ISSN: 0975-833X

Available online at http://www.journalcra.com

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

International Journal of Current Research
Vol. 13, Issue, 11, pp.19581-19586, November, 2021

DOI: https://doi.org/10.24941/ijcr.42582.11.2021

RESEARCH ARTICLE

CHARACTERIZATION OF THE CONDITION OF PAVED ROADS BY CLIMATIC ZONE IN TOGO

[1]Kodjovi Senanou GBAFA, [2]Ouro-Djobo Essoavana SAMAH, [3]Komlan Assogba KASSEGNE and [4]Sonnou TIEM

[1]Ecole Nationale Supérieure d'Ingénieurs de l'Université de Lomé
[2]Centre Régional de Formation pour l'Entretien Routier Lomé-Togo
[3]Ecole Nationale Supérieure d'Ingénieurs de l'Université de Lomé
[4]Ecole Nationale Supérieure d'Ingénieurs de l'Université de Lomé

ARTICLE INFO

Article History:
Received 25th August, 2021
Received in revised form
19th September, 2021
Accepted 24th October, 2021
Published online 26th November, 2021

Keywords

Paved Road Network,
Degradation, Traffic,
Foundations, Modeling,
Ecological Zone.

Corresponding author:
Salihu, D.A.,

ABSTRACT

The road network manager constantly needs information on the condition of paved roads in order to properly plan maintenance and renewal. The ideal would be to have a reliable model of the condition of the network and its degree of service. This work intends to build a road network model for Togo based on a characterization of the paved roads and prevailing climatic conditions. The characterization of the condition of the roads in their environment was based on extensive documentation and field surveys. The paved national Togolese road network supports heterogeneous class of T5 to T0 traffic, dominated by untreated bedrock structures (84.41%) mostly coated with asphaltic concrete (78.47%). The early onset of degradation, mainly of small amplitude, on the surface of the pavements is explained by the use of pavement materials without considering the diversity of traffic or climatic factors.

Citation: Dr. Bikramjeet Singh, Dr. Renu Bala Sroa, Dr. Jagvinder Singh Mann, Dr. Navjot Singh Khurana. "Quality of type 2 diabetes care based on glycaemiain sub-sahara africa: a systematic review*", 2021. International Journal of Current Research, 13, (11), 19581-19586.*

INTRODUCTION

A road network is a civil infrastructure of major economic importance whose long-term performance is strongly influenced by climate. Precipitation followed by high temperatures in the dry season puts environmental pressure on pavements and reduces their mechanical performance (Cervigni, Losos et Neumann). Successive rains alternating with hot dry seasons cause more and more degradation of paved roads in the tropics. In addition, climate change does not favour sustainable road infrastructure investments and requires better knowledge of the road network and its environment to help make them more résilient. Togo with nearly 14,000 kilometers of roads subdivided into four (04) categories (paved national roads, earth national roads, urban roads and rural tracks), is not spared. Thus, a better understanding of climate as a factor in the damage to paved roads and the deterioration of the interface between layers necessarily requires a characterization of the paved roads in relation to the environment or the ecological zones of Togo.

Methodology for collecting and analyzing the various indicators

Studyarea: Togo covers an area of about 56,600 km^2 and stretches from South to North (between the Atlantic coast and the border with Burkina Faso) over approximately 650 km. Located entirely in the intertropical zone, in the center of the southern coast of West Africa, between 6 ° and 11 ° North latitude and 0 ° and 1 ° 51 'East longitude, Togo presents climatic, geological. and plant diversities found in five (05) ecological zones (Ern) (Figure 1).

