalt pavement research. Highlights include: the purchase of the AMPT to test cylindrical specimens, several results of the CyPATS projects were implemented by industry such as the infrared line scanner and FBG sensor technology at the Port of Antwerp-Bruges, and in a new project Kielsbroek where the city of Antwerp will use ROAD-IT, rejuvenator for high recycling rate of RAP, bitumen-stabilised materials and the FBG-sensor technology. New projects such as the DIMinfra project in which SuPAR together with PXL Hogeschool supports the broad infra-industry in their digitization process, via simple tools to complex processes such as Green Public Procurement tool. Besides tesing materials, SuPAR is also taking steps towards using AI, for example for preventive road maintence (HAIRoad). Our new Alternative Materials cluster is well on its way with several projects using bio-based materials (AsSuRe-Bio, BioRoad etc, FWO PhD project on liging and waste cooking oil and BoRBs). Other projects such as EurIAC, De Oorzaak, Fate of Polymers, Large-scale Pavement Solar Collectors, PIONEERS were discussed as updates.

Dr. Ben Moins explained his research topic “CO2 Benchmarking of Asphalt Mixtures”. Based on a throrough analysis of Flemish asphalt mixtures, he benchmarked different types for Flanders, using key parameters such as transport and energy. He demonstrated that the MOW-reduction target (minus 23.7 percent annual emissions) is achievable when optimum scenarios are followed for the Flemish market.

Prof. David Hernando presented the Envision Sustainabiluty framework, which encourages systematic changes in the planning, design and delivery of sustainable, resilient and equitable civil infrastructure. SuPAR is member of this framework. The application of Envision projects are now reaching 283 billion dollars for in total 396 projects worldwide.

Since training and education is another way to implement new ideas and to prepare future engineers for the upcoming challenges, we announced next to our new Joint Master “Sustainable and Resilient Pavement Engineering”, three other trainings for industry: Basis Course Asphalt, Advanced Course Asphalt Pavements and Building Information Modelling. The last mentioned course is related to our new research vision on the urgent need to digitalize the pavement sector.

Research meets Industry!

Interactive session 2A:
Kennis en innovatie, een uitdaging voor de sector!

Knowledge and Innovation, a challenge for industry!

Wim Van den bergh[1*], Inge van Vilsteren[2]

[1] Sustainable Pavement and Asphalt Research (SuPAR), University of Antwerp, Belgium

[2] Rijkswaterstaat – Dutch Road Agency, The Netherlands

[*]Email: wim.vandenbergh@uantwerpen.be

ABSTRACT

This paper summarizes Session 2A, a continuation of the "Roadmap towards 2050: Aiming for a Sustainable Asphalt Industry" workshop held during AIS2023. At AIS2023, two key conclusions emerged: (1) the increased use of Reclaimed Asphalt Pavement (RAP) is necessary and achievable, provided market conditions such as availability, logistics, economic feasibility, and environmental benefits are favorable; and (2) although digitization is not new to the industry, a coherent, sector-wide approach is still lacking. These insights underscored the critical role of the University of Antwerp in driving research and implementation in both areas.

In this follow-up session, attended by 30 participants from across the asphalt sector, both topics—recycling of asphalt and digitization—were explored further to identify pathways for accelerating sustainable practices within the Flemish asphalt industry. The session began with engaging presentations on the status and challenges of each topic in both Flanders and the Netherlands. These set the stage for roundtable discussions focusing on key questions: Is RAP recycling currently maximized, and are new players emerging? What is the current level of digital maturity, and what improvements are needed? How can green public procurement support these goals?

Key Conclusions:

The overarching goal of the asphalt industry is to extend pavement service life, whether or not this involves higher RAP usage. Concerns persist, however, regarding the impact of RAP—particularly in SMA—on durability. Life Cycle Assessment (LCA) is essential to evaluate trade-offs between recycling rates and environmental impact. Quality improvements in RAP could be achieved through selective milling and differentiated storage based on binder type and aggregate properties.

Although many asphalt plants already separate top and base layers by stone type and gradation, standardized regulations on selective milling could provide a much-needed push. Mixtures like lean asphalt, with low binder content, show promise for very high RAP integration. Similarly, higher RAP content could be allowed in low-traffic roads (e.g., AB-4C) or even adapted for use in more heavily trafficked roads. Special attention is needed for the recycling of polymer-modified bitumen (PmB) mixtures, including SMA-C2 and those specified in SB250 v5.0.

Several stakeholders emphasized the need for targeted research on SMA-C2 recycling due to its high availability and current regulatory limitations. Potential research topics include advanced processing techniques, reversion to SMA-C1, use of fibers (as practiced in the Netherlands), and evaluating the impact on acoustic performance.

Though rejuvenators have been demonstrated (e.g., in the RejuveBIT project), their practical application remains limited. Current specifications do not offer a competitive advantage for rejuvenators, even at higher RAP percentages. While technologies for 50% RAP integration are feasible

in the medium term, the widespread use of rejuvenators is more realistic in the long term, especially in surface layers and PmB-based mixes, although 50% recycling in surface layers was allowed 20 years ago. Additionally, high RAP content can impact asphalt plant efficiency, making economic and environmental balances critical.

Understanding the quality and history of RAP—particularly how many times it has been recycled—is essential. Improved RAP classification based on mixture type, binder type, and age may be required, possibly leading to more refined RAP stock categories. While regional RAP stocks could improve feasibility, asphalt plants remain concerned about logistical and economic challenges.

The use of rejuvenators in warm mix asphalt (WMA) also shows potential but requires further research, particularly regarding weather conditions, workability, and service life. Though WMA offers certain advantages, RAP integration still presents a more effective environmental benefit.

On the topic of digitization, while data exists at various points in the asphalt value chain, real-time and on-site data—such as actual temperature and compaction—remain insufficiently integrated.

Final Message:

The session reaffirmed that both asphalt recycling and digital transformation remain high-priority research areas. The University of Antwerp is expected to continue leading innovation and collaborative efforts in both domains to support the transition toward a more sustainable and intelligent asphalt industry.

Session 2B:
Alternative materials: Focus on Bio-based materials

Bio-based binders: towards the decarbonisation of the asphalt pavement sector in Flanders?

Stefan Vansteenkiste[1*], Alexandra Destrée[1], Alexandros Margaritis[1], Ann Vanelstraete[1] [1] Belgian Road Research Centre (BRRC), Woluwedal 42, B-1200 Brussels, Belgium

[*]Vansteenkiste Stefan. Email: s.vansteenkiste@brrc.be

ABSTRACT

In 2019, the European commission launched the Green Deal initiative, and consequently set out an ambious plan to achieve a cleaner, healthier and climat neutral society. Member states engaged in reducing 55% of the greenhouse gas emissions (GHG) by 2030 and to attain carbon-neutrality by 2050.

At present, the construction of asphalt road pavements results in a depletion of high amounts of primary and fossil-based raw building materials, such as aggregates and bituminous binders. In particular, the use of fossil-based bitumen as derived from the refining of crude oil, negatively impacts to a large extent the environmental footprint in terms of GHG of asphalt pavements. Different approaches are available to overcome these concerns, among them an enhanced circularity by making increasingly use of reclaimed asphalt (RA), lowering the asphalt production temperature by applying warm mix asphalt (WMA) or the electrification of the laying and compaction process in situ.

Recently, the replacement of fossil-based binders with alternative bio-based binders draws more and more attention within the asphalt sector both in neighbouring countries as well as on a regional level in order to mitigate the high GHG emissions of asphalt pavements. Moving away from fossil-based materials by (partially) replacing bitumen by bio-sourced products may offer environmental and economical benefits, contributing to fulfill the European goal to transform to a more sustainable economy.

