# IMPACT OF DIFFERENT PERFORMANCE PREDICTION MODELS ON MECHANISTIC-EMPIRICAL FLEXIBLE PAVEMENT DESIGN

By

Momen Ragab Mousa Mohamed

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Civil Engineering-Public Works

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**Title of Thesis:**

IMPACT OF DIFFERENT PERFORMANCE PREDICTION MODELS ON MECHANISTIC-EMPIRICAL FLEXIBLE PAVEMENT DESIGN


**Key Words:**

Pavement Prediction Models; Transfer Functions; M-E; Pavement Design; Environmental Effect; Fatigue Damage



**Summary:**

Over the last several years, there has been a shift of the flexible pavement design from the Empirical to Mechanistic-Empirical (M-E) procedure. Several prediction models have been developed for the M-E procedure to analyze fatigue and rutting failures. Each model has its own parameters, limitations, and magnitude of failure damage. This research presents an assessment of the performance of commonly used fatigue and rutting models under different conditions of traffic loading and climate for new and rehabilitated pavement structures. The study was performed to calculate Ac thickness required for two existing pavement cross sections located on major road network in Egypt under wide range of ESALs and two different climatic conditions. Six fatigue models and four rutting models were considered in this study together with six fatigue/rutting failure criteria. A total of 880 computer runs were performed for different combinations of fatigue/rutting models, failure criteria, traffic conditions, and climate using OLFLEX software. This software was developed in a previous study at Cairo University based on Egyptian environmental conditions. For each run, the required AC overlay thickness and fatigue/rutting damage ratios were calculated. The analysis of results indicated that the design is mostly controlled by fatigue failure in old asphalt layer. The analysis also indicated that the Asphalt Institute (AI) and Transport and Road Research Laboratory (TRRL) models are the most appropriate ones to be used in the M-E flexible pavement design.

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# Dedication

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# Nomenclature

GARBLT = General Authority for Roads, Bridges and Land Transport

ME = Mechanistic-Empirical

AC = Asphalt concrete

AI = Asphalt Institute

TRRL = Transport and Road Research Laboratory

Mn = Minnesota

ARE =Austin Research Engineers

AASHTO = American Association of State Highway and Transportation

SHRP = Strategic Highway Research Program

NSHRP = National Cooperative Highway Research Program

ESAL = Equivalent Single Axle Load

# Abstract

Over the last several years, there has been a shift of the flexible pavement design from the Empirical to Mechanistic-Empirical (M-E) procedure. The main design considerations in the M-E procedure are: to limit the horizontal tensile strain induced at the bottom of the Asphalt Concrete (AC) layer to minimize fatigue cracking and; to limit the vertical compressive strain induced on the top of the subgrade to control permanent deformation or rutting. Several fatigue and rutting performance models or transfer functions have been developed by various highway agencies to relate the asphalt modulus and/or the measured strains to the number of load repetitions to fatigue and rutting failures. Each model has its own parameters, limitations, and magnitude of failure damage. The objective of this research is to assess the impact of using different transfer functions on the designed thickness of flexible pavements under different conditions of traffic loading and climate for new and rehabilitated pavement structures.

Two major roads located in North and South of Egypt were selected in the study to represent two different climate conditions. A wide range of traffic loading conditions (ESALs) is considered in the analysis together with six fatigue models and four rutting models. Moreover, six fatigue/rutting failure criteria were taken into consideration. This creates a total of 880 computer runs using OLFLEX software, a Mechanistic-Empirical overlay design system, which was developed in a previous study at Cairo University based on Egyptian environmental conditions. For each run, the required AC overlay thickness and fatigue/rutting damage ratios were recorded.

The analysis of results indicated that the overlay design is mostly controlled by fatigue failure in old asphalt layer. The analysis also indicated that the Asphalt Institute (AI) and Transport and Road Research Laboratory (TRRL) models are the most appropriate ones to be used in the M-E flexible pavement design.