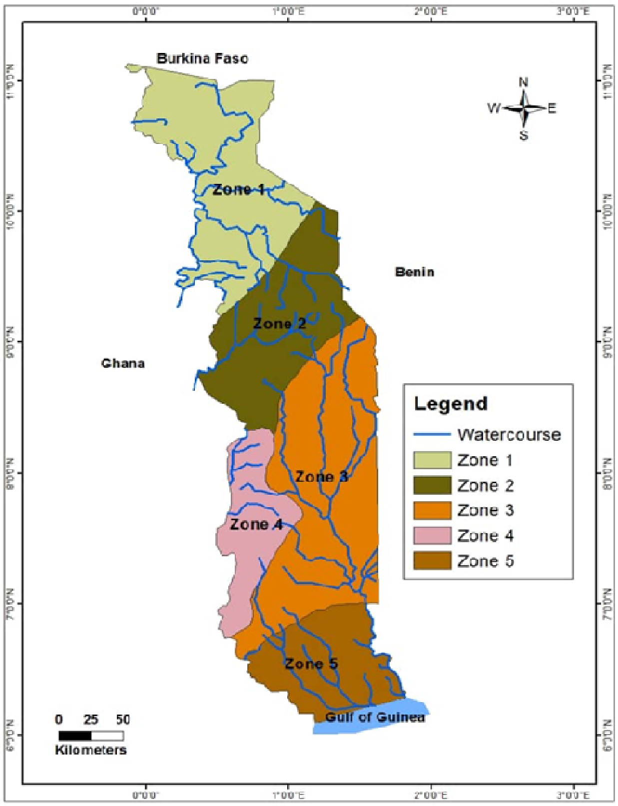

Figure 1. ***Study zone*** **(Ern)**

Ecological zone 1 is located in the northern part of the country and enjoys a tropical Sudanese-type climate with ferruginous-type soils and two seasons (a rainy season records average annual rainfall varying between 880 and 1380 mm from June to October and a dry season from November to May). The average monthly temperature varies from 25 to 30°C in the rainy season and 25 to 34°C in the dry season. Ecological Zone 2 or Northern Mountain Zone is an area of dense dry forests, open forests and grassy savannas. Located in the northern part of the Togo mountains, it is characterized by a tropical climate with tropical ferruginous soils and a high altitude Sudanese type climate, a rainy season with rainfall varying from 970 to 1832 mm / year from April to October and a dry season from October to March. In this area, the monthly average temperature varies between 20 ° and 32 ° C.

Ecological zone 3 or the central plains zone or the Guinean wooded savannah zone is dominated by large expanses of plains, with dome-shaped rocky hills rising to altitudes between 200 and 400 meters. The dominant vegetation is a more or less "Guinean wooded savannas"(Brunel). This ecological zone has a tropical climate enjoys a long rainy season with rainfall varying between 976 and 1850 mm / year. One finds here,mainlyshallow tropical ferruginous soils. Average monthly temperatures are between 24 ° and 31 ° C.

Ecological zone 4 or the Atakora unit, corresponds to the southern part of the Togo mountains (Sylvain et al., 1986). It is the domain of the humid and semi-deciduous forests of Togo.(Akpagana).The Atakora unit enjoys a transitional sub-equatorial climate(Trochain), characterized by a big rainy season from March to October marked by a drop in rainfall in August. The annual rainfall varies between 1420 and 1830mm. The dry season lasts 2 to 4 months between November and February(Guelly). Average monthly temperatures vary between 22 ° and 28 ° C with extremes of 20 ° C and 34 ° C.

Ecological zone 5, corresponding to the coastal plain of southern Togo, is dominated by the coastal sedimentary basin located in the extreme south of the territory (Pauline Y. D. Da Costa). It is characterized by a subequatorial or Guinean type climate with two rainy seasons, one big from March to July and the other small from September to November. The area is marked by a rainfall deficit and very low temperatures are recorded in the short dry season (Edjame). The rainfall varies between 580 to 1400 mm / year. Average monthly temperatures vary between 26 ° and 30 ° C with extremes of 19 ° C and 38 ° C.

Characterization of pavements in the different ecological zones

The lengths of the sections are recorded by GPS (Global Positioning System) and the network lengths are obtained by cumulating the sections that compose it.