In this contribution, an overview will be given with respect to the different bio-based materials from a wide variety of renewable sources such as agriculture (e.g. vegetable oils), wood/paper industry (e.g. lignin), waste cooking oil, pyrolyzed materials (e.g. bio-char), … and which are considered as promising candidates for replacement of the conventional bitumen. A classification into different families based on their origin will be attempted. Furthermore, their intrinsic potential for bitumen replacement will be shown, including some recent experiences or demonstration of their use in the field, in particular Flanders. However, in parallel remaining challenges will be addressed for their future implementation within the sector. Such challenges may occur at multiple levels such as economical, quality issues, health&safety, durability (performance). Finally, needs for future research will be highlighted.

Keywords: bio-binders, decarbonisation, sustainability, asphalt pavement.

The Road towards Circular Binders

Hans Hendrikse[1], Manager R&D Latexfalt

The road construction industry is in quite a peculiar place when it comes to sustainability: Bitumen, one of its main resources, is undeniably a product of the fossil-based oil industry. Yet, within this industry, it serves as a form of waste disposal: bitumen is the leftover product of fuel and chemicals produced from oil, which would have to be incinerated or landfilled if not made into roads. As such a waste product, it faces different challenges compared to traditional recycling industries. For one, it is chemically poorly defined as it is a complex residue of large hydrocarbons which serve the simple function of binding aggregate in a road, which has historically kept the need to unravel its chemical complexity low. In order to find a substitute however, bitumen will need to be better defined chemically, as a mimic needs to be designed after this chemical definition. Secondly, as bitumen is already a waste product, its commercial value is low. Thus, alternatives should have a comparable price or significant environmental benefits in order to be commercially viable. In this lecture we will address the questions 'How do we define bitumen chemically?' and 'What possibilities does replacing bitumen offer?' in order to demonstrate a clear path towards the success of biobased binders.

How do we define bitumen chemically?

Bitumen is the leftover-residue of oil distillation. It thus consists of a mix of large hydrocarbons, which have a relatively high boiling point, which in turn is mostly based on their molecular weight. The distribution of molecular weight of these molecules can be analyzed with gas chromatography, as shown in Figure 1. Here, we see a selection of standard 70-100 bitumen which all have a broad distribution of molecular weight. The width of this distribution varies from bitumen to bitumen, but their average is more or less the same. This, along with IR-spectroscopy to identify the molecular groups, gives a means of identifying bitumen: a broad distribution of various high molecular weight hydrocarbons.

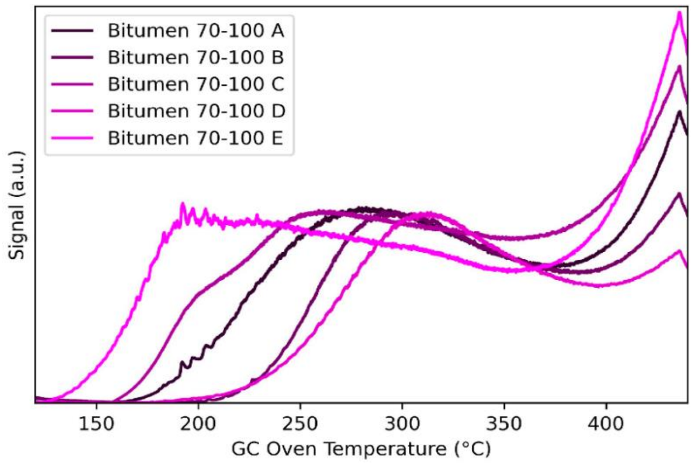


Figure 1. GC-chromatograms of various standard 70-100 bitumen.

What possibilities does replacing bitumen offer?

Replacing a compound with various hydrocarbons offers an interesting possibility for the recycling industry: Whereas most recycling aims to obtain a mono-disperse and a single type of hydrocarbon, here we are looking for a broad mix of various hydrocarbons. Thus, recycling streams which cannot be recycled due to having a broad molecular weight might find a purpose here, reducing the amount of waste streams that need to be incinerated or landfilled. At Latexfalt we have made a few bitumen mimics based on biobased resources and waste materials from society, which are heavily CO_2 negative and score well on ECI as shown in Figure 2. Furthermore, these mimics have a broad molecular weight distribution which results is comparable physical and mechanical properties compared to fossil-based bitumen.

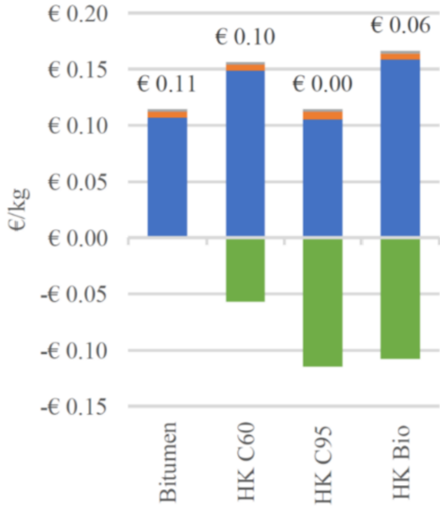


Figure 2. ECI of 60% biocircular (HK C60), 95% biocircular (HK C95) and

The success of biobinders

The success of biobinders is an interplay of cost, environmental benefit and quality. Using the above method, a high-quality binder can be made using various streams. It then becomes an interplay of the 3 components in order to find the optimal binder. Some options, like introducing waste-based materials, can lower cost and increase environmental benefits simultaneously. We have already demonstrated that a fossil-free binder is possible as shown in Figure 3, even when going completely fossil-free without hampering quality. Through initiatives like the CIRCUROAD project we are looking for ways to optimize all 3 factors, aiming to get market acceptation as soon as possible.

Figure 3. Application of biobased asphalt.

CIRCUROAD, *-evaluation, validation and implementation of bio-enriched binders in the Dutch road industry-*

Dineke van der Burg[1)] and Bert Jan Lommerts[2)]

[1)] **Rijkswaterstaat, the executive agency of the Ministry for Infrastructure and watermanagement,** *Senior Advisor Innovation*
[2)] **CIRCUROAD**, *materials experts and member core team*

In the Netherland a new triple-helix public-private partnership has been established to develop bio-enriched binders for flexible pavement applications. For this program, raw material suppliers, bitumen upgraders and producers, contractors, knowledge institutes, consultancy organizations and municipal, provincial and federal road owners have jointly set the objective to achieve a tangible contribution in 2023 to the reduction of CO_2 emissions in the Dutch road industry by using bio-based and sustainable concepts. Bio-based is one of the six road maps defined in the Dutch road sector and the other five activities are focusing on, viz., (1) service life extension using preventative maintenance measures, (2) recycling and/or upcycling, (3) quality control of processes and materials to achieve a higher service life of pavements, (4) low temperature asphalt production and improved energy efficiency of asphalt mills, (5) electrification of equipment and further initiatives to reduce CO_2 emissions during transport and application of asphalt.

Within CIRCUROAD, four different bio-enriched binder concepts are currently under evaluation and binders, mastics and asphalt mixtures have been tested by various parties in the market. All binders perform according to the Dutch RAW standards for SMA 8b mixtures and, therefore, it was decided to speed up the implementation by conducting pilot trails end of 2024. First test sections will be applied on the InnovA58 test tracks near Eindhoven and these tracks will be monitored in order to decide to upscale the amount of test sections throughout the Netherlands, which will subsequently be monitored on a TRL 7 level. In view of the relatively large number of municipalities, these test tracks will be coordinated by BouwCirculair, a separate organization coordinating the innovations for smaller road owners. Besides Rijkswaterstaat and provincial road owners, municipalities are key to achieve the 2030 CO_2 reduction targets as the majority of the asphalt volume in the Netherlands is applied for these road owners. The strength of the CIRCUROAD program is that it is has become a binding factor in the entire Dutch road construction sector as historic boundaries are rapidly vanishing in view of common drive to achieve the 2030 targets.

