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Editorial

Special Issue: Recent Advances and Future Trends in Pavement Engineering

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Received: 31 March 2020; Accepted: 3 April 2020; Published: 5 April 2020

Abstract: This Special Issue "Recent Advances and Future Trends in Pavement Engineering" has been proposed and organized to present recent developments in the field of innovative pavement materials and engineering. For this reason, the articles and state-of-the-art reviews highlighted in this editorial relate to different aspects of pavement engineering, from recycled asphalt pavements to alkali-activated materials, from hot mix asphalt concrete to porous asphalt concrete, from interface bonding to modal analysis, from destructive testing to non-destructive pavement monitoring by using fiber optics sensors.

Keywords: interface bonding; moisture damage; alkali-activated materials; RAP gradation; hot mix asphalt dynamic modulus; porous asphalt concrete; FOS; FBG; flow number; rutting; modal analysis

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The twelve articles and state-of-the-art reviews of this Special Issue, "Recent Advances and Future Trends in Pavement Engineering", partly provided an overview of current innovative pavement engineering ideas, which have the potential to be implemented in industry in the future, covering some recent developments.

The interface bond between layers plays an important role in the behavior of pavement structure, especially in asphalt pavements. However, this aspect has not yet been adequately considered in the pavement analysis process due to the lack of advanced characterizations of actual conditions. Recently, it became one of the most important research topics in the field of pavements. RILEM TC 206-ATB, TC 237-SIB, TC 241-MCD and TC 272-PIM are among the most important international research activities considering this topic. Le et al. [1] suggested an interesting methodology for considering the interaction between pavement layers represented by a horizontal shear reaction modulus. Using this methodology, the field condition of the interface bond between the asphalt layers of experimental pavements in a full-scale test can be assessed using back-calculation from non-destructive testing. This study is a very good example providing a better understanding of the structural behavior of asphalt pavements and can contribute to a better evaluation of their long-term performance.

Moisture susceptibility is still one of the primary causes of distress in flexible pavements, reducing the pavements' durability. A very large number of tests are available to evaluate the susceptibility of a binder aggregate combination. Tests can be conducted on the asphalt mixture, either in a loose or compacted form, or on the individual components of an asphalt pavement. Apart from various mechanisms and models, fundamental concepts have been proposed to calculate the thermodynamic tendency of a binder aggregate combination to adhere and/or debond under wet conditions. Soenen et al. [2] summarized literature findings on the applied test methods, the obtained results, and the validation or predictability of these fundamental approaches.

The need to differentiate the pavements according to the final intended use has created different paving solutions, in terms of construction technology and materials. From the traditional bituminous pavements, the new design solutions encompass the application of special asphalt concretes (porous or colored asphalt mixtures), paving blocks, cobble stone pavements or a special ultra-thin surface layer. Paving blocks represent a suitable alternative to cobblestone or bituminous sidewalks, bike or pedestrian lanes and to historic pavements, especially in old city centers. These are commonly employed as paving solutions due to the relatively low production and laying costs. Tataranni [3] suggested the use of a waste basalt powder to produce alternative paving blocks through the alkali-activation process. The production of paving blocks through the alkali-activation of waste basalt powder seemed to be a viable alternative for interlocking modular elements.

Utilizing recycled asphalt pavements (RAP) in pavement construction is known as a sustainable approach with significant economic and environmental benefits. RILEM TC 264-RAP experts conduct scholarly international research and knowledge dissemination with a focus on asphalt material recycling. While studying the effect of high RAP contents on the performance of hot mix asphalt (HMA) mixtures has been the focus of several research projects, limited work has been done on studying the effect of RAP fraction and particle size on the overall performance of high RAP mixtures produced solely with either coarse or fine RAP particles. It was concluded by Saliani et al. [4] that the RAP particle size has a considerable effect on its contribution to the total binder content, the aggregate skeleton of the mixture, ultimately the performance of the mixture and that the black curve gradation assumption is not representative of the actual RAP particles contribution in a high RAP mixture.

The dynamic modulus of hot mix asphalt (HMA) is a fundamental material property that defines the stress-strain relationship based on viscoelastic principles and is a function of HMA properties, loading rate, and temperature. Because of the large number of efficacious predictors (factors) and their nonlinear interrelationships, developing predictive models for dynamic modulus can be a challenging task. In the research of Ghasemi et al. [5], results obtained from a series of laboratory tests including mixture dynamic modulus, aggregate gradation, dynamic shear rheometer (on asphalt binder), and mixture volumetric were used to create a database which was used to develop a model for estimating the dynamic modulus.