The characteristics of the pavement structures were taken from road study reports as well as re-bonding plans(DGTP)and confirmed by field observations. The data include those on surface plaster and asphalt concrete coatings, and for the foundations untreated gravel, gravel treated with hydrocarbon binder and improved gravel with hydraulic binder (Ifsttar, Ageroute Senegal, egis, senelabo.btp).

Traffic class	*T5*	*T4*	*T3*	*T2*	*T1*	*T0*
HGV / day / direction	*< 25*	*< 50*	*< 150*	*< 300*	*< 750*	*< 2000*

(a) Deformation (b) Fatigue craks (c) Faïençage (d) Potholes

(a) Chunking (b) Transverse cracks (c) Joint crack

Figure 3. Les dégradations superficielles

Traffic data were extracted from traffic analysis reports from recent road studies in Togo (DGTP/DPESE). Expressed as average number of heavy goods vehicles (HGV) per day and per direction, it is organized in traffic classes (Ti) ranging from T5 for low traffic to T0 for high traffic as shown to Table 1 (Ifsttar, Ageroute Senegal, egis, senelabo.btp). Cumulative traffic (T_C) is calculated by considering an arithmetic increase (i) of 6% (value obtained from the traffic study reports available at the DGTP) using the expression (CEBTP):

$$T_c = 365 n t_1 \times \frac{2 + (n-1)i}{2}$$

$t_1$is the traffic in the year of commissioning and n the operating time already consumed by the roadway. For roads with different sections brought into service on different dates, a root mean square is calculated to estimate the traffic. The recurring overload phenomenon was taken into account for each section usingaggressivity coefficients (low, medium and high).

Analysis of degradation of paved roads in Togo: The VIZIR method(Paul Autret)was selected to assess the degradation(*Figures 2 and 3*), characterizing the structural condition of the pavement (deformations, longitudinal or fatigue cracks, crazing) and those reflecting a surface defect (tearing, cracking excluding fatigue cracks, etc.). Potholes are considered a structural degradation of the pavement.

- The cracking index (If) linked to the severity and extent of cracks and crazing;
- The deformation index (Id) linked to the gravity and extent of the deformation ;
- The pothole index (Indp) linked to the severity and extent of the potholes.

The surface degradation index (Is) is determined from various indices linked to the various structural degradations coupled with surface degradations (Figure 4):

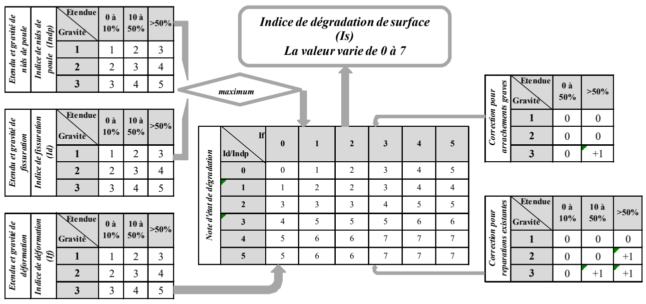

Figure 2. Determination of surface degradation index

Degradation is a function of time (number of wetting / drying cycles) and the type of structure. This is why the sections are chosen by age group (more than 10 years of operation / less than 10 years of operation). The paved road lengths studied by ecological zones are harmonized.

RESULTS

Characteristics of paved pavement structures in Togo: Togo's road network is made up of two types of pavement base structure. Thus, 1774.5 km or 83.82% of paved roads have an untreated base while 342.52 km or 16.18% have an asphalt base. These foundations are topped with a coating of either bituminous concrete on 78% (1652.32 km) of the network, or surface coating on 21.95% (464.69 km) of the network. The traffic encountered in the different ecological zones ranges from class T0 traffic to class T5 traffic. There is therefore an uneven distribution of types of pavement structures and traffic on the paved national road network in Togo (Figure 5). Ecological zone 1 (ZE1) has 489.16 km of paved roads of which 59.62% consists of untreated base and 67% of roads with asphalt concrete pavement. The traffic on the bituminous bases is exclusively of class T0 unlike the untreated bases where it is mainly of class T3 (88.88%). T1, T2 and T4 traffic are completely absent. Two thirds of the untreated base in this area are coated with asphalt concrete pavement compared to only one third with surface coating. T0 traffic is absent on surface plasters (Figure 6).

