Airfield and Highway Pavements 2021

Pavement Design, Construction, and Condition Evaluation

Selected Papers from the Proceedings of the International Airfield and Highway Pavements Conference 2021

>> June 8–10, 2021

Edited By

Hasan Ozer, Ph.D.

John F. Rushing, Ph.D., P.E.

ASCE

TRANSPORTATION & DEVELOPMENT INSTITUTE

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Preface

Airfield and highway pavements are critical components of our transportation infrastructure. Increasing demand on these assets creates a unique challenge for researchers and practitioners to find sustainable solutions to managing their life-cycle. The airfield and highway pavements specialty conference is a unique setting where the world's foremost experts in pavement design, construction, maintenance, rehabilitation, modeling, management, and preservation meet and present most recent developments in the pavement engineering area. Building on the success of our past conferences, the 2021 International Airfield and Highway Pavements Conference of ASCE's Transportation and Development Institute (T&DI) displayed the adaptive nature of our profession as we held our first completely virtual event from June 8-10, 2021.

The 2021 virtual conference was designed to feature plenary sessions and panel discussions on important topics facing government agencies and industry. Technical breakout sessions allowed researchers and practitioners to present deeper technical content on breakthrough practices and technologies. The virtual poster session allowed "on-demand" access to cutting edge research.

The proceedings of the 2021 International Airfield and Highway Pavements Conference have been organized into three publications and are described as follows:

Vol I: Airfield and Highway Pavements 2021: Pavement Design, Construction, and Condition Evaluation
This volume includes papers concerning mechanistic-empirical pavement design methods and advanced modeling techniques for highway pavements, construction specifications and quality monitoring, accelerated pavement testing, rehabilitation and preservation methods, pavement condition evaluation, and network-level management of pavements.

Vol II: Airfield and Highway Pavements 2021: Pavement Materials and Sustainability
This volume includes papers describing laboratory and field characterization of asphalt binders, modifiers and rejuvenators, asphalt mixtures and modification, recycled and waste materials in asphalt mixtures, unbound base/subgrade materials and stabilization, pavement life-cycle management, interactions of pavements and their environment, and recent advances in cementitious materials characterization and concrete pavement technology. In this volume, we also included papers introducing cutting edge innovative and sustainable technologies used in pavement applications.

Vol III: Airfield and Highway Pavements 2021: Airfield Pavement Technology
This volume includes papers on recent advances in the area of airfield pavement design, construction, and rehabilitation methods, modeling of airfield pavements, use of

accelerated loading systems for airfield pavements, and airfield pavement condition evaluation.

The papers have undergone a rigorous peer review by at least two to three international highway pavement and airfield technology experts and a quality assurance process before becoming a publication of ASCE – the world's largest publisher of Civil Engineering content.

The success of the conference is a tribute to the incredible efforts of the leadership team consisting of Conference Co-Chairs (Hasan Ozer, John Rushing, and Zhen Leng) and Advisory Board (Imad Al-Qadi and Scott Murrell) along with an outstanding Conference Steering Committee (Amit Bhasin, Rick Boudreau, Zeijao Dong, Jeffrey Gagnon, Tom Harman, Andreas Loizos, Geoffrey Rowe, Injun Song, Leif Wathne, and Richard Willis) and terrific support from ASCE T&DI staff. The efforts of the Conference Scientific Committee are graciously acknowledged for their role in reviewing papers and providing critical feedback to the authors.

We thank everyone who attended the virtual conference and hope to see everyone again in 2023!

Hasan Ozer, Ph.D., A.M.ASCE, University of Illinois at Urbana-Champaign
John Rushing, Ph.D., P.E., M.ASCE, U.S. Army Engineer Research and Development Center
Zhen Leng, Ph.D., M.ASCE, Hong Kong Polytechnic University

Contents

Influence of Tire Footprint Contact Area and Pressure Distribution on Flexible Pavement

Ainalem Nega, Ph.D.[1]; and Daba Gedafa, Ph.D.[2]

[1]Dept. of Civil Engineering, Curtin Univ., Perth, WA, Australia. Email: Ainalem.Nega@curtin.edu.au
[2]Dept. of Civil Engineering, Univ. of North Dakota, Grand Forks, ND. Email: daba.gedafa@UND.edu

ABSTRACT

Effect of tire-pavement contact pressure distribution on flexible pavement is generally complex and dynamic, and it is affected by tire types. In addition, there are several inconsistences in data analysis from several experimental studies in measuring contact pressure distribution between tire and pavement. The main purpose of this study is to evaluate the influence of tire footprint contact area and pressure distribution on flexible pavements. Tire-pavement contact stress and interaction model were simulated using 3D finite element for five layers (asphalt concrete, unbound base and subbase, compacted, and natural subgrade) of flexible pavement at various loads. An axisymmetric and tire-pavement 3D finite element model was developed. A good correlation agreement between contact area and deflection was observed. For thin and thick pavement in the static analysis, contact area reduced 3.5% and 3.8%, respectively, while the static deflection for thin pavement decreased from 43.5 mm when E = 0.01 to 30.5 mm when E = 100 GPa, reduction of 29.9%. Whereas for thick pavement, the deflection between static and rolling analysis was not significant, similar trends of deflection between thin and thick pavement were obtained. The tire's finite element model was validated using measured contact area and deflection. The results of analysis were then compared to simplify the results of the modeling considering its effects on flexible pavement. This finding may have important implication for design of relatively thin asphalt surface layered than thick pavement.