After a thorough cost-benefit analysis, it was decided to focus primarily of 30% bio-enriched binders as the risks associated with this transition of fossil-based technologies to bio-based binders is limited and, hence, market acceptance is enhanced. Furthermore, the price implications are significantly reduced, whereas, the benefits are still in line with the 2030 objectives. A first estimate of the Global Warming Potential resulted roughly in CO_2 neutrality for a 30% bio-enriched binder. The composition taken in this analysis was based on the average of the four bio-enriched binders of interest. This analysis will be further validated in detail via a PhD research program at the University of Utrecht. Furthermore, in this study also more economical aspects will be evaluated as well, like the long-term availability of bio-based feedstock and how future supply chains will have to develop in the asphalt industry. These are certainly important topics to understand the critical economical issues in order to debottleneck the implementation of new sustainable binder technologies.

After a successful start-up of CIRCUROAD over the last 18 month, the focus is now on the future in which the challenge arises to meet the 2040 targets. In 2025 the research will be focusing on other asphalt mixtures, like open-graded mixes, base-layers and dense top layers. Furthermore, the evaluation criteria for current bituminous binders are not entirely covering the relevant parameters for bio-enriched binders. Within the CIRCUROAD program, this aspect will be addressed using the expertise of various knowledge institutes in the Netherlands. Furthermore, the energy- and material transition are noticeable in various sectors. Continuous monitoring of these transitions to determine the impact for new concepts for sustainable binders for flexible pavements is certainly a relevant topic and these new initiatives can further contribute to the development of new and innovative technologies. A last, but certainly not the least challenge is to stimulate the use of bio-enriched binders in contracts between contractors and road owners. In view of the current standard NEN-EN 15804, the current ECI (MKI) method is not fully addressing all relevant parameters to take the benefits of carbon capture via bio-based binders into account. A joint task force will address this issue to come-up with a method enhancing the use of more sustainable concepts.

Bio-Composites for Advancing Sustainability in Pavement Engineering

Maria Chiara Cavalli[1*]

[1] Road and Railway Engineering Division, ABE School, The Royal Institute of Technology (KTH), Brinnelvagen 23, 114 28 Stockholm, Sweden

[*]Corresponding author. Email: mcca@kth.se

ABSTRACT

A significant portion of greenhouse gas (GHG) emissions associated with roads stems from the upstream emissions embodied in the materials used. Each ton of asphalt produced emits approximately 300 kg of GHG. In Sweden, annual road maintenance generates 50 tons of GHG, accounting for 10% of the nation's total emissions. Furthermore, Sweden has set the ambitious goal of achieving carbon neutrality by 2050. To support this objective, our research group explores the potential of replacing traditional road materials with novel bio-based alternatives that enhance sustainability and reduce long-term dependence on fossil-based materials. Our projects align with UN Sustainable Development Goals: Goal 9 (Industry, Innovation, and Infrastructure), Goal 11 (Sustainable Cities and Communities), and Goal 12 (Responsible Consumption and Production).

One focus of our research is the applicability of lignin—a rigid, waterproof "cement" that provides plants with structural strength and is a byproduct of the wood and paper industries. Replacing parts of the asphalt matrix with a lignin-based product has the potential to improve sustainability by reducing GHG emissions and increasing resistance to moisture damage, one of the major challenges in road maintenance.

In another project, we investigate oxidation mechanisms and explore how bio-based rejuvenators can mitigate their effects. This research aims to demonstrate how bio-based rejuvenators effectively reduce dependence on fossil fuels while maintaining material performance.

Finally, we use life cycle assessment (LCA) to evaluate how these bio-composites can be employed in real-world scenarios without increasing CO2 emissions. The goal is to create a practical tool to assist authorities and the research community in optimizing the efficient use of bio-asphalt.

Overall, we aim to design a new bio-based asphalt material that is not only sustainable and eco-friendly but also highly durable and performant.

Keywords: lignin, bio-rejuventors, LCA, oxidation, rheology

Interactive session 3A:
The road to carbon neutrality: 2050

Session 3A: The road to carbon neutrality – 2050

David Hernando[1], Katerina Varveri[2]

[1] Sustainable Pavement and Asphalt Research (SuPAR), University of Antwerp, Belgium

[2] TU Delft, The Netherlands

ABSTRACT

This document summarizes Session 3A focused on discussing the steps needed to meet the carbon neutrality goals set for 2050. The text begins with a summary of the keynote presentation and four short pitches and finalizes with the main conclusions from an interactive session where the attendees were broken up into groups to facilitate the discussion among participants.

The keynote speaker, Inge van Vilsteren (Rijkswaterstaat), shared the vision of the national Dutch Road Authority. This vision is built upon a series of steps that includes allowing 30% of RAP in surface layers in 2023, increasing this content to 40-60% in 2024, exclusive use of low-production technologies (e.g., warm-mix asphalt) starting in 2025, and valorizing waste streams and bio-based binders/additives, coupled with electrification of machinery, by 2030 to complement the remaining 30% that cannot be obtained from recycling existing pavement materials. She concluded her presentation by encouraging the audience to brainstorm, connect ideas, develop plans and take actions without further wait.

In the first pitch, Martin van Stek (Amman Asphalt GmbH), delved into solutions to reduce environmental impact and emissions at the asphalt plant. The highlighted solutions covered WMA by foaming bitumen, 100% recycling with reduced aging, an energy efficiency assistant tool, burners for carbon neutral fuels (e.g., green hydrogen), a blue smoke treatment to reuse smoke in the combustion chamber, and a dedusting unit to reduce VOC emissions.

Martin Diekmann (Wirtgen Group) stressed the need for a holistic approach (from foundation to surface, from cradle to grave) to assess carbon footprint in the road sector and to promote the principles of a circular economy. He showed that increasing RAP content in hot-in-plant recycling from 20% to 80% can drop global warming emissions by 23% while cold-in-situ recycling can lead to 45% savings compared to a traditional mill-and-fill recycling operation.

In the third pitch, Julien Van Rompu (Eiffage Route) explained the role of lower mixing temperatures and bio-binders as levers to decarbonize the road construction sector. He showed that bitumen production (26%) and mixture production (38%) can represent up to 2/3 of the total CO_2 emissions of hot mix asphalt. Then, Julien shared the R&D efforts in the development of bio-binders for the pavement industry and highlighted the carbon storage potential of Biophalt (13 kg of CO_2 per squared meter for a 6-cm-thick asphalt layer). The presentation concluded discussing the challenges for low-carbon asphalt, such as the evolution of industrial facilities, availability of bio-resources, and ensuring performance.

The last pitch, given by Rien Huurman (AsfaltNu), invited the audience to rethink asphalt production as the foundation for a sustainable asphalt industry. Rien described their efforts to produce high-quality WMA with increased recycling rates to support the goals of climate neutral, clean, healthy, circular, and high-quality asphalt mixtures. Those efforts are based on a special nozzle array to foam bitumen, and the LEAB (low-energy asphalt concrete) and MastiQ technologies, which have been successfully employed for premium SMA and PA surfaces in field sections.