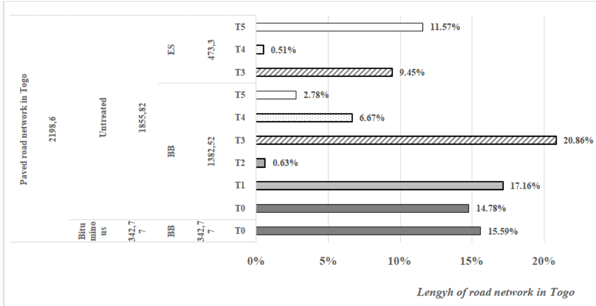

Figure 3. Characteristics of paved national roads in Togo

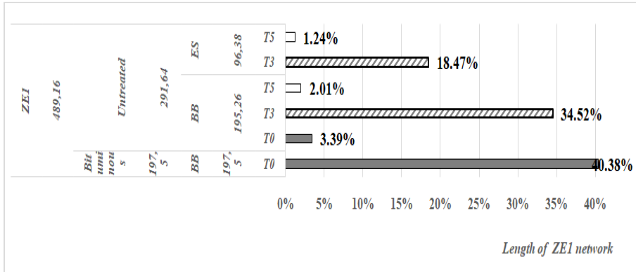

Figure 4. Characteristics of paved roads in ecological zone 1 (ZE1)

Ecological zone 2 consists of 407.38 km of paved roads exclusively on untreated base. It is 69% topped with an asphalt concrete coating. T0 traffic absent on surface plasters occupies second place (146.35 km or 35.93%) behind T3 traffic (191.82 km or 47.09%). T1, T2 and T4 traffics are also absent in ecological zone 2 (Figure7).

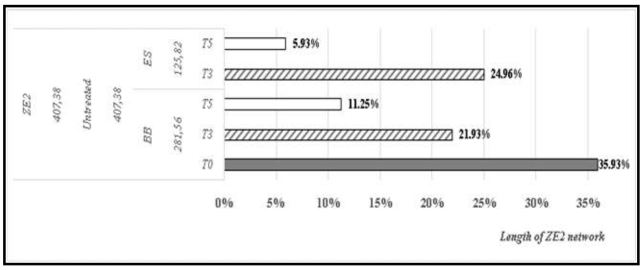

Figure 7. Characteristics of paved roads in ecological zone 2 (ZE2)

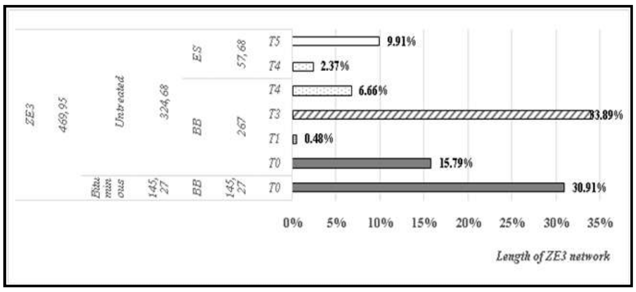

Figure 5. Characteristics of paved roads in ecological zone 3 (ZE3)

Essentially made up of untreated layers at 69.09% of the total length (469.95Km), the paved roads in ecological zone 3 mostly allow T0 traffic (220.47Km or 46.91%) encountered exclusively on bituminous base, followed respectively by traffic T3 (33.89%), T5 (46.56Km or 9.91%) and T4 (42.39Km or 9.02%).

T1 traffic is negligible while T2 is absent (Figure 8). For ecological zone 4 (ZE4), the paved roads are entirely untreated. Mainly coated with bituminous concrete 58% against the 42% remaining in surface coating. Most of the traffic is class T5 (174.74Km or 43.25%) followed by T4 (108 Km) T1 (86.26Km) and T3 (35.01Km) respectively. There isno T2 traffic (Figure 9).

