Proceedings of TRA2020, the 8th Transport Research Arena
Rethinking transport – towards clean and inclusive mobility

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Abstract

This publication presents the proceedings of TRA2020, the 8th Transport Research Arena, which was planned to be held on 27-30 April 2020 in Helsinki. The physical conference event was cancelled due to the COVID-19 pandemic.

All work presented in this Book of Abstracts was peer-reviewed and accepted for the conference. Authors were encouraged to publish their full paper in a repository of their choice with a mention of TRA2020. Authors were invited to provide a link to the full paper to be included in this Book of Abstracts. If the link is not available, please contact the corresponding author to request the full paper.

Selection of TRA2020 papers were published in Special Issues of following journals: European Transport Research Review (Vol. 11-12) and Utilities Policy (Vol. 62 & 64).

Papers with a TRA VISIONS 2020 senior researcher winner as an author are marked with large yellow stars. Smaller stars stand for papers with an author shortlisted in the TRA VISIONS 2020 competition. The EC has supported the best senior researchers involved in EU projects with the TRA VISIONS awards.

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FOREWORD

The main theme of Transport Research Arena 2020 was “Rethinking transport - towards clean and inclusive mobility”. The 2020 conference focused on climate change mitigation and adaptation as well as the development of user-oriented, accessible and sustainable transport and mobility solutions. Based on this, more specific key themes of TRA2020 were also formed.

Transport Research Arena is, as its name suggests, more than a conference. It is a strategic discussion forum for the European transport sector and the related research, industry and decision-makers. Once every two years, nearly 2,500 researchers and representatives of the public and private sectors meet to exchange experiences and expertise, explore new trends in the industry and consider the appropriate allocation of the European research and development funding in the coming years. The hosts and main organisers of TRA2020 are the Finnish Transport and Communications Agency Traficom, the Ministry of Transport and Communications, the Finnish Transport Infrastructure Agency, Business Finland, VTT Technical Research Centre of Finland and the European Commission as co-organiser.

TRA2020 was held in exceptional circumstances. The physical conference was to take place in Helsinki on 27-30 April 2020, but the COVID-19 pandemic prevented the organisation of a physical conference event. Therefore, it was considered important to give the conference papers an appropriate forum in a written publication. The TRA2020 Book of Abstracts contains the abstracts of and links to the conference papers approved for presentation (orally or by poster) in the conference. The publication has been approved by all authors.

Many actors and stakeholders contributed to the high-quality scientific content of TRA2020. First of all, we would like to thank the authors of the conference papers. Conference papers were sought for the 12 key themes of the conference, and a large number of quality paper proposals were received. We would also like to thank the volunteer and professional evaluators who invested their time and expertise in the peer review of the conference papers. This was essential in terms of producing high-quality content for TRA2020.

In addition, we would like to thank the members of the TRA2020 Management Committee and Programme Committee for the preparation of the conference programme and for their constructive cooperation. Also, our sincere thanks go to all other active participants, the wide range of stakeholders and colleagues who enabled the set-up of a high-quality programme through their activities. The joint preparation process provided an interesting perspective to the core of European transport research and innovation.