After the broad vision provided by the five speakers, four questions were posed to the audience (39 participants). For the first question, '*As of today (2024), how confident are you about the asphalt sector reaching carbon neutrality by 2050?*', 46% responded '*We will get there, one way or another'*, 49% responded '*It may or may not happen'*, 5% responded '*Definitely not happening'*, and nobody answered '*It will absolutely happen'*. In short, about half of the audience felt that the goal of carbon neutrality will be achieved while the other half showed some reservations. For the second question, '*My company is already taking clear steps to meet carbon neutrality goals by 2050*', 41% answered '*Strongly agree*', 50% '*Agree to some extent*', 6% '*Disagree to some extent*', and 3% '*Strongly disagree*'. While the response from 90% of the audience was positive, which is extremely encouraging, the response from the other 10% suggests that continued education is important to ensure all companies align with the carbon neutrality goals of the sector. The third question, which was open-ended, inquired the audience about the '*Key to achieve carbon neutrality in the asphalt sector*'. The more common terms were *collaboration, recycling*, and *bio-binders*. Other terms highlighted by the audience were *electrification* and *renewable energy sources*, *government strategy* and *vision*, *multidisciplinary, digitalization, lower temperatures, capture, champions, cost acceptance,* and *no hidden agendas*. For the last question, '*There is enough leadership in the asphalt sector to help achieve carbon neutrality by 2050*', 3% responded '*Strongly agree*', 26% '*Agree to some extent*', 56% '*Disagree to some extent*', and 15% '*Strongly disagree*'. This question clearly substantiated that a lot of the ongoing efforts are taking place in an individual basis without any stakeholder leading the way. After being asked how to solve the lack of leadership, several attendees mentioned collaborative projects between government, academia, and industry as a first step.

After this interactive section, the audience was broken up into four groups and each group was given 25 minutes to discuss two of the following questions before reporting back to the room:

- Q1: *What are the main barriers (technical, economic, policy, etc.) that may prevent us from meeting carbon neutrality by 2050?*
- Q2: *What is the most feasible path to achieve carbon neutrality by 2050? Who should collaborate? Who should lead?*

- Q3: *What's your vision for a carbon neutral (or low carbon) pavement in 2050? How different is it from what you saw today*?

For the first question, the groups reported the following barriers:

- Industry has technology that can support carbon neutrality goals; however, regulations, non-adaptative policy, and specification constrains from road owners as well as insufficient customer acceptance may slow down the changes needed.
- A lot of changes happening too fast, which can cause knowledge gaps (e.g., lack of knowledge on carbon capture).
- Insufficient investment in research.
- Procurement policy: traditional low-cost culture or not considering environmental impact in tendering (e.g., environmental costing approach).
- Risk of failure

Only one group addressed Q2 regarding the most feasible path to achieve carbon neutrality. They agreed that knowledge is in the industry but road authorities should lead the transition and accept the associated risks. Then, there was a discussion about collaboration vs competition. The general consensus was that the policy framework should allow room and reward companies for innovating; however, there should be collaboration among stakeholders to contribute different aspects that are needed to meet carbon neutrality in the sector as a whole.

Finally, the audience reported the following regarding the vision for carbon neutral (or low carbon) pavements:

- There is a need to overcome narrow thinking.
- Performance is too often overlooked.
- Need to incorporate fuel consumption in assessments.
- Circularity is more than road construction alone: explore other waste streams.
- Digitalization is a key enabler for cradle-to-grave approach.

Keywords: asphalt, carbon neutral, bio-binder, recycling, life cycle assessment.

Session 3B: Pavement monitoring and management

The Critical Role of Pavement Management System (PMS): Innovations Leading the Way

Ali Yeganeh[1*]

[1] BRRC, Antwerp

[*]Corresponding author. Email: a.yeganeh@brrc.be

ABSTRACT

Pavement Management Systems (PMS) play a crucial role in ensuring effective and sustainable road maintenance planning, especially on local roads, which represent nearly 90% of the road network in Belgium. This presentation examines the potential evolution of PMS methodologies, tracing the shift from traditional paper-based visual inspections by inspectors on foot to today’s advanced data collection and analysis methods involving interactive tablets, digital imaging, and emerging AI capabilities. Alongside these general advancements, the presentation will review the specific approach developed by the Belgian Road Research Centre (BRRC) for local roads.

Drawing on lessons learned from a recently completed project (i.e., INFRACOMS project) and an ongoing work (i.e., HAIRoad project), the discussion will cover the importance of effective road condition monitoring, from inventory data to current condition assessments. Moreover, innovative solutions such as AI-driven and data fusion techniques present potential pathways for achieving cost-effective, efficient, and objective data collection, supporting evidence-based decisions that drive sustainable road management practices.

In closing, the presentation emphasizes the importance of continuous improvement and innovation in pavement management systems, highlighting their potential to enhance road maintenance practices.

Keywords: Pavement Management Systems (PMS), Road Monitoring, Condition Data, Maintenance Planning, Data-Driven Decisions, Digital Monitoring, Proactive Maintenance

Efficient AI for road surface fault detection

Ali Anwar[1*]

[1] IDLab, University of Antwerp

[*]Corresponding author. Email: ali.anwar@uantwerpen.be

ABSTRACT

Maintaining roads is essential for socio-economic development and the well-being of citizens, as roads serve as a critical means for the transportation of both people and goods. The surfaces of roads undergo wear and tear due to continuous usage, making it imperative to assess the damages in a cost-effective and timely manner to identify repair windows. In contrast to traditional methods, which rely on human assessment of road damages, we propose to automate this process through the application of artificial intelligence (AI), opportunistic sensing, and sensor fusion. Firstly, sensors such as cameras, LiDARs, 3D sonars, and acoustic sensors could be mounted on vehicles that routinely traverse specific stretches of road. By collecting data in this manner, we utilize AI models to automatically classify the types and quantities of faults present in the images. Ultimately, information from multiple sensors can be fused effectively to ensure that faults are detected under various lighting and weather conditions—a critical design requirement, as detection of road conditions can significantly depend on local climatic factors. imec.ICON Hybrid AI for Predictive Road Inspection (HAIROAD) project will be presented in this regard, which aims to explore the proposed solutions. Based on our research findings, we have developed several AI approaches that perform well on Belgian roads, while being trained on data from road surfaces originating from diverse countries, including India, the USA, the Czech Republic, Japan, and Norway.

Keywords : Deep Learning for road monitoring, Sensor Fusion, Domain Generalization, Data-driven inspection

Advancements in pavement quality monitoring using sound and vibration

Thomas Weyne[1*]

[1] ASASense, Antwerp

[*]Corresponding author. Email: Thomas.weyne@asasense.com

ABSTRACT

Road monitoring is an important occupation of every organization that is responsible for them. Monitoring in general allows objectivation of the quality and better handling of the current situation. Timely detection of early wear allows for large savings in the maintenance cost. Continuous and opportunistic measurement makes it possible to monitor large areas, to monitor and predict the evolution of the road quality and to detect and alert for sudden deteriorations.

Much attention is given to pavement quality monitoring using visual Inspection and structural measurement tools, with or without the use of AI, but these are costly methods. Using the combination of sound and vibration, many structural parameters can be estimated at high precision, effortlessly and at a significantly lower cost. Moreover, using changepoint detection algorithms, sudden changes in the measurements can be found, even within noisy time series, and Long Term Degradation models can be used to predict the evolution of these parameters in time.

In this presentation, a short recap of the possibilities developed during the IMEC.icon project Mobisense and followup research will be given, as well as new work ASAsense and UGent have performed as part of the IMEC.icon Hairoads project since then. The estimation and correlation with known parameters such as IRI, MPD, CPX and the flatness coefficients, as well as other parameters such as the surface type and quality indicators from visual inspections used in the City of Ghent will be discussed in detail. A short exploration of the possibilities concerning changepoint detection and the prediction of long term degradation is also presented.