One of the most remarkable effects on the urban environment is the increase in impermeable surfaces which leads to problems related to water infiltration into the ground and the increase in wash-off volumes. The use of permeable and porous layers in urban applications for cycle lanes, footpaths and parking areas is growing in interest, considering their potential to tackle issues such as the urban runoff and the urban heat island effect. Tataranni and Sangiorgi [6] suggested the production of a low impact semi-porous concrete with a transparent polymeric binder and pale limestone aggregates. The application of synthetic aggregates seems to be a viable solution for the production of innovative and eco-friendly mixtures, allowing the recycling of waste materials.

Pavement design is essentially and usually a structural long-term evaluation process. It is very hard to devise an efficient method to determine realistic in situ mechanical properties of pavements, where the determination of strain at the bottom of asphalt pavement layers through non-destructive tests is of great interest. As it is known, fiber Bragg grating (FBG) sensors are the most promising candidates to effectively replace conventional strain gauges for a long-term monitoring application in a harsh environment. Kara De Maeijer et al. [7] summarized an overview of the recent developments worldwide in the application of fiber optics sensors (FOS) in asphalt pavement monitoring systems; to find out if those systems provide repeatable and suitable results for a long-term monitoring; if there are certain solutions to validate an inverse modelling approach based on the results of a falling weight deflectometer and FOS.

In the design of pavement infrastructure, the flow number is used to determine the suitability of a hot-mix asphalt mixture (HMA) to resist permanent deformation when used in a flexible pavement. Islam et al. [8] investigated the sensitivity of the flow numbers to the mix factors of eleven categories of HMAs used in flexible pavements. The flow number increased with increasing effective binder content, air voids, voids in mineral aggregates, voids filled with asphalt, and asphalt content.

Rutting is one of the most common distresses in asphalt pavements. The problem is particularly prevalent at intersections, bus stops, railway crossings, police check points, climbing lanes and other heavily loaded sections, where there is deceleration, slow moving or static loading. The most widely used methods to identify the source of rutting among flexible pavement layers are destructive methods; field trenching and coring methods. Chilukwa and Lungu [9] used the Transverse Profile Analysis method (TPAM), which is a non-destructive method to determine the layers of pavement responsible for rutting on sections. It was established that the TPAM was a simpler, faster and less costly method of determining the source of rutting failure compared to the traditional methods used in Zambia.

Rutting resistance can be improved by adding a small amount of RAP in asphalt mixes without significantly changing properties such as stiffness and low-temperature cracking resistance. However, there is no clear understanding of how RAP gradation and bitumen properties impact the mixture properties. Saliani et al. [10] indicated that the recovered bitumen from coarse RAP did not have the same characteristics as the fine RAP bitumen, and the interaction of RAP bitumen with virgin bitumen significantly depended on RAP particle size. The amount of active RAP bitumen in coarse RAP particles was higher than in fine RAP particles.

Kara De Maeijer et al. [11] investigated a feasibility of a natural peat fiber and finely ground peat powder as a modifier for bitumen. The rheological data showed stiffening effects of the powder fraction and the presence of a fiber network, which was strain-dependent and showed elastic effects. It was indicated that the fibers should improve the rutting resistance. The data revealed that the amount of added peat fibers and powder should be limited to avoid difficulties in the compaction of these asphalt mixtures.

Non-destructive testing (NDT) is an important part of optimizing any pavement management system. In the recent years, laser Doppler vibrometer (LDV) has been introduced to conduct non-contact measurements in road engineering. Hasheminejad et al. [12] investigated the quality of two types of commercially available LDV systems—helium–neon (He–Ne)-based vibrometers and recently developed infrared vibrometers. It was shown that the noise floor of the He–Ne LDV was higher when dealing with a non-cooperative dark surface, such as asphalt concrete, and it could be improved by improving the surface quality or by using an infrared LDV, which consequently improved the modal analysis experiments performed on pavement materials.

Acknowledgments: I would like to thank the authors who supported and contributed to my first Special Issue, the reviewers who dedicated their time to review the papers and MDPI Infrastructures Editorial Team.

Conflicts of Interest: The author declares no conflicts of interests.

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