

الآية



بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قال تعالى :

{وَأَنْزَلَ اللَّهُ عَلَيْكَ الْكِتَابَ وَالْحِكْمَةَ وَعَلَّمَكَ مَا لَمْ تَكُن تَعْلَمُ ۖ وَكَانَ فَضْلُ اللَّهِ عَلَيْكَ عَظِيمًا }

صِدْقَةُ اللَّهِ الْعَظِيمَةِ

سورة النساء الآية

الإهداء

إلى...

التي حملتني وهناً على وهن وسقتني حباً وألهمتني فكراً
أمي الحبيبة

إلى....

ذلك الشامخ بقامة النخيل الذي أفنى شبابه ليرى في ذاتي إمتداداً لذاته
أبي العزيز

إلى....

أعزائي وأحبائي
إخواني وأخواتي

إلى...

من نهلنا من بحر عمله الذاخر الاب الروحي
بروفيسور / جلال عبدالله علي

وإلى...

كل طالب علم ومعرفة

كلمة شكر

الشكر اولاً لله سبحانه وتعالى
ثم الشكر الجزيل إلى
الذي يقف اليراع معبراً عن قلة إمداده ويرجع مداد الفكر إلى الصفر لانعدام التعابير
التي تناسب مقامات المقصودين الذين لم ييخلوا بفكرهم وجهدهم لتري هذه الدراسة النور
فكان :

البروفيسور / جلال عبدالله علي

بحراً ننهل من فيضه كلما فكرت في الغوص الى الاعماق وجدته وضع على السطح
ما اريد .

فله منا خالص شكرنا وعظيم امتناننا

**ونقول له بشراك قول رسول الله S
(إن الحوت في البحر والطير في السماء ليصلون على معلم الناس
الخير)**

والشكر من قبل ومن بعد لله رب العالمين

التجريد

يهدف هذا المشروع الى تسليط الضوء على النظريات وطرق التصميم المختلفة الهندسية والانشائية لأرصفة المطارات الصلبة والمرنة، والوسائل المثلى لتطبيق نظم التصميم وبرامج الحاسوب على مطار الخرطوم الدولي الجديد ومطار مروحي كدراسة حالة، وبالتالي التوصل الى أفضل تصميم إنشائي لرصيف مطاري الخرطوم الدولي الجديد ومروحي.

كمرحلة أولى، تمت دراسة وسائل التصميم وبرامج الحاسوب الآلي المختلفة للتطبيق على دراسة وتصميم مطاري الخرطوم الدولي الجديد ومروحي. وفي المرحلة الثانية تم جمع بيانات حركة الطيران والركاب والشحن، بالإضافة الى معلومات عن تربة التأسيس ومقاومتها والمعدل السنوي للحرارة في المنطقتين. أما في المرحلة الثالثة فقد تم تقدير حركة الطيران المستقبلية للتصميمية للمطارين. وإعتماداً على حركة الطيران، ومعلومات التربة والمعدل السنوي لحرارة الهواء، فقد تم التصميم الإنشائي للمطارين باستخدام طريقتين مختلفتين للرصيف المرن والصلب على حد سواء. ومن ثم، تم إجراء المقارنة بين أساليب التصميم للتوصل للطريقة الأفضل للتصميم الإنشائي الأمثل والأرخص لمطاري الخرطوم الدولي الجديد ومروحي مع الأخذ في الاعتبار العناصر الإنشائية والبيئية والإقتصادية.

ABSTRACT

This project aims at highlighting the different theories and methodologies for airport pavement geometrical and structural design, both flexible and rigid pavements, and presents the ideal way to apply these methods and the associated software programs for Khartoum New International Airport (KNIA) and Morwei Airport as case studies. Thereafter, the most appropriate pavement design method for KNIA and Morwei airports is proposed and applied.

Initially, information was obtained regarding the design methods and computer programs intended for the design. The second stage involved the collection of the traffic data including aircraft, passengers and freight movements for both airports. In addition, sub-grade strength data and Mean Annual Air Temperature (MAAT) were also compiled. The third stage was composed of traffic movement analysis and forecasting. Using the future design traffic, sub-grade strength and MAAT values, the airports pavement were designed applying two deferent design methodologies for each of flexible and rigid pavements.

