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HASIL PENILAIAN SEJAWAT SEBIDANG ATAU *PEER REVIEW*
KARYA ILMIAH : PROSIDING

Judul Artikel	:	Surface Distress Index Updates to Improve Crack Damage Evaluation		
Jumlah Penulis	:	3 Orang (**Bagus Hario Setiadji***, Supriyono, Djoko Purwanto)		
Status Pengusul	:	Penulis ke-1		
Identitas Prosiding	:	a. Judul Prosiding	:	Advances in Engineering Research, Vol. 186 Proceedings of the 11th Asia Pasific Transportation and The Environment Conference (APTE 2018)
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Semarang, Desember 2021

Reviewer 1

Prof. Ir. Ludfi Djakfar, MSCE, Ph.D., IPU.
NIP. 196407091990021001
Unit Kerja: Fakultas Teknik Universitas Brawijaya

Reviewer 2

Prof. Ir. Mochamad Teguh, MSCE, Ph.D
NIP. 195808051987031001
Unit Kerja: Prodi Teknik Sipil, Universitas Islam Indonesia

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Malang, Oktober 2021
Reviewer 1

Prof. Ir. Ludfi Djakfar, MSCE, Ph.D., IPU.
NIP. 196407091990021001
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Yogyakarta, Oktober 2021
Reviewer 2

Prof. Ir. Mochamad Teguh, MSCE, Ph.D
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CERTIFICATE

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Surface Distress Index Updates to Improve Crack Damage Evaluation

B Setiadji, D Purwanto - 11th Asia Pacific Transportation and …, 2019 - atlantis-press.com

Road pavement is one of infrastructures that is currently getting most attention due to its important role in accelerating the economic growth rate of an area, opening up isolated regions and improving the connectivity among them. A road infrastructure has a life-cycle which starts from design to reconstruction. Among all phases of road life-cycle, maintenance work plays an important role to maintain the performance of the road always in the top level. To conduct road maintenance work, it is necessary to evaluate the condition of the road …

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The APTE Conference was founded in 1998 in Singapore. Since then, the Conference has been organized regularly every two years, hosted in Singapore (2004, 2007),China (2000, 2005, 2009), Indonesia (2010), Thailand (2012), Sri Lanka (2014), and the last one was Malaysia (2016).

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Prof. Ratnamsamy Muniandy, Universiti Putra Malaysia

Ho Seng Tim, Former Head of Singapore LTA's Road Safety Engineering Unit

Ir. Mochamad Basoeki Hadimoeljono, M.Sc., Ph.D, Indonesian Minister of Public Work & Housing (*in confirmation*)

50 Years of Road Safety in Singapore

A keynote topic by Mr. Seng Tim Ho

Road transport safety has a major impact to society and the environment. Safer roads lead to saving lives and reducing injuries on our road transport. This keynote presentation by Mr Ho will focus on how engineering road safety in Singapore has improved over the years, and become globally benchmarked to be among the safest countries in the world.

Mr Ho will highlight some of the key road safety initiatives that have been developed with examples of engineering road safety schemes that have been effectively used. These will include major national road safety projects like the Silver Zone to make roads safer for the seniors in an ageing society. Finally, Mr Ho will conclude with some key learning pointers for the success of road safety in Singapore.

Mr Ho is the former Head of Road Safety Engineering Unit in Singapore's Land Transport Authority (LTA). He has more than 35 years of experience in engineering road safety and traffic. He set up and pioneered the Unit, leading and managing new road safety initiatives and strategies. Despite increasing human and vehicle populations, Singapore's road fatality rates have decreased substantially.

In 2016, Mr Ho co-wrote a book chapter on Road Safety in "50 Years of Transportation in Singapore- Achievements and Challenges". Mr Ho and his team had won several awards including the prestigious Prince Michael International Road Safety Award (UK) in 2016 for the outstanding Silver Zone programme; in 2015 the Minister's Innovation Award (Singapore) for implementing Silver Zones through innovation use of road safety engineering measures; in 2011 the Institute of Transportation Engineers- Edmund R. Ricker Transportation Safety Council Award (US) for the efforts in improving road safety; in 2007 the Prince Michael International Road Safety Award (UK) for Road Safety Management in Singapore.

Mr Ho provides consultation and collaboration work in road safety, and conducts training on Road Safety Engineering and Management both locally and overseas. He represented the LTA at international conferences. In addition, he presented and published technical papers on road safety at conferences and journals.

In 2005, Mr Ho received the National Day Award (Long Service), the LTA Commendation Award (Service Excellence) and the LTA Long Service Award in appreciation for his loyal and dedicated service.

Mr Ho earned his MSc in Transportation Planning and Engineering from the University of Southampton (UK), and his BSc in Civil Engineering from the University of Brighton (UK).

‹ › ×

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Ni Luh Setyarini, Anissa Tajudin

Road is one of the important infrastructures in facilitating the mobility of goods and services in order to improve the national economy, but most of the roads are damaged by the effects of weather. The rain water interusion into the pavement layer make accelerates erosion process. The asphalt erosion...

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Sen Han, Tien Fwa, Mengmei Liu

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Ari Widayanti, Ria Soemitro, Januarti Ekaputri, Hitapriya Suprayitno

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H. Pasindu, Lalith Sirisumana, D. Jayaratne

Provincial level and Local roads comprise nearly 50% of the road network in mileage in Sri Lanka. They play a pivotal role in providing access to the local communities especially in rural areas and an essential component of the economic development of those areas. These roads are under the purview of...