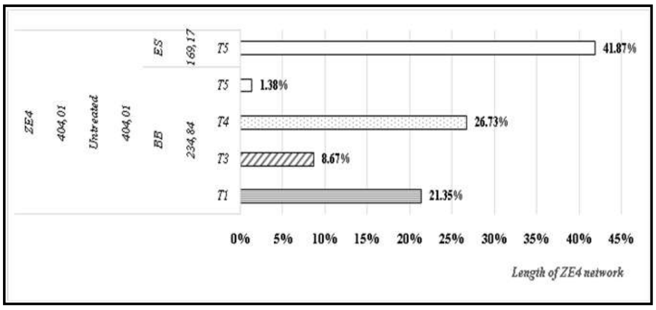

Figure 6. Characteristics of paved roads in ecological zone 4 (ZE4)

Made mainly of an untreated base, the pavements in ecological zone 5 (ZE5) are mostly (94%) coated with asphalt concrete against 6% with surface coating. Classes T0 and T1 traffics share a major part of the bituminous coated network in the respective proportions of 20.50% and 67.45%. T2, T3, T4, and T5 traffics although present are negligible T2 (3.24%), T3 (1.45%) and T4 (1.71%) (Figure 10).

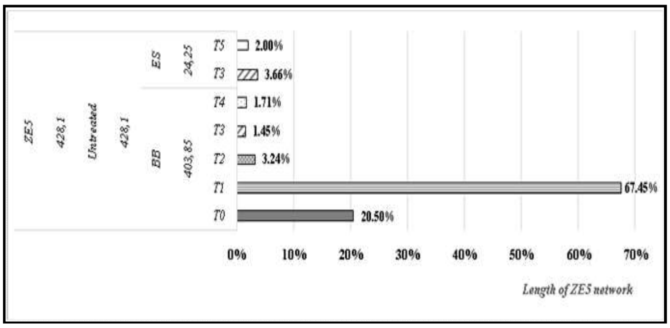

Figure 7. Characteristics of paved roads in ecological zone 5 (ZE5)

Assessment of the state of degradation of the paved road network in Togo: The structural degradations present are respectively deformations, fatigue cracks, chunking and potholes. The quantification of these degradations made it possible to assess the lengths of the network affected by each degradation and their distribution by degrees of severity (Figure 11).

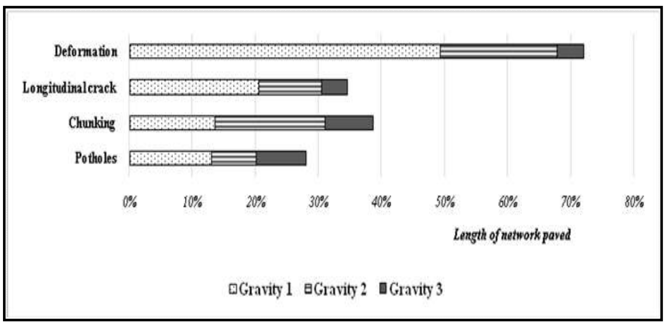

Figure 11. Distribution of the different degradations on the paved network in Togo

The most common structural degradations are deformations (72%), half of which are ofgravity 1, followed by chunking (38.6%) and longitudinal cracks (34.6%). For surface damage, faïençage hold the record with 55% followed by transverse cracks and joint cracks.

