DETERMINATION OF CRITICAL ASPHALT PAVEMENT VOIDS THROUGH LABORATORY AGING

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A Dissertation

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Doctor of Philosophy

at

The University of Connecticut

1992

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The University of Connecticut, 1992

This research attempts to determine critical asphalt pavement voids through laboratory aging. The critical voids are defined as void levels in the asphalt pavement system above which aging occurs rapidly.

A comprehensive literature review is compiled at the beginning of this dissertation. The review is intended to present a state of the art on research directed to understanding the phenomenon of asphalt pavement aging and to identify some promising aging and test methods.

An oven heating procedure is selected to duplicate long-term field aging. In this procedure, pavement samples are prepared at predetermined void levels and placed in the oven maintained at 140 degrees Fahrenheit (60 degrees Celcius) for a period of 24 hours. During this period, air at low pressure is applied to the samples.

After the aging is completed, the asphalt in the aged sample is extracted following the Abson recovery method. The effect of aging is then quantified in terms of percent penetration retained (PPR) and viscosity aging index (AI). The asphalt viscosity temperature susceptibility is also examined before and after aging.

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The results show that the relative aging rate of the asphalt in the mixture increases with air voids. The critical voids are determined to be between 9 and 13 percent, using the percent penetration retained, or between 9 and to 11 percent, using the viscosity aging index. It is also found that the viscosity temperature susceptibility of the asphalt tends to decrease after aging.

The critical voids determined can be used to establish an upper limit for asphalt pavement voids with the intent of controlling oxidative aging. It is recommended that such an upper limit should not exceed 9 percent.

APPROVAL PAGE

Doctor of Philosophy Dissertation

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Dedication

To my family;
my dear wife Anna,
and my daughter Debora.

HIDUP, adalah ....
Suatu keindahan yang harus dikagumi,
Suatu janji yang harus ditepati.

Acknowledgements

I would like to acknowledge the assistance I received from several institutions and individuals throughout my study period and during the preparation of this dissertation. I am grateful to the Civil Engineering Department of the University of Connecticut, the Connecticut Department of Transportation, and Parahyangan Catholic University (Bandung, Indonesia) for without their financial support my graduate study would not have been possible.

I am deeply indebted to Dr. Jack E. Stephens, my teacher and friend, for providing me a research assistantship and, more importantly, for his guidance and constructive suggestion throughout the development of this study. I would like to thank Dr. Erling Murtha-Smith for his assistance as my major adviser, and Dr. Christian F. Davis, Dr. Hallas H. Ridgeway, Dr. Kenneth R. Demars, and Dr. Dipak K. Dey for their participation in my final exam. I should express my appreciation to Dr. Richard D. Walker, my former adviser at Virginia Polytechnic Institute and State University, for his continuing encouragement which motivated me to do a Ph.D study. I would also like to extend my sincere appreciation Dr. A. Koesdarminta, Dr. Djoko Soelarnosidji, Dr. Pande R. Silalahi, Mr. Suhartono Susilo, and Mr. F. Vermeulen, of Parahyangan Catholic University, for giving me an opportunity to do graduate studies in the U.S.

I wish to thank my colleague Robert J. Balfe, for making Storrs an enjoyable town for me and my family to live in, and my friends Paulus P. Rahardjo, Robertus W. Triweko, Purnawarman B. Supardi, Markus R. Kusuma, Barita Manullang, Rini Sukwandi, Upadi Yuliatmo, Sujitno Sajuti, and Amir Awaluddin, for sharing with me their experience in doing graduate work in the U.S.

I shall be forever indebted to my parents, Mr. & Mrs. Suherman Budisantoso, Mr. & Mrs. Marcus H. Teha, and Mr. & Mrs. Jeff McLeod for their invalueable advice and support which gave me strength when it was needed most.

Finally, my hearty thanks go to my family; to my daughter Debora who missed my paternal care and attention during my study period, and to my dear wife Anna for her love, patience, and support which continually maintained my sanity. To them my study is dedicated.

Terima kasih.