Helsinki, 28 May 2020

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1 Scientific and technical sessions ................................................................. 9
  1.1 Scientific and technical session 1: The institutional and user responses to climate challenge ................................................................. 9
  1.2 Scientific and technical session 2: Zero emission mobility ...................... 15
  1.3 Scientific and technical session 3: Clean mobility policies ................... 20
  1.4 Scientific and technical session 4: City stories on sustainable and clean mobility .................................................................................. 26
  1.5 Scientific and technical session 5: Green shipping and clean ports .......... 31
  1.6 Scientific and technical session 6: Air quality, noise and particulate emissions .. 37
  1.7 Scientific and technical session 7: Clearing roadblocks for mobility as a service 43
  1.8 Scientific and technical session 8: Shared and servitised mobility .......... 49
  1.9 Scientific and technical session 9: Data and big data in mobility .......... 55
  1.10 Scientific and technical session 10: Safety through data, digitalisation and automation ........................................................................... 60
  1.11 Scientific and technical session 11: Novel perspectives to C-ITS and autonomous road transport .......................................................... 65
  1.12 Scientific and technical session 12: Future of automated transport ......... 72
  1.13 Scientific and technical session 13: Safety analysis excellence ............. 78
  1.14 Scientific and technical session 14: Travel behaviour and needs .......... 85
  1.15 Scientific and technical session 15: Vehicles, vehicle systems and technologies 91
  1.16 Scientific and technical session 16: Acceptance of automated transport ...... 100
  1.17 Scientific and technical session 17: Modelling of traffic flow ............... 107
  1.18 Scientific and technical session 18: Collaborative urban planning and stakeholder engagement .............................................................. 114
  1.19 Scientific and technical session 19: Safety and security in cyberspace ....... 120
  1.20 Scientific and technical session 20: Service provision and quality .......... 125
  1.21 Scientific and technical session 21: Simulation, modelling and algorithms – studies, tools and examples ................................................... 128
  1.22 Scientific and technical session 22: Smart city mobility solutions .......... 135
  1.23 Scientific and technical session 23: Rethinking public transport, commuting and mode choice ................................................................. 139
  1.24 Scientific and technical session 24: Thought – tried – tested – taken to use; Test sites, labs and pilots ................................................................. 146
  1.25 Scientific and technical session 25: Electrification and energy alternatives I 151
  1.26 Scientific and technical session 26: Electrification and energy alternatives II 159
  1.27 Scientific and technical session 27: Catering non-motorised transport ...... 166
  1.28 Scientific and technical session 28: Pedestrian safety and Vulnerable Road Users ......................................................................................... 170
  1.29 Scientific and technical session 29: Tomorrows Europeans railways ...... 175
  1.30 Scientific and technical session 30: New technologies for railways ........ 183
  1.31 Scientific and technical session 31: Insights into system resilience ......... 190
1.32 Scientific and technical session 32: Infrastructures for the era of automation. 195
1.33 Scientific and technical session 33: Aviation – market and technology trends . 202
1.34 Scientific and technical session 34: Novel views on risk and safety management......................................................................................................................... 208
1.35 Scientific and technical session 35: Innovations in logistics and freight........... 214
1.36 Scientific and technical session 36: Railways safety and reliability visions ...... 222
1.37 Scientific and technical session 37: Best practices for infrastructure safety and reliability ........................................................................................................ 227
1.38 Scientific and technical session 38: Waterborne – pushing technology forward 233
1.39 Scientific and technical session 39: Exploring shipping and maritime operations .......................................................................................................................... 239
1.40 Scientific and technical session 40: Drivers’ and humans’ behaviour and their environment .............................................................................................................. 246
1.41 Scientific and technical session 41: Research in pavement and material engineering.................................................................................................................. 253
1.42 Scientific and technical session 42: Maintenance and asset management...... 260
1.43 Scientific and technical session 43: Gender neutrality and special groups needs ....................................................................................................................... 266
1.44 Scientific and technical session 44: Corridors – connecting markets in a sustainable way......................................................................................................... 270
1.45 Scientific and technical session 45: Innovation for a multimodal society ...... 275
1.46 Scientific and technical session 46: Advances in Public-Private Partnerships ... 279
1.47 Scientific and technical session 47: Building human capital for the future mobility system ................................................................................................................. 284
1.48 Scientific and technical session 48: Perspectives on policy, regulation and pricing.................................................................................................................... 290
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Abstract

The paper presents both the modeling and the experiment to measure the longitudinal static strain over the inner perimeter of a tire. These measurements are expected to help at updating some unknown geometrical and mechanical parameters of tires for achieving more accurate simulations under conventional CAO software (namely, Solidworks). Compared to the literature, a distributed fiber optic sensing is used to measure the inner liner tire strain profile along the perimeter. Based on the Rayleigh scattering, this technology provides a fine spatial resolution, namely, less than 1 cm. The preliminary results show the typical Mexican-hat-like circumferential strain distribution and the contact patch length. Both quantities are shown to be related to the static load.

Keywords: Strain measurement; Fiber optic; Rayleigh scattering; Contact-patch length; Finite element modeling, static loading

1086 A review of damage modelling approaches for layered composites

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Abstract

The increasing application of layered composites in the aerospace and automotive industries warrants a need for high-fidelity computational models to ensure robust and reliable designs. The robust predictive modelling of damage thresholds is an important aspect of the overall design and manufacturing lifecycle of composite structures. Composites display a highly nonlinear material behaviour and have a wide range of failure modes extending across length scales. Most of the defects or inherent discontinuities in composites arise at a micro-scale (fibre level) and accumulate into larger cracks at structural level under service loads. The mathematical modelling of this damage envelope involves discontinuities in displacement fields; this poses numerical challenges with regards to automatic initiation, propagation and prediction of growth characteristics of cracks. The current study aims at providing a detailed review and qualitative comparison of different damage modelling methods available in the literature to model damage behaviour in such layered composite laminates.