Keywords: Tire-pavement contact stress; flexible pavement; tire foot print contact area; axisymmetric; thin pavement, thick pavement; finite element model

INTRODUCTION

The importance of road transportation and development has been growing in the entire world since the past three decades – not only as the result of the development of the road infrastructure but also as a result of the technical development of trucks (Hernandez and Al-Qadi 2016; Hernandez et al. 2015; Huhtala et al. 1989). Transportation vehicles have become heavier and heavier, and their load – carrying capacity has also become greater and greater. Engines are more powerful, cabs more comfortable, and important developments have been made in axles, tires and suspensions (Hernandez and Al-Qadi 2016; Huhtala et al. 1989).

Where the deteriorating flexible pavement infrastructure and investigation load conditions are, tire-pavement contact stresses usually receives a special attention (Hernandez and Al-Qadi 2016) not clear. Pavement contact stresses are not the only directly affect related to several and/or various types of distresses as discussed by Hernandez's but are also the only feasible manner to compare the effect of various tire types on pavement damage (Al-Qadi and Wang 2011; Nega and Nikraz 2017) such as conventional dual-tire and wide-base tires.

The increased traffic roads and heavier urban vehicles cause much more distress to road pavements than ever before in history. The regulation of weights and dimensions are even more significant in the wake of substantial pressure from the development and transportation industry to allow on the highways pavements (Gungor et al. 2016; Nega and Nikraz 2017).

The effect of tire-pavement contact pressure distribution on flexible pavement is generally complex and dynamic, and it is affected by axles, tires, geometry configurations, and vehicles types including load – carrying capacity (Dessouky et al. 2014; Nega and Nikraz 2017). There are several inconsistences in data analysis from several experimental studies to understand and evaluate the influence of tire-pavement contact area and pressure distribution between the tire and pavements including setting the acceptable standard for thin and thick pavements.

The main purpose of this study is to evaluate the influence of tire print contact area and pressure distribution on flexible pavements. Tire-pavement contact stress interaction model was simulated using 3-D finite element for five layers. An axisymmetric and tire-pavement 3D finite element model was developed, and deflection for thin and thick pavements was determined using the statics analysis.

TIRE-PAVEMENT FE MODEL DESCRIPTION

The tire-pavement pressure distribution is generally known to be complex and affected by tire type. There are many inconsistencies in the data from various experimental studies measuring the distribution of contact pressure between tire and pavement. Simplifying assumptions have been used in literatures, including the use of a circular contact with contact pressure equal to the tire pressure (Nega 2016; Nega and Nikraz 2017).

The flexible pavement was composed of five layers: Asphalt concrete (AC), unbound base and subbase, compacted and natural subgrade. Each layer's thickness changes depending on the type of flexible pavement considered. In the case of a thick pavement, the thickness of the AC and unbound base were 50 and 100 mm, respectively. The thickness of unbound subbase, compacted and natural subgrade were 250, 75 mm and infinite, respectively. Regarding the material properties, the AC layer was assumed linear elastic with varying modulus between 1.2 and 1.5 GPa. Assuming AC as linear elastic material instead of viscoelastic is not expected to have a negative consequence on the conclusion of this particular study (i.e. second step for validation) because the main objective is not the study of flexible pavement behavior, but analyzing the impact of tire-inflation pressure on the flexible pavement.

Unbound subbase, compacted and natural subgrade were determined by the Mohr Coulomb and Drucker-Prager model (Nega et al. 2015) because the illustration of the typical cross section of the five layer linear elastic of the flexible pavement model is considered a viscoelastic on the pavement area, which means the unbound base was considered nonlinear for the thin pavement and linear elastic for a thick pavement (Hernandez and Al-Qadi 2016; Nega 2016).

The model was verified using Falling Weight Deflectometer (FWD) data from seven main roads and creep test to assure the integrity of the in site experimental data were used in the verification of the finite element (FE) model in ABAQUS. The detail experiments can be found (Mulungye et al. 2007; Nega et al. 2015; Nega et al. 2016; Owende et al. 2001). For a thin pavement, the stress level in base layer is significant (Hernandez and Al-Qadi 2016), so the stress-dependency of the resilient modulus becomes significant. However, in the case of thick