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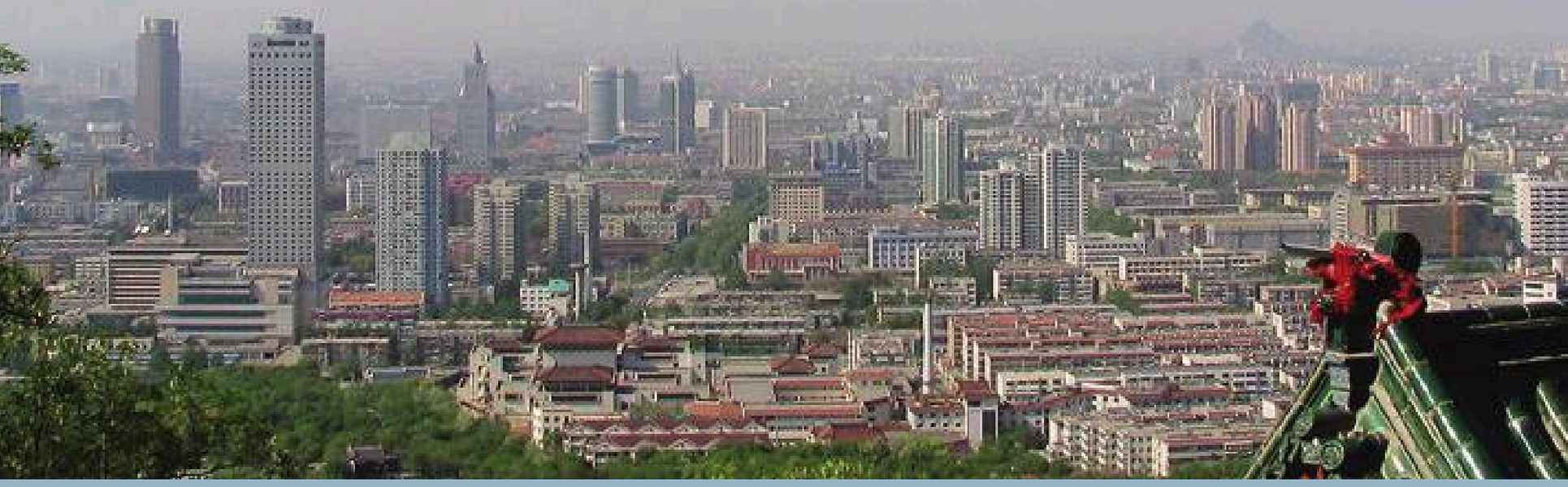

Innovative and Sustainable Solutions in Asphalt Pavements

Edited by

Dharamveer Singh, Ph.D.

Chichun Hu, Ph.D.

Jan Valentin, Ph.D.

Zhen (Leo) Liu, Ph.D.

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Preface

Recently significant emphasize have been given to explore sustainable solutions for construction of asphalt pavements. The utilization of recycled mix, warm mix technology, and innovative pavement design, performance evaluation methods have been reported by many researchers. This Geotechnical Special Publication (GSP) contains 30 papers that were presented at the GeoChina 2016 International Conference on Sustainable Civil Infrastructures: Innovative Technologies for Severe Weathers and Climate Changes, held in Shandong, China on July 25-27, 2016. Major topics covered are:

- Recycling of asphalt pavements;
- Pavement design, modeling, performance evaluation & management;
- Sustainable long life pavements;
- Warm mix asphalt.

The overall theme of the GSP is innovative and sustainable solutions in asphalt pavements, where the presented papers address different research issues and findings of this theme. This publication provides a good and timely overview of recent trends and the newest aspects of the key research areas related to asphalt pavements. It provides an effective means of sharing recent technological advancements, engineering applications and research results among scientists, researchers and engineering practitioners.