Keywords: Composite laminates; Damage modelling; eXtended Finite Element Method (XFEM); Phase-Field Method (PFM); Continuum Damage Method (CDM); Cohesive Zone Method (CZM)

1159 Improving porous asphalt mixes by incorporation of additives


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Abstract

Porous asphalt (PA) mixtures have shown a huge range of benefits such as noise reduction, better skid resistance and mitigation of hydroplaning effect. However, due to high voids content, this mixture is prone to ravelling and clogging and therefore its service life is limited. Strong interlock between bitumen and aggregates is an important requirement to keep the aggregate structure intact and thus ravelling in check. Some additives have been widely used in order to enhance the mechanical properties of conventional dense-graded asphalt mixtures (DGAM). Incorporation of additives can improve the stability and cohesion of the porous asphalt mix. In this paper, the suitability of different type of aramid fibers in PA mixtures is analysed with the purpose to improve the durability while maintaining the proper functionality requirements. In this study, volumetric analysis was carried out to assess the effect of five different types of fibers on the functional performance of the porous asphalt mixtures. In addition, dry and wet Cantabro tests were carried out to evaluate the performance of porous asphalt concrete with aramid fiber. Binder drain down tests were also performed in order to assess the potential of fibers to be used as stabilizer additives.

Keywords: porous asphalt mixes; additives; aramid fibers; synthetic fibers; Cantabro test

Full paper: https://www.researchgate.net/profile/Anik_Gupta

1.42 Scientific and technical session 42: Maintenance and asset management

134 Low-cost system for monitoring road friction properties

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Abstract

The knowledge of the friction conditions on driving surfaces on the public road network is a major factor in providing traffic safety. Whenever the specialised measurement equipment is used, it is difficult or even impossible to quickly perform the measurements on all sensitive locations during emergency events. By installing moderately priced and easy to control yet still accurate enough devices for measuring the longitudinal deceleration during braking onto the vehicles that travel over the road network performing their everyday assignments, the friction measurements are available quickly and with minimal additional cost. We present a prototype of a low-price device, which can be installed in the vehicles that traverse the roads on a daily basis. Its application quickly and effortlessly provides the braking-test-based friction data on the critical location on the road surface and their conveyance to the road administration authorities as the basis for taking measures for condition improvement.

Keywords: road friction, skid resistance, braking deceleration, single board computer, database, connected system
Improving porous asphalt mixes by incorporation of additives

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Abstract

Porous asphalt (PA) mixtures have shown a huge range of benefits such as noise reduction, better skid resistance and mitigation of hydroplaning effect. However, due to high voids content, this mixture is prone to ravelling and clogging and therefore its service life is limited. Strong interlock between bitumen and aggregates is an important requirement to keep the aggregate structure intact and thus ravelling in check. Some additives have been widely used in order to enhance the mechanical properties of conventional dense-graded asphalt mixtures (DGAM). Incorporation of additives can improve the stability and cohesion of the porous asphalt mix. In this paper, the suitability of different type of aramid fibers in PA mixtures is analysed with the purpose to improve the durability while maintaining the proper functionality requirements. In this study, volumetric analysis was carried out to assess the effect of five different types of fibers on the functional performance of the porous asphalt mixtures. In addition, dry and wet Cantabro tests were carried out to evaluate the performance of porous asphalt concrete with aramid fiber. Binder drain down tests were also performed in order to assess the potential of fibers to be used as stabilizer additives.

Keywords: porous asphalt mixes; additives; aramid fibers; synthetic fibers; Cantabro test

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1. Introduction

Porous asphalt (PA) pavements provide improved resistance to noise and skidding. Further, PA pavements reduce water splashing caused due to the passage of vehicles and improve visibility of the pavement surface in wet weather (Arrieta & Maquilón, 2014). Moreover, PA also contributes to minimize the impacts of impermeability created by urbanization (Rodríguez-Rojas, Huertas-Fernández, Moreno, Martínez, & Grindlay, 2018). Various researchers have found that the implementation of PA pavements can be enough for mitigating flood for return periods normally used in urban designs (Kumar, K., Kozak, J., Hundal, L., Cox, A., Zhang, H., Granato, 2016; Rodríguez-Rojas et al., 2018). Thus, the integration of porous asphalt pavement systems in urban road network system may result into significant ecological advantage due to their capability to attenuate peak runoff flows which can be a major reason of local flooding and sewer pipe overflows.