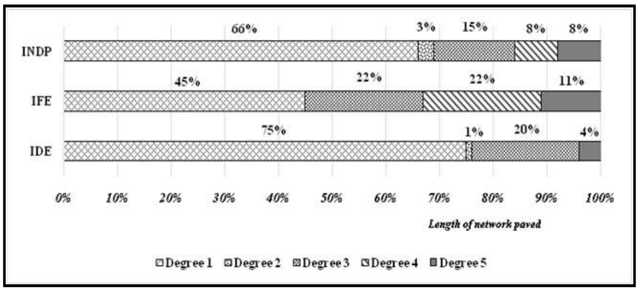

Figure 12. Degradation index (Id, If and Indp) for the paved network in Togo

Assessment of the coated network in Togo: For the degradation indices calculated (Figure 12) a high proportions of the network is assigned todegree 1. These are respectively the deformation index (Id = 75%), the cracking index (If = 45%) and the pothole index (Indp = 66%). Degree 3 remains average for the three indices (15% to 22%). Degree 5 remains low with 4% for deformations, 11% for cracks and 8% for potholes. The otherdegreesremainnegligible for all three indices. The combination of the various degradation indices with the degrees of severity, the extent of chunking and repairs made it possible to define the condition index (Is) of the network and to classify its condition qs : good, average or bad (Figure 13).

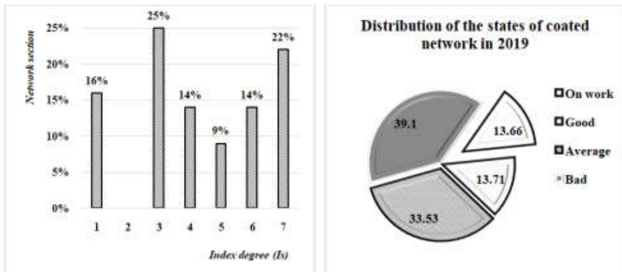

Figure 8. Indices of degradation and condition of the paved road network in Togo

DISCUSSION

Togo's paved national road network supports varing traffic depending on road sections. It varies between classes T5 and T0 traffic. But class T2 traffic remains negligible in the network (0.63%) and class T4 is low (7.18%). A large proportion of the network supports T0 (30.37%), T1 (17.16%), T3 (30.31%) and T5 (14.35) traffic. This variety of traffic is supported by two types of beds: 15.59% of the network supporting mainly T0 traffic consists of bituminous bases and more than 84%, untreated beds. A good part of the heavy traffic (T0, T1, T2, T3) on the road network is therefore supported by an untreated base. The road surface consists mainly of bituminous concrete (78.47%) and surface coating (21.53%). Although we can observe a predominance of heavy traffic on asphalt concrete type pavements, the structural distribution of pavements in Togo does not seem to respect the choices of bedding and coating materials based on traffic criteria.

We are therefore witnessing a disorderly distribution of traffic in relation to pavement materials. Referring to the different ecological zones, the bituminous beds are mainly found in ecological zones 1 and 3. They are used for the bedding of recently rehabilitated pavements under class T0 traffic. This could be explained by a recent awareness of the poor performance of untreated beds for the highest traffics. But the share of the untreated base network supporting higher class traffic (T0 and T1) is still significant and is found in the five ecological zones. In addition, the choice of the type of coating does not seem to consider the climatic characteristics of the project areas. Indeed the results obtained show a distribution type of coating in disagreement with the porous properties of the coating. The high impermeability of asphalt concrete type coatings compared to surface armature would normally have favored its use in the wettest areas(Vallon). But 41.87% of the network in ecological zone 4, the wettest zone in Togo, is done with a surface coating. At the same time, ecological zone 1, the driest zone in the country has less than 20% of its network with surface coating done.

The assessment of the condition of the pavements of the paved national road network identified the presence of potholes, faïençage, cracks and deformations. Deformations and faïençages representingrespectively 72% and 38.6% of the total length of the network, are the most common structural damage. Longitudinal cracks and potholes follow with 34.6% and 28% respectively. The preponderance of deformations of small radius (49.3% of gravity 1) indicates an interface defect between the surface layer and the bases of the roadways in the network (Hicks). This phenomenon results in a rapid development of crazing and cracks (Brodeur) which, under the combined action of water and traffic, form to potholes (Bodin). The strong presence of degradations of low amplitude (gravity 1 and gravity 2) shows that the pavements in Togo do not deteriorate because of fatigue of the base materials under the action of traffic as shown by mechanical models of the pavement (CEBTP), (Setra-Lcpc). But the degradation process begins with bonding defects at the interface which evolves into deformations and cracks. The latter facilitate infiltration and create disorders in the foundations of roadways which result in potholes. The combination of the different degradations in the pavement condition assessment process shows a discontinuity for the degree 2 condition index. This results in a rapid evolution of deformed surfaces into cracks which combine to present states of degradation of higher degrees. The prominent presence of the degree 3 state explains this evolution of degradation.