Comparison was carried out for each airport pavement types to find the most suitable design for KNIA and Morwei airport, and also in term of the cheapest one among of flexible and rigid pavements, on several design environmental and economical factors

TABLE OF CONTENTS

الآية.....	i
الإهداء.....	ii
كلمة شكر.....	iii
التجريد.....	iv
ABSTRACT.....	v
Table of contents	vi
List of tables.....	x
List of figures.....	xii
Terms and abbreviations.....	vix

1. CHAPTER ONE: INTRODUCTION

1.1 General.....	1
1.2 Project Objectives.....	1
1.2.1 General Objective.....	1
1.2.2 Specific Objective.....	1

2. CHAPTER TWO: BACKGROUND AND LITERATURE REVIEW

2.1 Background.....	4
2.2 Major Pavement types.....	4
2.3 Airport Pavement Courses.....	6
2.4 Material for Flexible and Rigid Airports Pavement.....	6
2.5 Pavement Performance.....	7
2.6 Soil Investigation and Evaluation.....	8
2.7 California Bearing Ratio (CBR).....	10
2.8 The Plate Bearing Test.....	10

3. CHAPTER THREE: DESIGN METHODOLOGY

3.1 Introduction.....	11
3.2 Geometric Design.....	11
3.2.1 Definition of terms.....	11
3.2.2 Runway Configurations.....	12
3.2.3 Runway Length.....	16
3.2.4 Runway Width.....	17
3.2.5 Orientation.....	18
3.3 Structural design.....	20
3.3.1 Flexible Pavement Design Methods for Airports.....	21
3.3.2 Rigid Pavement Design Methods for Airports.....	25

4. CHAPTER FOUR: FORECASTING FOR AIRPORT PLANING

4.1 Introduction.....	28
4.2 Demand Analysis and Traffic Forecast.....	30
4.3 Forecast Requirements.....	30
4.4 Khartoum airport data analysis.....	30
4.4.1 Passenger movement.....	31
4.4.2 Aircraft movement.....	33
4.4.3 Cargo movement.....	35
4.5 MEROWI airport data analysis.....	37
4.5.1 aircraft and passenger movement.....	38
4.5.2 Cargo movement.....	39
4.6 Forecasting Methods.....	39

4.6.1 Time series method.....	39
4.6.2 Market Share Analysis.....	40
4.6.3 Econometric Models.....	40
4.6.4 Annual Growth	42
4.7 KNIA Forecast.....	42
4.7.1 Traffic forecast analysis.....	46
4.8 Merowe forecast.....	47
4.8.1 Traffic Forecast analysis.....	48
CHAPTER 5 – CONCLUSION AND RECOMMENDATION	
5.1 Site of Khartoum New International Airport (KNIA).....	49
5.2 GEOMETRIC DESIGN.....	50
5.2.1 Runway Length.....	50
5.2.2 Runway Width.....	51
5.2.3 Orientation.....	51
5.3 STRUCTURAL DESIGN.....	53
5.3.1 KNIA Soil Investigation.....	53
5.3.2 MAAT for KNIA.....	53
5.3.3 KNIA Design traffic mix.....	53
5.3.4 Flexible Airports Pavement Design Process.....	54
5.3.5 Design of rigid pavement of KINA	71
5.4 Site of MEROWI AIRPORT.....	76
5.5 GEOMETRIC DESIGN.....	76
5.5.1 Runway Length.....	77

5.5.2 Runway Width.....	77
5.5.3 Orientation.....	77
5.6 STRUCTURAL DESIGN.....	78
5.6.1 MEROWI Airport Design traffic mix.....	78
5.6.2 Flexible Airport pavement Design process.....	79
5.6.3 Design of rigid pavement of MEROWI AIRPORT.....	94