The concept of permeable pavements was proposed in 1960’s with the aim of promoting infiltration, lowering sewer loads, reduction in floods and recharging groundwater levels (Thelen, E., 1978). In the 1970s, the concept was refined for the determination of capabilities of permeable pavements considering the cost and efficiency parameters (U.S. Environmental Protection Agency,1980). In various states in US, a range of fully permeable pavement systems were developed for slow moving and light traffic, and the projects were claimed quite successful with minor flaws, which were mainly due to improper control on silts entering the porous pavement site and therefore clogging the pavement (H. Li, Jones, & Harvey, 2013, Hein, D., Schaus, L., 2016). Still, these failures led researchers to think about the concerns associated with design and maintenance of permeable pavements.

It was observed in various studies, that if properly designed, permeable asphalt pavements can be the best management practice for storm water runoff problems as well as groundwater recharge (Hansen, 2008, H. Li et al., 2013). Therefore, it becomes very important to come up with a design of permeable porous asphalt pavement that can perform well within its intended design period.

Porous asphalt (PA) mixtures have very high air void content due to which it lets water to pass through its structure. The open aggregate structure is achieved by incorporating lesser fines in mix, which in turn exposes the structure of mixture to environment (Aman, Shahadan, Zaime, & Noh, 2014). Due to the passage of water, the binder tends to oxidize more and hence, bonds in PA mixtures weaken leading to particle loss (Aman et al., 2014). Raveling is the major concern in PA mixtures (L. T. Mo, Huurman, Woldekidan, Wu, & Molenaar, 2010)(Zhang & Leng, 2017, Zhang & Leng, 2017, L. Mo, Huurman, Wu, & Molenaar, 2009, Quantao Liu, Yu, Schlangen, & Van Bochove, 2014, Quantao Liu et al., 2014, James, Watson, Taylor, Tran, & Rodezno, 2017, Frigio & Canestrari, 2018) which is responsible for its lower durability and lesser service life. The occurrence of raveling can be mitigated by increasing the binder content in the mix, however more binder can also lead to binder drainage. Therefore, to compute the optimum binder content a balanced design is required to keep both particle loss and draindown requirements well within the permissible limits.

Some additives can also be incorporated either in the binder or directly into the mix to improve the raveling resistance of the PA mixtures. Additives like warm mix modifiers, Nano-silica, crumb rubber, fibers are widely used in the conventional dense graded mixtures to improve the mechanical resistance (Kassem, Saleh, Zalghout, & Chehab, 2018). However, very few studies have been done of incorporation of these additives in the PA mixtures. The fibers can be broadly classified into two categories- natural and synthetic. Natural fibers like cellulose and mineral fibers improve the stability of the binder and reduce the draindown of the PA mixture (Afonso, Dinis-Almeida, & Fael, 2017). Cellulose fibers also improve the rutting resistance of the PA mixtures but could reduce the air voids in PA mixtures which can lead to less permeability. On the other hand, synthetic fibers like polyester fibers improve the abrasion resistance of the PA mixtures, but can have adverse effects on the indirect tensile strength and stiffness (Ma, Li, Cui, & Ni, 2018). However, no literature is available on the use of aramid fibers in PA mixtures.

2. Experimental plan

The main objective of this paper is to evaluate the effect of different fibers on functional and structural performance of porous asphalt mixes. In this study, a total of 5 different types of aramid fibers (four different types and one different size) are used to analyze the functional and mechanical performance of the fibers with comparison to the reference mixture. Mixtures with different fibers will be tested to calculate the optimum binder content. Further, the influence of fibers on binder stability and volume of air voids will also be investigated. The laboratory plan followed shown in Fig. 1, utilizes dry and wet Cantabro tests, binder draindown tests and volumetric analysis of the porous asphalt mixes. The parameters such as difference in particle loss, binder draindown percentage and voids in the mixture will be used to compare the different types of mix.
3. Materials

