

الاية

بسم الله الرحمن الرحيم

وَعِنْدَهُ مَفَاتِحُ الْغَيْبِ لَا يَعْلَمُهَا إِلَّا هُوَ وَيَعْلَمُ مَا فِي الْبَرِّ وَالْبَحْرِ وَمَا تَسْقُطُ مِنَ وَرَقَةٍ
إِلَّا يَعْلَمُهَا وَلَا حَبَّةٍ فِي ظِلْمَةٍ إِلَّا يَعْلَمُهَا وَلَا رَطْبٍ وَلَا يَابِسٌ إِلَّا فِي كِتَابٍ مُبِينٍ ﴿٥٩﴾

صدق الله العظيم

سورة الانعام

Dedication

To the souls and memories of my parents, may God rest them in peace.

To my brother and sisters who shared the naughty childhood, the dreams and reality.

To my children who are my life fruits and the meaning of living.

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Sincere thanks go to my supervisor Professor Dr. Galal A. Ali, for his invaluable advice, persuasion and guidance throughout the master courses and thesis study. His motivation to develop my interest in pavement industry is gratefully appreciated.

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Abstract

Flexible pavements are widely used despite some doubts regarding their economics under different conditions. Lack of research, less construction technology know-how and cement high rates compared with asphalt in the past are the main reasons for not implementing concrete pavement in Sudan.

The purpose of this study is to conduct comparison in total present cost between flexible pavement and jointed plain concrete pavement to locate a feasible long term good performance pavement type.

Two roads were selected to illustrate the case study, Elmonerra – Elsaffya road is considered as national highway (Road A), and Omdurman ring road representing the state road (Road B). The principles and cost comparison were applied for the two case study roads.

The two most important parameters that govern pavement design, namely sub -grade strength and traffic loading was determined in this study from Road A and Road B material laboratory tests reports and traffic surveying data. For flexible pavement design of both roads, the sub-grade resilient modulus M_R was obtained from correlation with CBR. The design traffic in term of million ESAL was obtained from AASHTO equation for 20 year design life. The rigid pavement design used modified modulus of sub-grade reaction k as measure of sub-grade strength, while design traffic was also million ESAL.

The AASHTO and PCA methods were applied for rigid pavement design in comparative manner with AASHTO and Asphalt Institute (AI) methods for flexible pavement design.

Typical standard pavement cross sections obtained by AASHTO design for flexible and jointed plain concrete pavements were adopted for life-cycle cost analysis (LCCA). The two components of LCCA, construction and maintenance costs were calculated for the entire roads using 2014 rates. The total present-worth of cost for each road pavement cost were used for comparison. It was found that the feasible long term pavement performance can be achieved by using jointed plain concrete pavement with saving of (28 %) for road A and (6 %) for road B.

تجريد

ان الرصف الاسفلتي لتعبيد الطرق يعتبر الاوسع استخداما" على الرغم من وجود بعض التحفظات حول مدى جدوى ملائمة اقتصاديا" في ظل ظروف مختلفة. كما وان قلة اجراء البحوث العلمية ومعرفة التقنيات الحديثة للتشييد وارتفاع اسعار الاسمنت مقارنة باسعار الاسفلت في السابق من اهم معوقات استخدام الرصف الصلب في السودان.

الهدف الرئيسي لاجراء هذه الدراسة هو عقد مقارنة للتكاليف الكلية الخاصة بتشبيد كل من الرصف المرن والرصف الصلب باستخدام البلاطات القصيرة الغير مسلحة لغرض الحصول على رصف ذو جدوى اقتصادية ويتمتع باداء جيد طويل المدى.

تم اختيار مشروع طريق المنيرة – الصفية والذي يمثل الطريق القومي (الطريق ا) وقطاع من طريق امدرمان الدائري الذي يمثل الطريق الولائي (الطريق ب) كحالتين للدراسة وتم تطبيق المبادئ الرئيسية والمقارنة عليهم .

