ADAPTATION OF AUSTROADS MECHANISTIC-EMPIRICAL PAVEMENT DESIGN FOR TROPICAL CLIMATES

Rajapakshe Pathirannehelage Piyumee Kaushalya Premarathne

(178064C)

A thesis submitted in partial fulfilment of the requirements for the degree Master of Philosophy

Degree of Master of Philosophy

Department of Civil Engineering

University of Moratuwa
Sri Lanka

March 2022

DECLARATION

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R.P.P.K. Premarathne

The above candidate has researched for a Master of Philosophy (MPhil.) under my supervision.

Signature of the supervisor: ………………………………… Date: 30/04/2023

Professor. W.K. Mampearachchi

Signature of the supervisor: ………………………………… Date: 30/04/2023

Professor. M. Gunaratne

ABSTRACT

Many road agencies have employed conventional empirical pavement design methods, such as the American Association of State Highway and Transportation Officials (AASHTO) and Transport Research Laboratory (TRL) Overseas Road note 31 guidelines, to design and analyse flexible pavements. Empirical pavement design methods utilise empirical formulae based on past experiments conducted in extreme weather conditions. They have significant drawbacks permitting limited freedom for pavement designers, leading to material constraints in road projects. Such restrictions may result in high costs for hauling materials from far sites, leading to increased costs for road construction projects. Road agencies have identified the advantages of mechanistic-empirical (M-E) pavement design methods that accommodate available materials resulting in economical designs. However, performance models given in M-E methods are derived under laboratory conditions and require calibrations to the field. Austroads is one of the most recognised M-E guidelines widely used in Australia and New Zealand. It accompanies a user-friendly and time-efficient software package-CIRCLY. This research was focused on adapting the Austroads M-E pavement design guidelines for tropical climates. Austroads suggests two performance models, each for fatigue cracking and subgrade rutting. This research focused on calibrating the default performance models proposed by Austroads by finding the most suitable damage exponent (b) and shift factor (SF) for tropical climates. Calibrating the default fatigue performance model was only considered. Data from two A-class roads were obtained for model development and model validation. Cumulative damage factor (CDF) representing the accumulated fatigue damage was estimated at varying damage exponents (b) and shift factors (SF) using the mechanistic design software-CIRCLY. The alligator cracking index (ACI) suggested by the Federal Highway Administration (FHWA), quantifying the fatigue damage level, was calculated using visual surveys to detect and classify pavement distresses. It could be observed that the CDF have a strong relationship with the ACI. The most robust relationship between the ACI and the CDF could be observed at the damage exponent (b)= 5.1 and the shift factor (SF)= 2.5. CDF values were computed for the model validation by inputting the calibrated damage exponent (b=5.1) and shift factor (SF=2.5) to the mechanistic design software-

CIRCLY. ACI values were predicted by substituting these calculated CDF values for the derived regression model. When the observed ACI values were plotted against the predicted ACI values, it could be noticed that the best-fit curve for the observed ACI and predicted ACI has $R^2 = 0.99$ and slope = 1.007. This observation emphasizes the accuracy of the derived model, thereby justifying its use for the design and analysis of flexible pavements for tropical climatic conditions. Therefore, it can be justified that adapting the Austroads mechanistic pavement design guideline for tropical climates is highly favourable by modifying the default performance relationships. The use of mechanistic tools to design and analyse pavements was strongly emphasised during the analysis steps, ensuring the reliability of such tools in pavement design and analysis. As the M-E design procedure allows the designer to use available materials, adapting the M-E design procedure will address the material constraint in road construction projects and deliver more cost-effective designs. This will finally help reduce unwanted expenditures and improve the economic aspect of road construction projects.

Keywords: Mechanistic-Empirical (M-E) Pavement Design, Austroads, Modified failure functions, Alligator Cracking Index (ACI), CIRCLY, Cumulative Damage Factor (CDF), Tropical climates

DEDICATION

To

My Loving Motherland, Sri Lanka

ACKNOWLEDGEMENTS

I want to offer my immense gratitude to my research supervisor Professor. Wasantha Kumara Mampearachchi, at the Department of Civil Engineering, University of Moratuwa, Sri Lanka, offered me this excellent opportunity to pursue my passion for research and academia. I am thankful for the great exposure you gave me to build my confidence and the invaluable support throughout these years to achieve this most extraordinary milestone.

I want to thank my second supervisor, Professor Manjriker Gunaratne, University of South Florida, Tampa, for his outstanding support throughout the research and positive input to make this research a success. I am grateful to Professor. J.M.S.J. Bandara, Dr. H. R. Pasindu at the Department of Civil Engineering, University of Moratuwa, Sri Lanka and Dr S. P. Jayakody at the Southeastern University, Sri Lanka, for your timely instructions and valuable advice in making this research a success.

My genuine appreciation goes to all the Road Development Authority (RDA) staff, who supported the collecting and analysing of data. I want to thank all the Planning Division directors and the RDA's Research and Development (R and D) for providing me with the necessary data. I want to thank the RDA's audit director (retired), Mr Keerthi Damboragama, for your immense support for the data collection. I thank Senior Engineer Mr Sugeeth Samarasinghe for his invaluable support throughout the research. I am obliged to Mr Kasun Muthunayake and Mr Imesh Pushpakantha at the Planning Division of RDA for serving me in obtaining the required data on time.

Further, I would like to thank Ms Melani Jayakody, Mr Uditha Padmaperuma, and Mr Pathum Fernado for supporting me throughout this project. I want to thank all the academic and non-academic staff members at the Civil Engineering Department, University of Moratuwa, Sri Lanka, who helped me.

Last but not least, throughout this study, I appreciate the encouragement and support from my loving family and friends. I would not be who I am without my family and friends.

R.P.P.K. Premarathne

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LIST OF ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
AADT	Average Annual Daily Traffic
ABC	Aggregate Base Course
AC	Asphalt Concrete
ACI	Alligator Cracking Index
CBR	California Bearing Ratio
CDF	Cumulative Damage Factor
CESAL	Cumulative Equivalent Standard Axle Load
DBST	Double Bitumen Surface Treatment
DESA	Design Equivalent Standard Axles
ESAL	Equivalent Standard Axle Load
FHWA	Federal Highway Administration
FHWA RIP	Federal Highway Administration's Road Inventory Program
FWD	Falling Weight Deflectometer
M-E	Mechanistic-Empirical
M_R	Resilient Modulus
MCC	Manual Classified Count
MEPDG	Mechanistic-Empirical Pavement Design Guide
MSE	Mean Squared Error
NCHRP	National Cooperative Highway Research Program
NDT	Non-Destructive Testing
NPS	National Park Service
PCI	Pavement Condition Index
PMS	Pavement Management Systems
PSI	Present Serviceability Index
RDA	Road Development Authority
RF	Reliability Factor
RI	Roughness Index
SAR	Standard Axle Repetitions
SF	Shift Factor
TLD	Traffic Load Distribution
TRL	Transport Research Laboratory
WMAAT	Weighted Mean Annual Air Temperature
WMAPT	Weighted Mean Annual Pavement Temperature
SAST	Single Axle Single Tyre
SADT	Single Axle Dual Tyre
TAST	Tandem Axle Single Tyre
TADT	Tandem Axle Dual Tyre
TRDT	Tridem Axle Dual Tyre

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