The materials that were used to design the porous asphalt mixtures, include penetration grade 50/70 bitumen, Ophite aggregates and limestone filler. According to Spanish guidelines (PG-3, 2015), the minimum air voids in PA mixtures is 20%. The mix were designed to target the PA-16 gradation according to Spanish guidelines (PG-3, 2015). Five different composition and size of aramid fibers are used (Fig. 2). Two types are regular aramid fibers of size 6mm (AR1 and AR2) as shown in Fig. 2 (a), (b) respectively. Figure 2 (c) are aramid fibers used in the study of 12mm size (A12) whereas Fig. 2 (d) shows aramid fibers of 6mm size coated with latex sizing (AL) and aramid chopped fibers with a polyurethane sizing (AP) are shown in Fig. 2 (e). A reference mix was also designed without adding any fiber, the optimum binder content in that case was 4.5% and is denoted by Ref4.5. A total of 35 Marshall specimens were prepared for this study. The binder content of PA mixtures was designed according to European standards for draining bituminous mixtures (EN 13108-7) and the Spanish guidelines “General Technical Requirements for Works of Roads and Bridges” (PG-3, 2015).

4. Results and discussion

4.1. Volumetric Analysis

Air void content is the most important parameter that influences the structural as well as functional characteristics of the PA mixtures. PA mixtures with high air voids will have high permeability, and it can drain large amount of water through their structure. However, PA mixtures with high air voids, have low durability due to limited resistance towards raveling and cracking. The volumetric analysis was done according to the European standards EN 12697-8. The calculated air voids for different mixtures are shown in Figure 3. It was observed that the all the mixtures with and without fibers followed the minimum criteria of 20% air void content.

The influence of AR2 and A12 fibers on the void content was found to be negligible as compared to reference mixture. Maximum reduction in air void content was observed by AL and AR1 fibers.
Figure 2. Types of fibers used in the study: (a) Aramid 6mm (AR1); (b) Aramid 6mm (AR2); (c) aramid 12mm (A12); (d) Aramid 6mm with Latex (AL) (e) Aramid 6mm with polyurethane (AP)
Highest voids were found in AP mix. Highest reduction in air voids in case of AL may be because the latex coating, which may have enhanced the compaction achieved at the same compaction effort, resulting into lesser air voids content.

### Figure 3. Air void content

![Air void content chart](image)

#### 4.2. Mechanical performance test

Since raveling is one of the most common type of failures that is prominent in PA mixtures (L. T. Mo et al., 2010; Zhang & Leng, 2017, Manrique-Sanchez, Caro, & Arámbula-Mercado, 2018), Cantabro test in dry and wet conditions were carried out. Cantabro test is widely used to calculate the abrasion resistance of the porous asphalt mixes (Mohd Shukry et al., 2018, Afonso et al., 2017, Katman, 2005, M. Li et al., 2016, Qingquan Liu & Cao, 2009, Lyons & Putman, 2013, Manrique-Sanchez et al., 2018, Chen, Sun, Liao, & Huang, 2012) shown in Figure 4.

![Cantabro Test Equipment](image)

#### Figure 4. Cantabro Test Equipment
This test is conducted following EN 12697-17 standard, this test is like Los Angeles test using the same equipment as for virgin aggregates but is carried out without any steel balls for Marshall samples of PA. The sample is placed in the Cantabro machine for 300 revolutions. The particle loss is the difference between the initial and final weight of the sample. Wet Cantabro test is conducted to compute the particle loss in wet conditions according to NLT 362/92. In wet Cantabro test, the samples are kept at 25°C then they are immersed in 60°C for 24 hours each and then the samples are again kept at 25°C and then the same procedure is followed to calculate the particle loss. The maximum particle loss in dry and wet conditions is limited to 20 and 35% respectively (PG-3, 2015). For every fiber, a minimum of three specimens were tested for both dry and wet Cantabro test. Specimens before and after carrying out Cantabro test are shown in Figure 5.