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Properties of Asphalt Mixtures with Multiple Recycled Asphalt Material

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Abstract: Asphalt recycling is a crucial part of end-of-life strategies for pavements which are for many years in operation. It fully respects the defined trends of European Union to become a non-waste society with challenging targets for the whole industry. In case of pavement engineering recycling technologies are well know and have been developed for several decades covering cold ad hot solutions depending on the preferences of particular markets. The question presently is how to deal with pavements once recycled. Since such material will not last in the pavement forever it is important to understand if it can be used more efficiently than like aggregates. In this respect solutions have been searched both in cold and hot recycling adding at least 30 % of once recycled material in new asphalt mixtures. In parallel it was analyzed what kind of activity can be identified for these recycled asphalt materials. For the experimental study original reclaimed asphalt was used in a standard way for cold recycled mix using either bituminous emulsion or foamed bitumen. The mix was laboratory aged according to test protocol drafted for European market. Aged cold recycled asphalt material was crushed to simulate a second cold milling and gained granular material was again used as reclaimed asphalt in cold recycled mixes and in standard hot mix asphalt (HMA). Different binders were applied for HMA analyzing the effect of additives used. In case of cold recycled mix mainly the content of added binder was analyzed. For designed mixes mechanical and functional tests were performed to get a more complex understanding of the impact of multiple recycling on mix behaviour. From the perspective of functional testing mainly stiffness and crack behaviour was analyzed. The paper summarizes gained results and gives an overview of potentials related to multiple recycling of asphalt pavements including the influence of selected additives.

INTRODUCTION

Cold recycling of asphalt pavements is a widely applied and mostly approved procedure for full-depth rehabilitation measures. Whereas the mix design procedures for optimizing the properties of cold recycled mixtures are well researched, the end-of-

life strategies for this type of pavement layers are not known so far. Nevertheless, modern pavement materials have to consider end-of-life characteristics in order to avoid costly and environmental hazardous disposal of these materials in the future.

The recycling of road material in new pavements is a proven practice since several centuries. For asphalt pavements the most common applied recycling procedures are hot recycling in new hot-mix asphalt as well as cold recycling in new base layers with bitumen emulsion, foamed bitumen and/or hydraulically binders. In recent years also applications in warm mix asphalt are more common and seen as an alternative to HMA containing RAP. The procedures for recycling in these materials are widely well researched and described in several guidelines [e. g., Wirtgen 2012, Grilli et al. 2012] and further prescribed for the European harmonization process in CoRePaSol project [Valentin et al. 2014].

Though, what have not yet been researched are the end-of-life characteristics of cold recycled materials. For hot recycling process [De Visscher et al. 2012] showed that the commonly used hot recycling process can be repeated several times considering moderate contents (50%) of RAP in new hot mixtures. The properties of the aged binder in the reclaimed asphalt can be leveled by virgin binder with reduced viscosity which results in new asphalt mixtures reaching similar quality compared to asphalt mixtures fully composed by new materials.

In order to assess the recyclability of pavement layers composed of cold recycled materials, a laboratory campaign was conducted on newly produced cold recycled mixtures. After the accelerated aging of the materials in laboratory their applicability in new road materials was evaluated.

Firstly, the recyclability in new cold-recycled materials was assessed. Even three recycling cycles were analyzed in order to evaluate the multiple-recycling characteristics. Secondly, the recyclability of cold-recycled material in new hot and warm-mix asphalt was evaluated. One of the main goals was to check if the bituminous binder from the cold recycled mixture can be reactivated in new hot/warm-mix asphalt layers. This would enable the upgrading of cold recycled base layers even to continuously bound asphalt base, binder or surface layers.

MIX DESIGNS AND MATERIAL FOR MULTIPLE RECYCLING

For the evaluation of the end-of-life-properties of cold recycled road materials two sets of experiments were conducted. In the first step the multiple recyclability of cold recycled material in new cold-recycled mixture was analyzed. In the second step the recyclability of cold recycled base layer material in a new HMA or WMA was tested. Therefore, two cold recycled mixtures were prepared in laboratory and artificially aged. These aged materials were then applied as reclaimed road mixtures. In parallel four different cold recycled mixes representing main combinations of used binders were prepared and artificially aged. Resulting material was used for one type of cold recycled mix with reduced bitumen emulsion content as well as in hot/warm asphalt mix applicable for wearing courses. This paper shows only the results for multiple cold recycled mixes.