CONCLUSION

The characterization of the paved national road network in Togo makes it possible to understand some difficulties that undermine the design process, which are out of phase with the operation of the pavements. Thus, the use of materials in the base of pavements respects neither the distribution of traffic nor the distribution by class of traffic on the road network. In addition, the choice of the type of coating is not always in accordance with the climatic properties in the project areas. This leads to premature deterioration of the road surface.The analysis carried out made it possible to observe on the surface of the roadways tears, deformations, potholes, longitudinal cracks and crazing. These degradations are largely of low amplitudes (93.39% for the tears; 94.20% for the deformations; 71.89% for the potholes; 88.11% for the longitudinal cracks and 80.34% for faïençage. These low amplitude degradations are the results of interface defects between the road surface and the base layer (Hicks).

RÉFÉRENCES

Afidegnon, D. «Les mangroves et les formations associées du sud-est du Togo: analyseéco-floristique et cartographie par télédetectionspaciale.»Thèse de doctorat, Université du Benin (Togo) (1999).

Akpagana, K. «Recherchesur les forêtsdenseshumides du Togo. Thèse de Doctorat Sciences Naturelle. » Université de Bordeaux III (1989).

Bodin, D. P.-C. «A continuum damage approach to asphalt concrete modelling. » Journal of EngineeringMechanics (ASCE). (2004).

Boussafir, Yasmina. «Les effets de la secheressesur les chaussées à faibletraficdans la régioncentre.» JNGG (2006).

Brodeur, M., Carrier, J., Durand, J.-M., Fauteux, E., Fortin, S., & al. Manuel d'identification des dégradations des chausséessouples. Quebec: Service de la qualité et des normes, 2002.

Brunel, J. F. Végétation. In: "Atlas du Togo". Paris: J. A., 1981.

CEBTP. «Guide pratique de dimensionnement des chaussées pour les pays tropicaux.» Ministère des relations extérieurescoopérationetdéveloppement de la republiquefrançaise (1984).

Cervigni, Raffaello, et al. Cervigni, Raffaello; Losos, Andrew Michael; Enhancing the climate resilience of Africa's Infrastructure: the roads and bridges sector (English). Washinton, D.C.: World Bank Group, 2016.

DGTP. «Rapport de la mission de collectes de donnéesroutièresinformatisées. » 2019.

Di Benedetto, H. et F. J. Corté. «Matériauxbitumineux, Volume 2. » Hermes (2005).

Doré, G., P. Drouin et P. Desrochers P. and Ullidtz, P. Pierre. «Estimation of the Relationships of Flexible Pavement Deterioration to Traffic and Weather in Canada. » 2006.

Doré, Guy et al. «Impact des changementsclimatiquessur les chaussées des réseauxroutiers Québécois. » Ouranos (2014): 63.

Edjame, Kodjovi. «Approchegéophysique de définition du climat du littoral océanique et du Bas-Togo. » Revue de GéographieTropicale et d'Environnement (2011).

Ern, H. «The vegetation Togo, Gliederrung, endangerment, conservation. » Willdenowia, 9 (1979): 295-312.

esgis; PRE-CI; AFT. Assistance technique pour l'amélioration de l'organisation du secteur des transports routiers de marchandises en Côte d'Ivoire. Abidjan: République de Côte d'Ivoire, 2015.

Gaussen, F. Bagnouls& H. «Saison sèche et indicexérothermique.» Bull. Soc. Hist. Nat de Toulouse (1953): 193-240.