Keywords :

Influence of As-Constructed Asphalt Pavement Air Voids on Pavement Performance

Fan Gu[1*]

[1] School of Traffic & Transportation Engineering, Changsha University of Science and Technology, China

*Corresponding author. Email: fan.gu@csust.edu.cn

ABSTRACT

The objective of this study is to determine the effect of in-place air voids on the performance of asphalt pavements using data from the LTPP program. The challenge is to isolate the effect of as-constructed air voids from the other factors that can affect pavement performance. In this study, we develop a four-layered artificial neural network model to determine the relationship between in-place asphalt air voids and pavement performance. We find that reducing in-place asphalt air voids is effective in improving fatigue cracking performance, but not sensitive to the rutting performance. The asphalt pavement with 4-5% in-place air void exhibits the lowest roughness.

Keywords: Long-term pavement performance database, Neural network modeling, Pavement performance prediction, In-place air voids

Session 4:
Global trends in asphalt and road research

A Methodology for the Life Cycle Management of European road pavements

Davide Lo Presti[1,2*], Gabriella Buttitta[1,2], Ana Jimenez Del Barco Carrión[3], Ali Azhar Butt[4], John Harvey[4]

[1] UNIVERSITY OF PALERMO - Department of Engineering, University of Palermo, Viale delle Scienze ed.8, Palermo 90128, Italy

[2] National Sustainable Mobility Center (Centro Nazionale per la Mobilità Sostenibile-CNMS), Italy

[3] University of Granada– LabIC.ugr, Department of Construction Engineering and Engineering Projects, Avenida Severo Ochoa S/N, 18071 Granada, Spain

[4] University of California Davis- One Shields Avenue, Davis, CA 95616, United States

*Corresponding author. davide.lopresti@unipa.it

ABSTRACT

International and European standards are rapidly advancing to provide practitioners with robust guidance for consistent and accurate sustainability assessments across various sectors. In the civil engineering domain, significant progress has been made in developing specifications for the building sector, where many guidelines are either in place or in progress. However, the same level of development is lacking for infrastructure, leaving notable gaps that hinder the broader implementation of sustainability practices in this field.

The PavementLCM project, funded by the Conference of European Directors of Roads (CEDR), was initiated to address these deficiencies within the European context. Its primary mission is to enable road authorities to design and maintain road pavements through the application of life-cycle thinking, in order to evaluate environmental, economic and social impacts over the entire lifecycle of a project and/or an asset. PavementLCM's success relied heavily on collaboration with industry stakeholders and road authorities to create a framework and guidelines tailored to help the practitioners throughout the Sustainability Assessment (SA).

This comprehensive framework distinguishes between two primary systems—pavement materials and pavement activities—to ensure a nuanced and precise evaluation. It incorporates a set of measurable indicators alongside best practices to guide the assessment process. Moreover, the guidelines developed as part of the project offer a clear, step-by-step methodology, aligning with existing European standards for the environmental assessment of buildings (EN 15643-2:2011) and civil engineering works (EN 17472:2022). By doing so, the PavementLCM project seeks to harmonize the

Life Cycle Management of road pavements across Europe, fostering consistency and reliability in sustainability practices.

The ambition of the PavementLCM team extends beyond its original scope and context. While the framework is designed to address regional challenges, its principles and methodologies offer valuable insights that could inspire similar initiatives worldwide. By addressing current gaps in sustainability assessment for road pavements, the project aspires to pave the way for broader adoption of life cycle thinking in civil engineering, ultimately contributing to more sustainable and environmentally responsible development globally.

Keywords: Life Cycle Management; road pavements; sustainability assessment

Geopolymer Concrete - A Sustainable Option For OPC Concrete Pavement Infrastructure

Girish Murgod [1*]

[1] Department of Civil Engineering, Manipal Institute of Technology, Manipal Academy of Higher Education, Udupi, Karnataka, India

[*]Corresponding author. Email: girish.murgod@manipal.edu

ABSTRACT

Concrete (rigid) pavement is gaining popularity in tropical monsoon regions, such as Karnataka's coastal areas, due to its durability, load-carrying capacity, low maintenance, and resilience to rainfall damage. However, concerns about diminishing aggregate resources and the environmental impact of cement production have prompted researchers to explore sustainable alternatives for Pavement Quality Concrete (PQC). Cement manufacturing is energy-intensive, consuming approximately 4 gigajoules per ton of cement produced, and emits nearly an equal amount of CO2, contributing to global greenhouse gas emissions. Additionally, the construction industry consumes over 12 million tonnes of natural aggregates annually, exacerbating environmental degradation.

One approach to sustainable pavement construction is the use of industrial by-products as substitutes for conventional materials. Fly ash from thermal power plants and ground granulated blast furnace slag (GGBS) from the steel industry are widely used to partially replace cement, reducing its carbon footprint. Recycled concrete aggregates from demolished structures can replace natural aggregates, conserving resources and minimizing environmental impacts from quarrying. These strategies align with the need for sustainable development without compromising performance.

Geopolymer cement, an eco-friendly alternative to Portland cement, shows promise but remains underexplored for paving applications. While the use of alternative materials in rigid pavement construction contributes to sustainability and cost reduction, challenges persist. These include material availability, consistency, long-term durability, economic feasibility, and regulatory compliance. Successfully addressing these issues requires balancing innovation and practicality to ensure alternative materials meet safety, durability, and cost-effectiveness standards.

This transition to sustainable materials could significantly enhance the ecological footprint of pavement construction, offering a pathway to environmentally responsible infrastructure development.

Keywords: Geopolymer concrete, pavement quality concrete, fatigue, curling stress, green house potential.

Smart Pavement Engineering at Uminho

Elisabete Freitas[1*], Joel Oliveira[1], Hugo Silva[1], Jorge Pais[1], Raúl Almeida[1], Paulo Ramísio[2], Orlando Lima[1,3,] Élida Margalho[1,3]

[1] University of Minho, ISISE, ARISE, Department of Civil Engineering, Guimarães, Portugal

[2] University of Minho, CTAC, Department of Civil Engineering, Guimarães, Portugal

[3] Centre of Physics of Minho and Porto Universities (CF-UM-UP), Guimarães, Portugal

[*]Corresponding author. Email: efreitas@civil.uminho.pt

ABSTRACT

The University of Minho (UMinho) has been at the forefront of innovative research in smart pavement engineering, aiming to address the growing demand for sustainable and resilient urban infrastructure. This work emphasizes the research projects dedicated to developing and implementing advanced materials and technologies to improve the functionality, durability, and environmental impact of road systems. A primary focus is on smart and multifunctional materials, including photocatalytic pavements incorporating titanium dioxide (TiO_2). These materials enhance air purification while improving mechanical performance, durability, and resistance to environmental wear. Projects like NanoEcoBuild and NanoAir explore sustainable construction techniques and nanotechnology applications for air-cleaning road surfaces. To combat urban heat islands, the MicroCoolPav Project has demonstrated the effectiveness of phase-change materials integrated into coaxial fibres, enabling temperature regulation on road surfaces. Winter safety innovations include superhydrophobic coatings, developed for anti-icing solutions, which delay ice formation, reduce adhesion, and maintain friction under icy conditions. Additionally, thermochromic nanosensors are being investigated to improve road marking visibility and durability, contributing to safer transportation networks. A critical component of UMinho's approach is the application of Life Cycle Assessment (LCA) to evaluate the environmental and societal impacts of pavement systems. The project REV@CONSTRUCTION delved into advanced monitoring systems equipped with fibre optic cables, multiple sensors, and real-time data processing to provide comprehensive insights into pavement performance and lifespan. These tools are essential for optimizing infrastructure design and ensuring long-term sustainability. UMinho's research bridges technical innovation with societal benefits, focusing on public health (project RES2VALHUM), urban sustainability, and the interaction between roads, vehicles, and pedestrians through research based on virtual reality like ANPEB and IMPACT. The University of Minho is paving the way for smarter, safer, and more sustainable infrastructure systems by integrating cutting-edge materials science with environmental and social considerations.