هنالك عدة عوامل تتحكم في عملية التصميم لعل من اكثرها تأثيرا عاملي مقاومة الطبقة التأسيسية وحركة المرور التصميمية والذين تم حسابهما للطريقين باستخدام البيانات الحقلية للمسح الحركي وتقارير اختبارات المواد. في حالة تصميم الرصف المرن تم قياس مقاومة الطبقة التأسيسية باستخدام معامل المرونة M_R والذي يتم الحصول عليه معايرة بقيم معامل تحميل كاليفورنيا CBR. اما الحركة التصميمية فتم حسابها بواسطة معادلة AASHTO باستخدام وحدة الحمل المحوري القياسي المكافئ ESAL وذلك باستخدام فترة 20 عاما عمر التصميم للمشروع للطريقين. اما في حالة تصميم الرصف الصلب فتم قياس مقاومة الطبقة التأسيسية بواسطة معامل رد الفعل k والذي تم الحصول عليه باستخدام AASHTO. اما الحركة التصميمية لهذا النوع من الرصف تم حسابها بوحدة الحمل المحوري القياسي المكافئ ESAL كما تم في تصميم الرصف المرن.

تم تطبيق طريقتي الجمعية الامريكية لموظفي الطرق الولائية الاشنتو AASHTO وجمعية الاسمنت البورتلاندي PCA للرصف الصلب مقارنة بطريقة الاشنتو AASHTO وطريقة معهد الاسفلت AI لتصميم الرصف المرن.

تم اعتماد القطاع العرضي النموذجي لنوعي الرصف المرن و البلاطات القصيرة JPCP لكل طريق والمصممين على طريقة الاشنتو وذلك لغرض عمل تحليل لدورة التكاليف خلال فترة عمر تصميم الطريق LCCA والتي تعتبر من اهم

مكوناتها تكاليف التشييد وتكاليف الصيانة. هذه التكاليف تم حسابها لكامل طول الطريقين لكل نوع من الرصف باستخدام السعر الحالي للعام ٢٠١٤ . واخيرا تم ايجاد القيمة الحالية الكلية للتكاليف واجراء المقارنة التي اثبتت الجدوى الاقتصادية لاستخدام الرصف الصلب بواسطة البلاطات القصيرة لاداء جيد طويل المدى وذلك بتوفير في التكلفة الكلية تبلغ نسبة (28 %) للطريق القومي و نسبة (6 %) للطريق الولائي.

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ABBREVIATIONS

AASHTO	American Association of State Highway officials
AC	asphalt concrete
ADT	average daily traffic
(ADT) _o	average daily traffic at start of design period
AI	Asphalt Institute
AS	area of steel
a_1, a_2, a_3	layer coefficients for asphalt surface, base, and subbase courses, respectively
CBR	California Bearing Ratio
CF	condition factor
CRCP	continuous reinforced concrete pavement
C _d	drainage factor for rigid pavements
C _w	allowable crack width
DTD	design temperature drop
D _{SB}	thickness of subbase under concrete slab
D _{SG}	thickness of subgrade above a rigid foundation
EALF	equivalent axle load factor
ESAL	equivalent single-axle load, which is the total number of repetitions of a standard 18-kip axle load during the design period
E _{SB}	resilient modulus of subbase for concrete pavement
E _c	elastic modulus of concrete
f _c	ultimate compressive strength of concrete
f _s	allowable stress in steel
f _t	concrete indirect or splitting tensile strength
HMA	hot mix asphalt
.h	concrete slab thickness
JPCP	jointed plain concrete pavement
k	modulus of subgrade reaction
k_{∞}	modulus of subgrade reaction when D _{SG} is greater than 10 ft
LSF	load safety factor
M _R	resilient modulus; or effective roadbed soil resilient modulus
N _{max}	maximum number of steel bars per traffic lane
N _{min}	minimum number of steel bars per traffic lane

n_i	number of passes of i_{th} axle load; or predicted number of load repetitions during i_{th} period; or predicted number of repetitions during i_{th} stage
PCC	Portland cement concrete
PSI	present serviceability index
P_{max}	maximum percent steel
P_{min}	minimum percent steel
SN	structural number
S_C	modulus of rupture of concrete
TH	average daily high temperature during the month the pavement is
	Constructed
TL	average daily low temperature during the coldest month of the
year	
Tf	truck factor
l_t	length of steel bar
W_{18}	allowable 18-kip single-axle load applications for a given
reliability	
X	crack spacing
Y	design period in years
Z	concrete shrinkage
Z_R	normal deviate for a given reliability R
α_c	coefficient of thermal expansion for concrete
α_s	coefficient of thermal expansion for steel
γ_C	unit weight of concrete
ΔPSI	serviceability loss
σ_w	wheel load stress
μ	allowable bond stress for deformed bars