Table of Contents

List of Tables

List of Figures

Chapter I

Introduction

1.1 Background

Many highway agencies are concerned with the performance and life of pavements. In the small state of Connecticut, there are over 30,000 miles of roadways. Continuing development increases this mileage by over 2 % annually. In the fifties, the average life of bituminous pavement was 16 years. Today, the life of many roads is only 8 years. Since the Connecticut Department of Transportation spends about 70 million dollars a year to maintain its roads, the reduction in pavement life of 50 % could result in an increase in the state pavement expenditures by about 35 million dollars a year (1).

The performance of bituminous pavement is a function of pavement stiffness, pavement support, and loading. As there is little probability that loading will decrease and improved support requires complete rebuilding, improved overlay life must come about through control of overlay stiffness. Aging increases stiffness and must be controlled for any significant improvement in performance.

Traditionally, the prediction of long-term pavement performance has been based on the properties of the neat asphalt. However, recent studies show that using only the properties of the asphalt prior to being mixed with aggregates and compacted into pavement is inadequate. Mixing temperatures, storage conditions, climatic conditions, access to oxygen, and other factors are also important.

The importance of aging in the deterioration of asphalt pavement is graphically illustrated locally on Road I-384 around Willimantic. The cracking of the asphalt surface over the concrete bridge decks is as intense as that of the adjacent pavement, yet the flexing due to loading is minimal. Aging has caused the mix to become excessively hard and brittle and susceptible to cracking failure.

This problem can be explained based on the relative coefficients of expansion of stone and asphalt and the effect of traffic on the pavement. The coefficient of expansion for asphalt is about 18 times that for stone. As day progresses, the sun warms the pavement and both asphalt and aggregate expand. The asphalt must move with respect to the aggregate and the resistance is less in the vertical direction. The asphalt flows upward and tends to raise the upper portion of the aggregate with it. During the night, the temperature falls and the materials contract. The cohesion of the asphalt cannot pull the aggregate as tight as originally compacted by the roller. Consequently, the voids in the pavement steadily increase until air can pass freely through the pavement which results in hardening of the asphalt film in the pavement system. Traffic tends to recompact the pavement layer slowing the level of void increases. The traffic on this particular road is apparently not enough to recompact the pavement.

It is easy to make an asphalt aggregate mixture that, upon compaction, will have no air void and so should not age. Unfortunately, the asphalt content of the mixture will be very high and the pavement will rut and shove under traffic. Reducing the asphalt and fine aggregate content increases the pavement stability but makes for difficulties in compacting to a low air void level. All present day mixtures are then compromises between long life (high asphalt and/or fines for dense mixtures) and high stability (low asphalt with little fines for open mixtures). An example for the latter is that a typical specification for the harsh mixtures now in use would require at least 5 % but not more than 9 % voids in the compacted layer. The lower limit is intended to insure adequate space so that if any further densification should occur, especially in hot weather, the asphalt would not be squeezed out. With very little information available, the upper limit has been set arbitrarily with the intent of controlling air aging.

1.2 Objectives

The purpose of this research is to obtain a better understanding of the aging of asphalt pavements associated with the air void content. The study is intended to determine what portion of aging of the mixture is due to oxidation and what minimum level of mixture voids is necessary for the access of oxygen to cause aging by subjecting the mixture to laboratory aging. The results will provide a rational means for the establishment of the upper limit of air void contents for a mixture to control age hardening.

A review of previous related work that has been used to assess the effect of aging is also compiled. The review is intended to present various aging procedures and test methods which show promise for further laboratory investigation. A suitable procedure will then be adopted for this study.

The objectives of the research are :

1. To determine if there is a critical air void range in asphalt pavements above which the aging occurs rapidly.
2. To study the effect of air void levels on the aging rate of asphalts in the pavements.
3. To investigate the effect of mixture types and aggregates used on the aging of asphalt mixtures.
4. To evaluate the effectiveness of the laboratory aging used in this study, and
5. To find out if the resulting information can be used to enhance the present design specification.

The research approach includes preparing samples at various air void contents, aging the samples artificially, and evaluating the property of the asphalt binder before and after the artificial aging. A correlation between the air void and the aging rate will be developed. A break point in a plot of asphalt rheological property versus air void should indicate the critical void for the pavement.