CHAPTER SIX: RESULTS AND COMPARISON

6.1 Results.....	99
6.2 Bill of quantity.....	99
6.2.1 KNIA.....	99
6.2.2 MEROWI.....	100
6.3 Comparison.....	101
6.4 Discussion.....	102
6.5 Summary.....	102
6.6 Recommendations.....	103
6.7 References.....	104
APENDICES	105

List of tables

Table (2.1): Recommended Soil Boring Spacing and Depths.....	10
Table (3-1): Runway widths.....	18
Table (4.1): passenger movement.....	32
Table (4.2): aircraft movement.....	34
Table 4.3: cargo movement.....	36
Table 4.4: aircraft and passenger movement.....	38
Table (4.2): KNIA 2034 forecast data.....	46
Table (4.3): Merowe f 2034 forecast data.....	48
Table (5-1) Wind Data of (KNIA).....	52
Table (5.2) Average temperature in the year	53
Table (5-3): Traffic mix information	54
Table (5-4): Traffic Mix Groups	55
Table (5-5) TA values by fatigue criteria	55
Table (5-6) TA values by deformation criteria	55
Table (5-7) fix values (asphalt concrete tensile strain).....	56
Table (5-8) fatigue Fihvalues.....	56
Table (5-9) fix values (sub-grade vertical strain).....	57
Table (5-10) deformation Fih regression constants.....	57
Table (5-11) the Equivalent DC-8 repetitions for fatigue analysis.....	59
Table (5-12) the Equivalent DC-8 repetitions for deformation analysis	60
Table (5-13): Allowable Traffic Value for Each Strain Criterion.....	64
Table (5-14): Appropriate Traffic for the Fatigue Analysis.....	65

Table (5-15) :Appropriate Traffic for the Permanent Deformation.....	66
Table (5-16) PCA Slab Thickness Calculation.....	72
Table (5-17) Wind Data for MEROWI AIRPORT.....	77
Table (5-18): Traffic mix for MEROWI AIRPORT.....	79
Table (5-19): Traffic Mix Groups.....	80
Table (5-20) TA values by fatigue criteria.....	80
Table (5-21) TA values by deformation criteria.....	81
Table (5-22) Fix values (asphalt concrete tensile strain).....	81
Table (5-23) fatigue Fih values.....	81
Table (5-24) fix values (sub-grade vertical strain).....	82
Table (5-25) deformation Fih regression constants.....	82
Table (5-26) the Equivalent DC-8 repetitions for fatigue analysis.....	83
Table (5-27) the Equivalent DC-8 repetitions for deformation analysis.....	84
Table (5-28) :Allowable Traffic Value for Each Strain Criterion.....	88
Table (5-29): Appropriate Traffic for the Fatigue Analysis.....	89
Table (5-30): Appropriate Traffic for the Permanent Deformation.....	89
Table (5-31) PCA Slab Thickness Calculation.....	95
Table (6.1) KNIA and MEROWI Design Results.....	99
Table (6.2): KNIA Runway flexible pavement construction cost	99
Table (6.3): KNIA Runway rigid pavement construction cost	100
Table (6.4): MEROWI Runway flexible pavement construction cost	100
Table (6.5): MEROWI Runway rigid pavement construction cost.....	100

Table (6.6) Summary of Runways Cost analysis.....101

List of figures

Figure (1-1): Location of Khartoum New International Airport (KNIA).....	2
Figure (1-2) Location of Merowe Airport.....	3
Figure (2-1) typical flexible pavement cross-section.....	5
Figure (2-2) typical rigid pavement cross-section.....	5
Figure (3-1): Single runway configuration.....	13
Figure (3-2): parallel runway configuration.....	14
Figure (3-3): intersecting runways configuration.....	15
Figure (3-4): open-V runways configuration.....	16
Figure (3-5): Wind rose coordinate system and template.....	20
Figure (3-6) steps to create job in FAARFIELD program.....	24
Figure (3-7) steps to design pavement thickness in FAARFIELD program.....	25
Figure (3-8) steps to create job in FAARFIELD program.....	27
Figure (4.1): passenger movement	32
Figure (4.2): aircraft movement.....	34
Figure (4.3): cargo movement.....	36
Figure (4.4): aircraft and passenger movement.....	38
Figure (4.5): forecasting for international passenger	43
Figure (4.6): forecasting for domestic passenger movement.....	43
Figure (4.7): forecasting for international aircraft movement.....	44
Figure (4.8): forecasting for domestic aircraft.....	44
Figure (4.9): forecasting for international freight movement.....	45
Figure (4.10): forecasting for domestic freight movement.....	46