Keywords: smart pavements, photocatalysis, urban heat islands, thermochromic markings, structure, environment and society impacts.

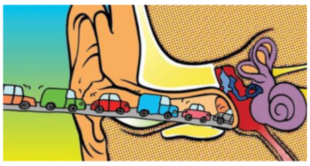
Poster session

De Oorzaak: A citizen science approach to assess the impact of environmental noise in urban environments

De Oorzaak: A citizen science approach to assess the impact of environmental noise in urban environments

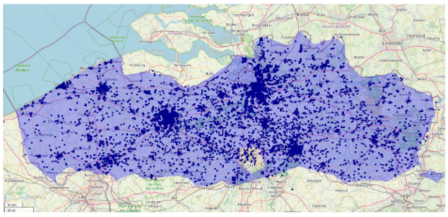
Ablenya Barros*, Paulien Decorte, Jonas Lembrechts, Karolien Couscheir, Sanne de Rooij, and Cedric Vuye
*ablenya.barros@uantwerpen.be

The human auditory system is extraordinarily sensitive to even small air pressure changes from sound waves. Noise is a phenomenon sensed and evaluated by everybody, causing short-term negative effects on concentration and stress. Accumulatively, **noise exposure can evoke serious health risks.**



Citizen science (CS) is a collaborative approach to scientific research that actively involves the general public in data collection. To enhance the understanding of environmental noise's impact on health, stress, and sleep, we initiated a large-scale CS project, ***De Oorzaak***, in Flanders (Belgium). Below are described some of its ongoing initiatives.

The Large Sound Survey



A **51-question** survey open for all adult residents in Flanders, on sociodemographic background, quality-of-life aspects, and noise annoyance. It gathered **10,000 answers** and served to select participants from Antwerp, Ghent and Leuven for the sensor network phase.

The soundscape survey and the Apple Watch study

Citizens went on soundwalks and filled a questionnaire based on the ISO 12913-2 **soundscape** method. Over **3,500 answers** evaluated the perceived quality of auditory experiences across Flanders.

Participants willing to shared their **Apple Watch data** provided insights into noise exposure, sleep quality, and heart rate variability, which could be linked to the Sensor data and noise perception surveys.

The acoustic sensor network

Citizens hang an **IoT-based sensor** in their bedroom windowsill for a 2-month measurement. The sensor is equipped with a Class II microphone, GPS, and a SIM card for data transmission. The sensor network covers over **1500 locations and one year (April 2024 to April 2025),** with 6 measurement waves, besides surveys on noise perception filled weekly.

The sleep quality study

100 participants, with half hypersensitive to noise, participate in a one-night ambulatory sleep study. Sleep quality was monitored using electrodes, stress biomarkers were sampled, and indoor and outdoor noise levels were recorded.

Combining these elements, we aim to bring environmental noise monitoring to a new level, using an explicit interdisciplinary design, strong ties with academic, industry and governmental partners, and a key role for thousands of citizens.

University of Antwerp
SuPAR | Sustainable Pavements and Asphalt Research

DE OORZAAK

Asphalt Innovation Symposium
December 12, 2024
Antwerp, Belgium

Adhesion Mechanism in Fibre Reinforced Foamed Asphalt (FIFA)

Adhesion Mechanism in Fibre Reinforced Foamed Asphalt (FIFA)

PhD Candidate: Ecem Nur Barisoglu*
Supervisors: Wim Van den bergh
Dirk Lamoen

LinkedIn page

Motivation

Achieving sustainable road construction, driven by the European Green Deal and sustainable development goals (SDGs) , needs innovative, long-term strategies in the road industry. Despite advancements in road industry, challenges remain in incorporating high percentages of Reclaimed Asphalt Pavement (RAP) material in Cold Recycling with Foamed Bitumen (CRFB) due to material complexity. Ongoing innovation is crucial to improve our understanding of bonding, combining principles from chemistry, physics, and engineering for enhanced pavement durability.

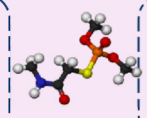
Objective

- ❑ Enhance bonding mechanism in CRFB mixtures
  - Incorporate fibers into 100% RAP in the pavement base layer
  - Address the weakest spotin the pavement
- ❑ Conduct a comprehensive investigation on FIFA
  - Examine micromechanical properties
  - Explore physicochemical properties
  - Focus on the micro and nano levels
- ❑ Develop a novel composite material

Research Methodology

Step 1

Selection of materials based on chemical, rheological and microstructural characterization:
FTIR, DSR, CLSM, SARA, molecular weight, Element analysis



Step 2

Molecular Dynamics (MD), molecular structure construction: Thermodynamics and physical properties;
Density, cohesive energy, work of cohesion, Surface free energy (SFE)

Step 3

Experimental validation and correlation; morphology
Establish a link between SFE calculation from contact angles and MD

Expected Research Outcomes

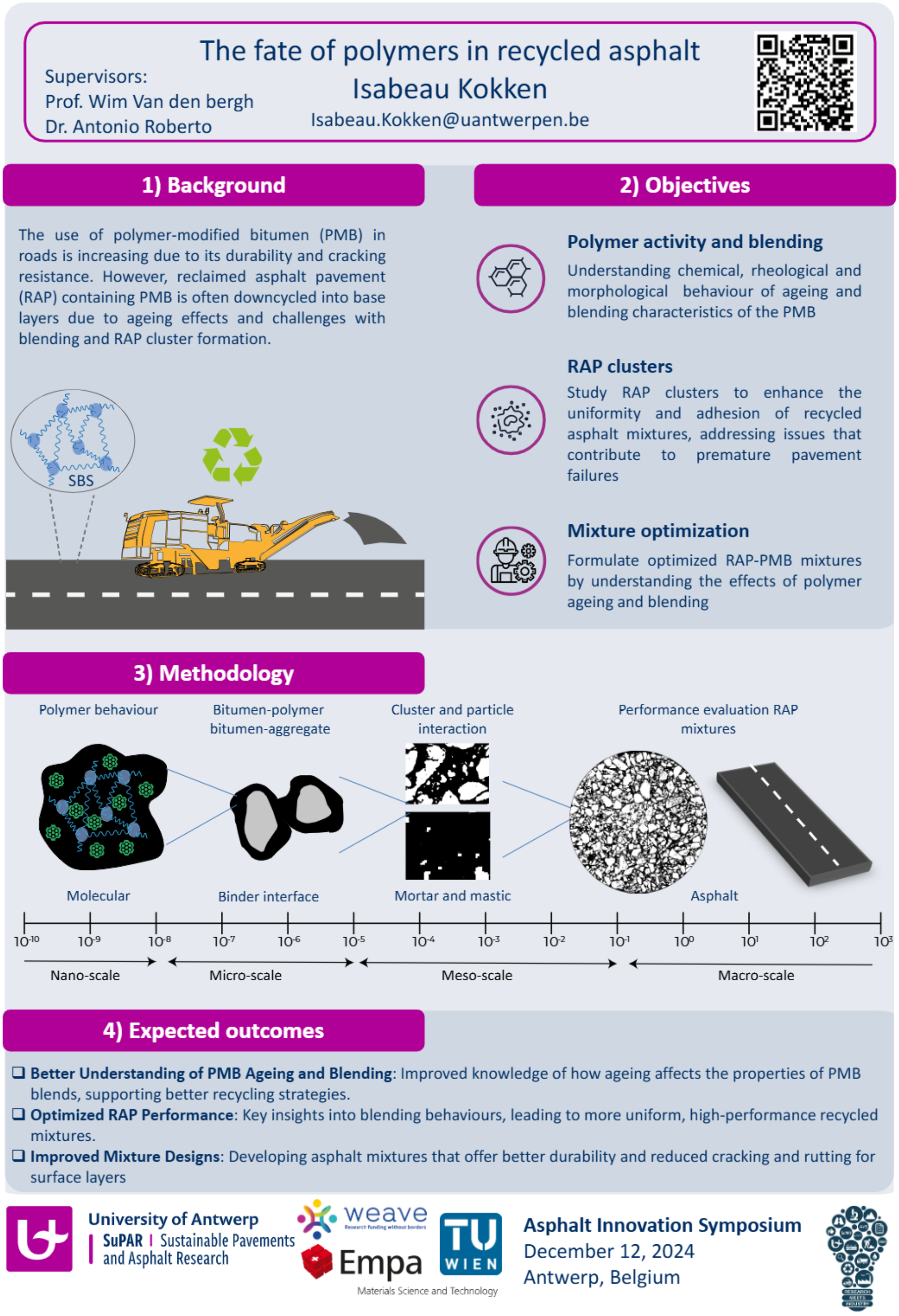
- ❑ Enhanced understanding of the bonding mechanisms within FIFA, particularly at the interface between components.
- ❑ Insights into the complex interaction of different constituents (fibre, RAP, cement, foamed bitumen, water) and their influence on moisture damage mechanisms.
- ❑ Contribution to the selection of optimum material properties, considering adhesion and moisture sensitivity, potentially reducing pavement maintenance and replacement costs.