![Figure 5. Cantabro test (a) Samples before Cantabro test; (b) Samples after dry Cantabro test (c) Samples after wet Cantabro test.](image)

The results obtained from Cantabro tests are shown in Figure 6, it was found that comparing to reference mixture without fibers, all mixtures with aramid fibers showed lower particle loss. AL fibers considerably reduced the particle loss to approximately half value of the reference mixture, followed by regular AR1 aramid fibers. Among all mixtures with fibers, the least reduction was observed in AP mixture, however, it still provides better result as compared to reference mixture. Therefore, it can be explained that the presence of polyurethane with aramid fiber reduces the abrasion resistance considerably. For wet Cantabro test, the particle loss is more than the dry particle loss as in wet Cantabro test, the samples were immersed in water at high temperature resulting in lesser abrasion resistance. However, the effect of moisture is observed to be least in the case of mixtures AR1 whereas fibers with polyurethane coating (AP) have the maximum moisture susceptibility. Mixtures with AL fibers showed minimum absolute particle loss under wet conditions. All fibers except AP fibers improved the resistance of PA mixtures towards abrasion. It is evident that all mixtures displayed good results as no mixture exceeded the limit of 20% in dry conditions and 35% particle loss in wet conditions.
Draindown test is of particular importance in porous asphalt mixtures due to their high air voids. As at elevated temperatures, the binder has the tendency to drain from the aggregate structure. This test is conducted according to EN 12697-18. In this test, uncompacted mixture is placed in the wire mesh basket positioned on a dry paper/plate. Further, the entire set is placed in the oven for 3 hours at the compaction temperature. Then, the set is removed from the oven and the paper/plate is weighed again. The binder draindown is computed by following equation 1. The binder draindown value must not exceed 0.3% of initial mixture weight.

\[
\text{Binder draindown} = \frac{\text{final paper/plate weight} - \text{initial paper/plate weight}}{\text{Initial mixture weight}}
\]  

Figure 7 shows the result of draindown tests. It was observed that overall the mixtures performed well as the binder draindown is found to be negligible and the results were quite low as compared to maximum permissible limits (0.3%). AL fibers had no draindown whereas the AR2 fibers have the maximum binder drainage which shows that the aramid fibers coated with latex improves the binder stability in comparison to uncoated regular aramid fibers. However, the difference in results is not vast (in the range of 0.01%).
5. Conclusions

In this paper, the feasibility of incorporating aramid fibers as additives in the PA mixtures is discussed, considering different sizes and compositions. The influence of fiber on the air voids content of the mixture is not significant comparing to the reference mixture without adding the fiber, fixing other parameters such as binder content and gradation. Based on the analysis of results from this study, following conclusions can be drawn.

- AL fibers reduced the abrasion loss significantly, this may be due to presence of latex which provides strength to the mix and better compactibility AR1 fibers that are regular aramid fibers displayed lower particle loss as fibers with polyurethane coating AP which shows that polyurethane was not successful in improving the abrasion resistance especially in the wet condition. The particle loss is observed to be higher in the case of 12mm size aramid fibers, it may be due to lesser homogeneity of longer fibers as a result of improper mixing when compared to AR1 fibers.
- AR1 fibers showed minimum moisture susceptibility as the particle loss in Wet Cantabro test followed by A12 fibers and AR2, which suggests that use of regular aramid fibers result in maximum moisture resistance, as addition of polyurethane and latex have adversely affect the mix in wet condition resulted in higher particle loss.
- All mixtures performed well in draindown test. Maximum draindown was observed in the case of AR2, which suggests the least binder stability in the case of mixtures with AR2 fibers whereas no draindown was observed in the mixture with AL fibers which showed best accommodation of bitumen in the mix. It can be concluded that the latex improves the binder stability, thus allowing increased binder content in the mix. AP and AR1 fibers had no influence on the draindown as the draindown obtained was similar to that of reference mixture.
- Mixtures with AL fibers showed minimum air voids and maximum abrasion resistance whereas AP have maximum air voids and minimum abrasion resistance. Thus, air voids maintain an inverse relationship with the abrasion resistance. However, this relationship can be understood better by studying more types of fibers and mixes in laboratory.

For future line of work, it is recommended to extend the analysis of influence of aramid fibers to indirect tensile strength testing (ITS) and low temperature cracking resistance. It is also recommended to analyze the effect of increasing the bitumen content on binder draindown and strength of porous mixes containing aramid fibers. Further, the effect of mixing temperature, mixing time, aggregate composition and effect of short term and long-term ageing on performance of porous asphalt mixtures should also be studied.

Acknowledgements

This study is part of SAFERUP! an Innovative Training Network devoted to “Safe, Accessible and Urban pavements”. SAFERUP! Project has received funding from the European Union’s Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 765057. The author will also like to thank Teijin Company for providing fibers from the study.

References


