EVALUATION OF THESTRUCTURAL PERFORMANCE OF ASPHALTIC CONCRETE HIGHWAY PAVEMENT (ZUBA-GWAGWALADA-SHEDA AS A CASE STUDY)

BY

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DECLARATION

I hereby declare that this thesis has been composed by me and that it is a record of my own research. It has not been accepted in any previous application for a higher degree. All quotations and other sources of information are specifically acknowledged by means of references.

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CERTIFICATION

This thesis titled "**EVALUATION OFTHE STRUCTURAL PERFORMANCE OF ASPHALTIC CONCRETE HIGHWAY PAVEMENT (ZUBA-GWAGWALADA-SHEDA AS A CASE STUDY)"** by MBAEZUE NKWUTE DONATUS has been duly supervised, corrected and hereby approved. It meets the regulations governing the award of Doctor of Philosophy (Ph.D) in Civil Engineering of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated first to Divine Spirit for Its guidance, enlightenment and support throughout its duration and then to my dear wife Uche Judith and my beloved children Chioma, Ugo, Chu and Ife for their patience, encouragement, support and continuous words of advice: Chioma from Port-Harcourt, Ugo from Glasgow, Chu from Atlanta, and Ife from Halifax.

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ABSTRACT

This research is a study of the structural performance of the asphaltic concrete pavement of the Zuba-Gwagwalada-Sheda section of the Lokoja-Abuja highway from chainage 1km+500m to chainage 29km+800m. A Pavement Serviceability Rating (PSR) was conducted, followed by a Pavement Condition Index (PCI) study. A Truck traffic study was then conducted and used to determine Equivalent Standard Axle Loads (ESALs). Further, the Benkelman Beam (BB) and the Dynamic Cone Penetrometer (DCP) tests were carried out. Laboratory tests including bitumen penetration and bitumen content, Marshall Stability and Flow, Particle size distribution, and California Bearing Ratio (CBR) among others were then conducted on the pavement layer materials to obtain engineering properties relevant to pavement performance. Whereas the visual pavement distress survey recorded alligator cracking and rutting or permanent deformation as the most prominent distresses, PSR and PCI studies individually rated the pavement as "poor". The predicted ESALs were obtained as 13.76 million standard axles. Whereas the BB study indicated that the pavement has failed, the DCP test results indicated that strength properties of the lower pavement layers exceeded minimum requirements. Results of laboratory tests compared fairly well with requirements of national and international specifications which constitute the benchmark for good performance. Resultsof the 13.76 million ESALs and CBR of subgrade of 16.2%from these tests and the American Association of State Highway and Transportation Officials' (AASHTO's) flexible pavement performance equation were used to obtain the Structural Number (SN) of 4.9, required of the pavement to support the predicted loads. The actual Structural Number of 4.33 of the existing pavement based on pavement layer thicknesses and layer structural coefficients was less than the required SN. This difference between the required and the actual (or applied) Structural Numbersis a major determinant of pavement life span.Future truck loads were also predicted to cumulate to 26.63 million ESALs in the next 20 years: an indication therefore that the pavement under study may require to be reconstructed to the standard of a perpetual (long lasting) pavement if premature failure is to be avoided.

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LIST OF ABBREVIATIONS/SYMBOLS

σ	-	Stress, σ_c - Compressive stress
σ_t	-	Tensile stress
ε	-	Strain
ε_c	-	Compressive strain
ε_t	-	Tensile strain
AASHTO	-	American Association of State Highway and Transportation Officials
AC	-	Asphaltic Concrete
$ADTT_n$	-	Annual Daily Truck Traffic,n years after opening the road to traffic
$ADTT_p$	-	Present Annual Daily Truck Traffic
AI	-	Asphalt Institute
a_i	-	Structural layer coefficient of the ith pavement layer
ASTM	-	American Society for Testing and Materials
BB	-	Benkelman Beam
BC	-	Binder Course
BS	-	British Standard
CBR	-	California Bearing Ratio
CDV	-	Corrected Deduct Value
CSIR	-	Division of Roads and Transport Technology of South Africa
Cv	-	Ratio of volume of compacted aggregate to volume of aggregate plus binder
DCP	-	Dynamic Cone Penetrometer
DCPI	-	Dynamic Cone Penetrometer Index
Di	-	Thickness of the ith pavement layer
DSN	-	Deviator Structural Number
DV	-	Deduct Value
E	-	Young's Modules of Elasticity
E*	-	Dynamic Complex Modules of Elasticity
ESALs	-	Equivalent Standard Axle Loads

$ESAL_o$	-	Equivalent Standard Axle Loads, at the time the road was opened to traffic
$ESAL_n$	-	Equivalent Standard Axle Loads, n years after the road was opened to traffic
FMW	-	Federal Ministry of Works
GP	-	Poorly Graded Granular Material
GW	-	Well Graded Granular Material
HDM	-	Highway Design and Maintenance Model
J1	-	Component of Strain in Phase with Stress in a visco-elastic material eg., Bitumen
J2	-	Component of Strain 90^0 out of phase with stress in a visco-elastic material.
kN	-	Kilonewton
LEF	-	Load Equivalency Factor
LL	-	Liquid Limit
MDD	-	Maximum Dry Density
MN	-	Meganewton
MOW	-	Ministry of Works
M_r	-	Subgrade Resilient Modulus
NCAT	-	National Centre for Asphalt Technology
N_f	-	Number of load repetitions to failure
N_P	-	Non Plastic
OMC	-	Optimum Moisture Content
PCC	-	Portland Cement Concrete
PCI	-	Pavement Condition Index
PCR	-	Pavement Condition Rating
PEU	-	Pavement Evaluation Unit (of the Federal Ministry of Works)
PI	-	Plasticity Index
PL	-	Plastic Limit
PSI	-	Pavement Serviceability Index
PSR	-	Pavement Serviceability Rating

RD	-	Average Depth of Wheel-path rut
RRD	-	Representative Rebound Deflection
S_{bit}	-	Stiffness modulus of bitumen
S_E	-	Stiffness modulus
SGC	-	Superpave Gyratory Compactor
SHRP	-	Strategic Highway Research Program
S_{mix}	-	Stiffness modulus of a bituminous mix
SST	-	Superpave Shear Tester
Superpave	-	Superior Performing Asphalt Pavements
SV	-	Slope Variance
T	-	Temperature in 0C
t	-	Time of loading in seconds
TDV	-	Total Deduct Value
TGF	-	Traffic Growth Factor
TLF	-	Truck Load Factor
UCS	-	Unconfined Compression Strength
VIM	-	Voids in Mix (of Asphaltic Concrete)
V_v	-	Void content
WASHO	-	Western Association of State Highway Organizations
WC	-	Wearing Course