*Corresponding author email: Ecemnur.Barisoglu@uantwerpen.be

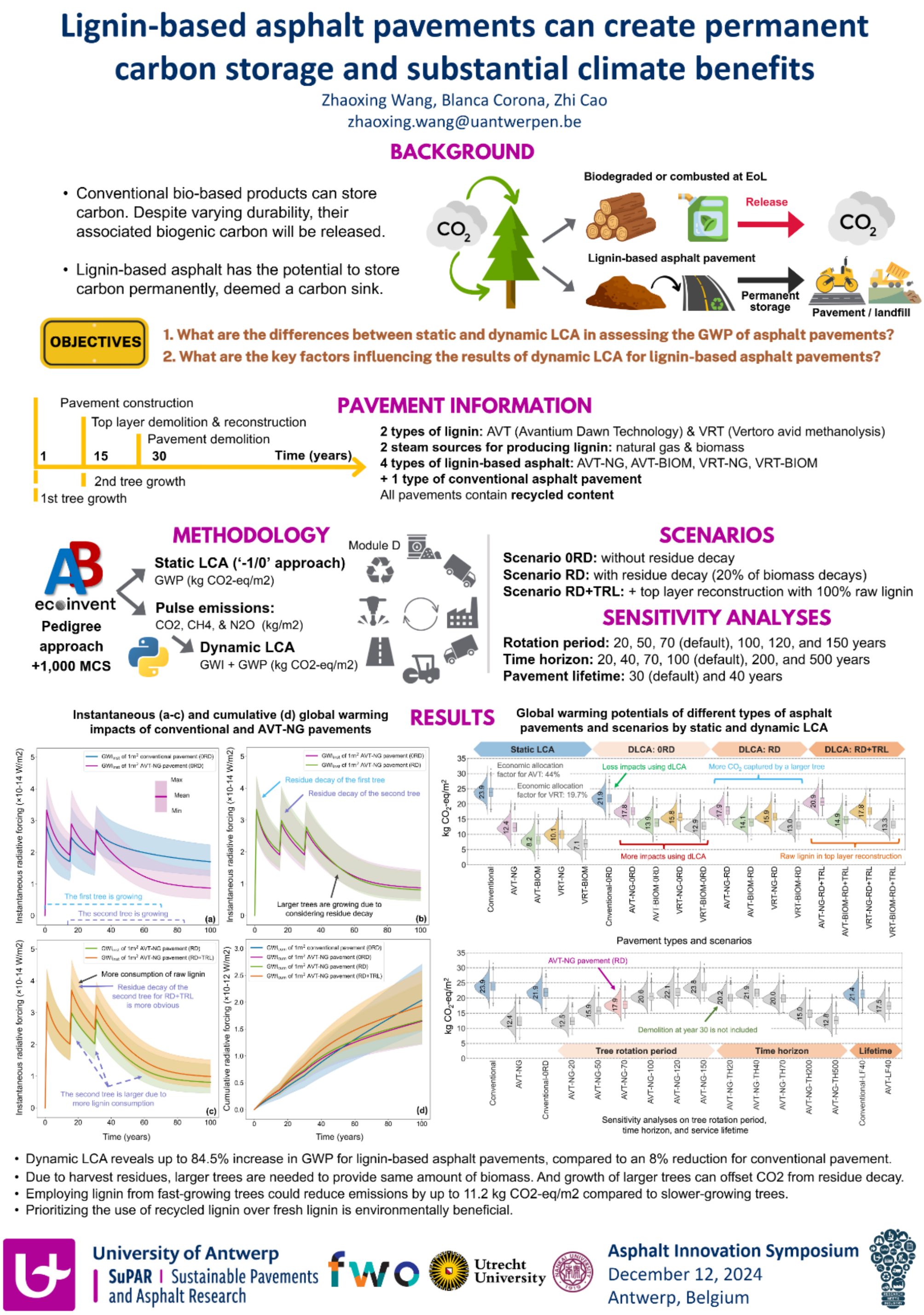
University of Antwerp
SuPAR | Sustainable Pavements and Asphalt Research

Asphalt Innovation Symposium
December 12, 2024
Antwerp, Belgium

The fate of polymers in recycled asphalt



Lignin-based asphalt pavements can create permanent carbon storage and Addressing pavement ageing, VOC emissions, and traffic pollution



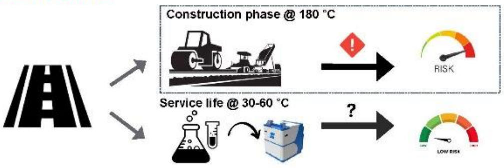
Asphalt pavements are substantial source of primary and secondary pollutants

Asphalt pavements are substantial source of primary and secondary pollutants

Ali Zain Ul Abadeen
alizainul.abadeen@uantwerpen.be

BACKGROUND

- Volatile organic compounds (VOCs) emitted from asphalt pavements represent a significant source of urban air pollution, with complex implications for atmospheric chemistry and human health.
- Selected Ion Flow Tube Mass Spectrometry (SIFT-MS) enabled characterization of VOC profiles including aliphatic hydrocarbons (C_2-C_{12}), aromatic compounds (BTEX), and oxygenated species.



1. What are the qualitative and quantitative characteristics of VOC emissions from asphalt pavements measured through SIFT-MS using direct measurement and fume bags?
2. What is ozone formation potential (OFP) and carcinogenic risk (CR) of these emissions?

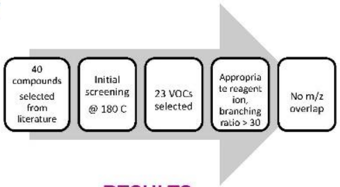
METHODOLOGY

Syft SIFT-MS

Direct measurement
Headspace method

Fume bags
1 L Tedlar® sampling bag

OFP
CR



CALCULATIONS

OFP:

$$OFP_i = C_i \times MIR_i$$

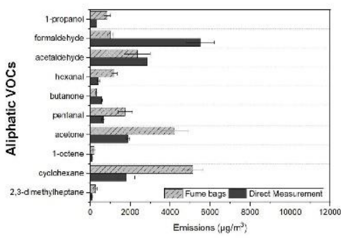
Where C_i is the VOC concentration (mg/m³) and MIR_i is its Maximum Incremental Reactivity (g O_3/g VOC).