Guelly, KudzoAtsu. «GueReconquêteforestièresur le plateau akposso (Togo): stratégiespaysannes, caractéristiquesbotaniques et écologiques.» Journal d'agriculturetraditionnelleet de botaniqueappliquée, 36e année, bulletin n°1 (1994): 15-28.

Hicks, R., Santucci, L., Aschenbrener, T. «Introduction and seminar objectives. Moisture sensitivity of asphalt pavements. » A National Seminar. San Diego, California, 2003. 3-20.

Ifsttar, Ageroute Senegal, egis, senelabo.btp. Catalogue de structures de chausséesneuves et Guide de dimensionnement des chaussées au Sénégal. Republique du Sénégal, Ministère des Infrastructures des Transports Terrestres et du Désenclavement, 2015.

K. Batawila, S. Akpavi, K. Wala, M. Kanda, R. Vodouhe et K. Akpagana. «Diversité et gestion des légumes de cueillette au Togo. » African Journal of Food Agriculture Nutrition and Development (1997).

Kalenda, MukokoGustave. «Comportement des sols latéritiquescompactésdans les remblais et digues de retenue des rejetsminiers du Katanga (RDC). » Thèse de Doctorat, UniversitéCatholique de Louvain (2014): 319.

Kokou, K. et Guy Caballé. «Les ïlotsforrestiers de la plainecotièretogolaise.» Bois etforêt des tropiques (2000).

Lepert, Ph et Ibrahim Mama Sanda. «Déploiement d'un systèmed'aide à la gestion des routes au Niger. » Routes/Roads, Numérospécial "Entretien des routes", AIPCR avril 2015.

Mahamadou, SouleyIssaka et al. «Etude des matériauxlatéritiquesutilisés en construction routière au Niger: méthoded'amélioration. » RencontreUniversitaires de Génie Civil (2015).

Mauduit, V. et al. «Dégradationprécoces des couches de roulementbitumineuses à la sortie des hivers. » Revue RGRA (2007): 99-104.

O'Flaherty, C. «Highway: The Location, Design, Construction and Maintenance of Pavement. » Highway (2002): 210-266.

Paul Autret, Jean-Louis Brousse. «VIZIR: Méthodeassistée par ordinateur pour l'estimation des besoins en entretien d'un réseauroutier.» Techniques etméthodes des laboratoires des ponts et chaussées 1991.

Pauline Y. D. Da Costa, Jacques Medus, René Flicoteaux, Jacques Salaj, BohumilHarmsmid, Pascal Affaton, KomlaviSeddoh. «Biostratigraphie de la bordure septentrionale du bassincôtiertogolais. Apport des donnéespalynologiques et structurales. » REV. CAMES (2013).

Pearson, Karl. «Mathematical contributions to the theory of évolution-regression, heredity and panmixia. » Mathematical theory of evolution (1896): 253-318.

Rakotomalala, Ricco. Analyse de corrélation, Etude des dépendances-Variables quantitatives, Version 1.1. Lyon: Université Lumière Lyon 2, 2017.

Robertson, Gordon. «Quantifier les impacts du changementclimatique pour le secteurroutier de l'Afriquesubsaharienne-Approcheétude. » aurecon (2011).

Setra-Lcpc. Conception et dimensionnement des structures de chaussée-Guide technique. Paris-France: Laboratoire central des ponts et chaussées-Service d'étude des routes et autoroutes, Ministère de l'équipement, des transports et du tourisme, 1994.

SITRASS. La surcharge des poidslourds au Burkina Faso: un fléauéconomique et social, impactessur les infrastructures et l'économienationale. Ouagadougou: Pépublique du Burkina Faso, 2009.

Trochain, J. L. «Accord interafricainsur la définition des types de végétation de l'Afrique tropical. » 1957.

Vallon, Patrice. «Les enduitssuperficiels: choix des differentes techniques. » Cete. Lyon: Ministère de l'écologie, du développement durable et de la mer en charge des technologies vertes et des négociationssur le climat, 2010.

****