Figure (4.11): forecasting for aircraft movement.....	47
Figure (4.12): forecasting for passenger movement.....	48
Figure (5-1) primary proposed sites of KNIA.....	49
Figure (5-2) Orientation Runway for KNIA.....	52
Figure (5-3) the cross of curves presented the design thickness of criteria.....	61
Figure (5-4) The cross of curves presented the design thickness of criteria.....	62
Figure (5-5) Typical Plan and Cross Section for KNIA Runway Pavement designed by AI method.....	63
Figure (5-6): Allowable Traffic Value and Predicated Traffic Value Curves for Compressive Strain.....	67
FIGURE (5-7): Allowable Traffic Value and Predicated Traffic Value Curves for Tensile Strain	67
Figure (5-8) Typical Plan and Cross Section for KNIA Runway Pavement designed by AI (nomographs)	68
Figure (5-9) Typical Plan and Cross Section for KNIA Runway Pavement designed by FAARFIELD program.....	70
Figure (5-10) Typical Plan and Cross Section for KNIA Runway Pavement designed by PCA method.....	73
Figure (5-11) Typical Plan and Cross Section for KNIA Runway Pavement designed by FAARFIELD program.....	75
Figure (5-12) Orientation Runway for MEROWI AIRPORT.....	78
Figure (5-13) the cross of curves presented the design thickness of criteria.....	85
Figure (5-14) The cross of curves presented the design thickness of criteria.....	86

Figure (5-15) Typical Plan and Cross Section for MEROWI AIRPORT Runway Pavement designed by FAARFIELD program	87
FIGURE (5-16): Allowable Traffic Value and Predicated Traffic Value Curves for Compressive Strain.....	90
FIGURE (5-17): Allowable Traffic Value and Predicated Traffic Value Curves for Tensile Strain.....	90
Figure (5-18) MEROWI flexible Pavement Design by Asphalt Institute Method (nomographs).....	91
Figure (5-19) Typical Plan and Cross Section for MEROWI AIRPORT Runway Pavement designed by FAARFIELD program.....	93
Figure (5-20) Typical Plan and Cross Section for MEROWI AIRPORT Runway Pavement designed by PCA method.....	96
Figure (5-20) Typical Plan and Cross Section for MEROWI AIRPORT Runway Pavement designed by FAARFIELD program.....	98
Figure (6-1) KNIA Runway Cost analysis of pavement types.....	101
Figure (6-2) MAROWI Runway Cost analysis of pavement type.....	102

Terms and Abbreviations

AASHTO: American Association of State Highway and Transportation Officials.

AC: Advisory Circular.

Aerodrome: A defined area on land or water (including any buildings, installations and equipments) intended to be either wholly or in part for the arrival, departure and surface movement of aircraft.

AI: Asphalt Institute.

Aircraft Stand: A designated area on apron intended to be used in parking an aircraft.

Apron: A defines area, on a land aerodrome intended to accommodate aircraft for purposes of loading or unloading passengers.

ASTM: American Society for Testing and Materials.

CBR: California bearing ratio.

FAA: Federal Aviation Administration

FAARFILLD: FAA Rigid and Flexible iterative Elastic Layered Design.

HMA: Hot Mix Asphalt

ICAO: International Civil Aviation Organization

KNIA: Khartoum New International Airport

MAAT: Mean Annual Air Temperature

PBT: plate bearing test

PCA: Portland Cement Association

Runway: A defined rectangular area on a land aerodrome prepared for the landing and take-off of aircraft.

Shoulder: An area adjacent to the edge of a pavement so prepared as to provide a transition between the pavement and the adjacent surface.

Taxiway: A defined path on a land aerodrome established for the taxiing of aircraft and intended to provide a link between one part of the aerodrome and another.