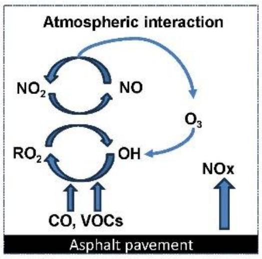
CR:

$$R = C_i \times SF_i$$

Where SF_i carcinogenic slope factor of VOCs component i, μg/m³.

RESULTS





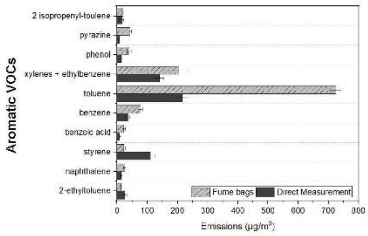


Table 1. Carcinogenic VOCs species based on direct measurement and fume bag measurement.

Rank	VOCs Species	Direct Measurement		Fume bag measurement	
		R-value	Risk Assessment	R-value	Risk Assessment
1	Acetaldehyde	0.0062700	High risk	0.005170	High risk
2	Formaldehyde	0.0715000	High risk	0.013000	High risk
3	Naphthalene	0.0008500	Medium risk	0.000425	Medium risk
4	Benzene	0.0000702	Medium risk	0.000176	High risk
5	xylenes + ethylbenzene	0.0005375	High risk	0.001813	High risk

R values below 1 × 10-6 indicate no carcinogenic risk, values between 1 × 10-6 and 1 × 10-4 represent medium risk, and values exceeding 1 × 10-4 indicate high risk levels

Table 2. Top 10 VOCs species based on OFP for direct measurement and fume bag measurement.

Rank	VOCs Species	Direct Measurement		VOCs Species	Fume bag	
		OFP (mg/m³)	%		OFP (mg/m³)	%
1	formaldehyde	52.03	63.17	acetaldehyde	15.36	28.25
2	acetaldehyde	18.64	22.63	formaldehyde	9.46	17.39
3	pentanal	3.30	4.01	pentanal	8.89	16.34
4	cyclohexane	2.25	2.73	cyclohexane	6.40	11.77
5	hexanal	1.74	2.11	hexanal	5.22	9.59
6	xylenes	1.09	1.32	toluene	2.9	5.33
7	toluene	0.86	1.04	1-propanol	2.08	3.84
8	1-propanol	0.81	0.99	xylenes	1.59	2.92
Sum	—	80.72	98.01	—	51.92	95.43

- Ozone Formation Potential (OFP) leads to ground-level ozone through photochemical reactions, with formaldehyde and aldehydes as major contributors.
- Secondary Organic Aerosol (SOA) formation occurs through gas-to-particle conversion, with VOCs as precursors to be investigated further.
- Health Risk Assessment reveals significant concerns from both acute and chronic exposure, with formaldehyde, acetaldehyde, and benzene classified as high-risk compounds causing respiratory, carcinogenic, and neurological effects.
- Comparative analysis of direct measurement and fume bag sampling revealed differences in quantitative values but similar peaks.

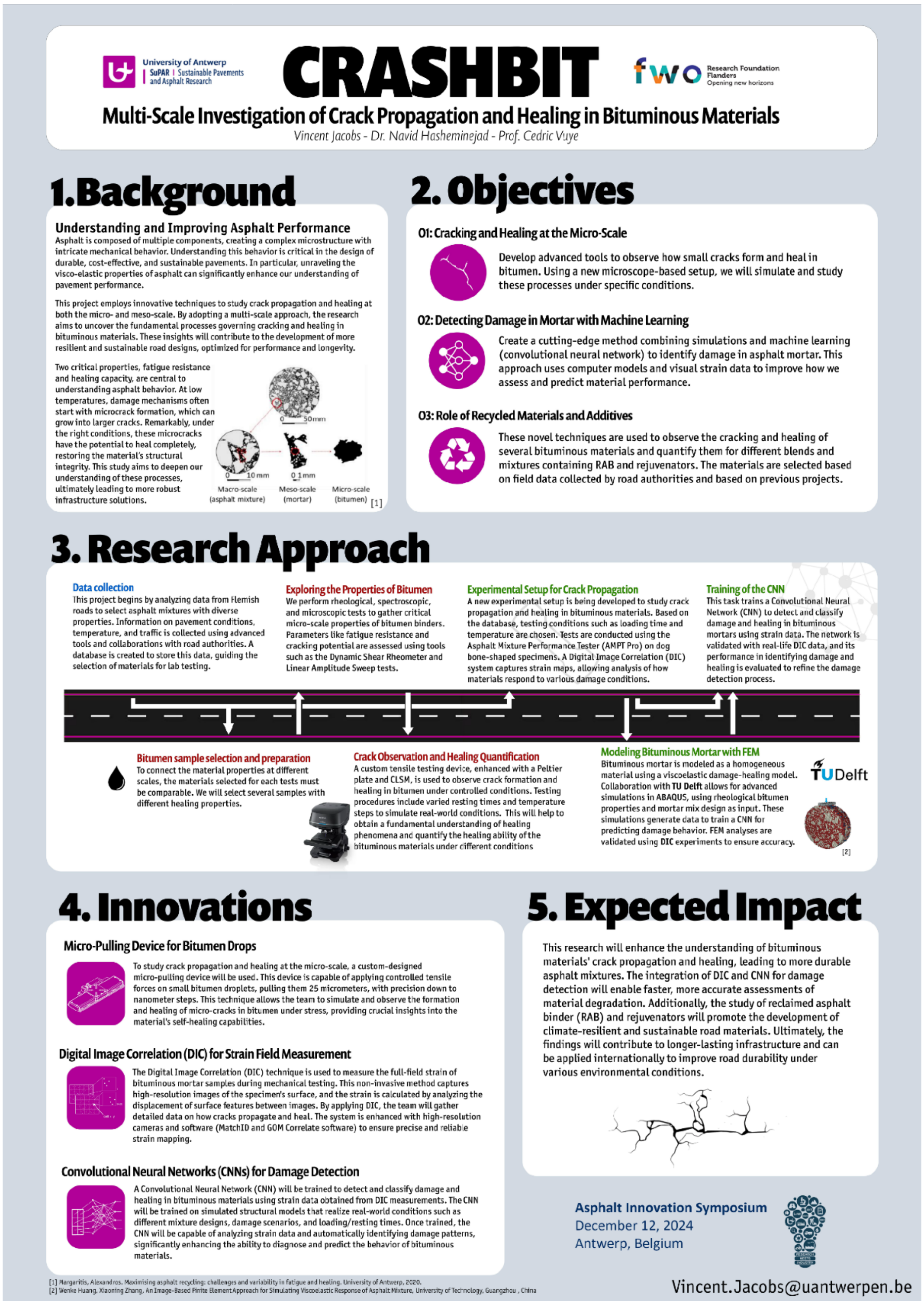
Supervisors: Seyed Reza Omranian, Johan Blom, Sammy W. Verbruggen, Cedric Vuye

University of Antwerp
SuPAR | Sustainable Pavements and Asphalt Research

Sustainable Energy, Air & Water Technology
University of Antwerp

Asphalt Innovation Symposium
December 12, 2024
Antwerp, Belgium

Crashbit: Multi-Scale Investigation of Crack Propagation and Healing in Bituminous Materials



RESEARCH
MEETS
INDUSTRY