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Bagus Setiadji, Supriyono, Djoko Purwanto

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Moe Lwin, Lee Kelvin, Ho Yong, Wang Xuechun

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Lu Chu, Tien Fwa

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Anissa Tajudin, Ni Luh Setyarini, Devy Darmawati

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Asep Nurhidayat, Djoko Utomo, Rizqon Fajar, Sucipto, Hera Widyastuti

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Adhi Muhtadi, Indrasurya Mochtar, Hera Widyastuti

Electric Railway (KRL) is the backbone of public transportation in Jakarta. But KRL share capital is still 4.1%. Therefore this paper seeks to reveal what characteristics play a role for travellers to use KRL regularly or temporarily. The study was conducted in October 2017 at several Jakarta KRL stations....

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Sasika Ranawaka, Handunneththi Pasindu

Highway work zones are present in most urban and rural road networks due to road rehabilitation, maintenance, utility installation works that are carried out on roadways. The impacts related to highway work-zone include traffic delays, vehicle operating cost increase, increase in road accidents, accessibility...

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Ahmad Utanaka, Hera Widyastuti

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Study Of The Implementation Of Regulations In The Framework For Sustainable Transportation

Juanita Kombaitan, Iwan Kusumantoro, Heru Putro

Here discussed aspects of existing regulation in Indonesia related to the implementation of traditional modes. The main aim of the research is to show the importance of regulatory aspects and the regulatory framework for the implementation of traditional transportation as a form of protection. Approach...

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Traffic Impact Assessment due to Green Campus Concept Implementation

Andrean Maulana, Oka Purwati

Green campus is a concept for the implementation of sustainable policies within the scope of campus. One of them is for transportation aspect. One example of green campus guidance is UI Greenmetric, The policy on transportation in the guidelines is parking area reduction for private vehicles. The micro...

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Eco-Fishing Port Assessment Model as an Environmental Management Tool on Coastal Fishing Port 'Pondokdadap' - Indonesia

Achmad Wicaksono, Bagyo Yanuwiadi, Agus Dwiyanto

To manage fishery resources in Indonesia with the principle of sustainability, it is necessary to apply the eco-fishing port concept. This study aims to develop a model for assessment of eco-fishing port with prevailing conditions and regulations in Indonesia. From the model that prepare, the application...

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Nuri Onat, Murat Kucukvar, Omer Tatari

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11th Asia Pacific Transportation and the Environment Conference (APTE 2018)

New Low-Speed Testing Device for Skid Resistance of Highways and Airfields

Sen Han, T. F. Fwa, and Mengmei Liu

Abstract— **Low speed skid resistance measurement is of great significance to analyse the actual causes of insufficient friction of pavement, and to formulate appropriate maintaining measures. At present, the British Pendulum Tester (BPT) and Dynamic Friction Tester (DFT) are commonly used to measure the low-speed skid resistance of pavement. However, previous studies have shown that there are operational limitations in the use of BPT and DFT. A new low speed friction tester (WFT) developed by Chang'an University was introduced in this paper. The stability, accuracy and efficiency of BPT, DFT and WFT were compared through laboratory tests and field tests. The influence of test speed on WFT test results in the range of normal walking speed was evaluated. Results show that the stability of WFT test was better than that of BPT and DFT. BPT test results were unreliable and DFT was unsuitable for coarse surfaces or groove surfaces of pavement. WFT is time efficient in testing time, especially in field tests. The study also shows that the test speed had little effect on the WFC at the statistical significance level of 95%. Therefore, WFT can be used as a practical alternative to BPT and DFT, for testing the low-speed friction of pavement in laboratory and field.**

Index Terms— **Road engineering, low-speed skid resistance, British Pendulum Tester, Dynamic Friction Tester, Walking Friction Tester.**

I. Introduction

Skid resistance is considered to be one of the most important characteristics of pavement, and has become a matter of immediate concern to highway authorities. Lack of adequate friction between the tire and road surface can lead to traffic accidents, especially in wet weather [1]. The existing skid resistance measuring methods can be divided into low speed and high speed methods. The common low speed testing instruments include the British Pendulum tester (BPT) and the Dynamic Friction Tester (DFT). For high speed testing equipment, there are relatively more choices, such as locked-wheel skid tester, Scrim, Mu-Meter, grip tester and so on [2-4]. Both low speed skid resistance and high speed skid resistance are important properties for comprehensive evaluation of pavement skid resistance, but in actual engineering, only high-speed skid resistance of pavement is often measured. Low speed skid resistance is also the critical factor for the in-depth analysis of insufficient skid resistance of pavement, and the necessary information for making corrective maintenance or repair measures. This paper reviews the current low speed skid resistance test methods, pointed out their limitations, and emphasizes the need for a better test method. The Walking Friction Tester (WFT) developed by Chang'an University was used to evaluate the low-speed skid resistance of the pavement reliably and accurately.

S. Han is with the School of Highway, Chang'an University, 710064, Xi'an, China (e-mail: hyram_hs@chd.edu.cn)

T.F. Fwa is with the School of Highway, Chang'an University, 710064, Xi'an, China.

M. Liu is with the School of Highway, Chang'an University, 710064, Xi'an, China.

II. Mechanism of Low Speed and High Speed Skid Resistance

Skid resistance is composed of adhesion and hysteresis, the former is related to the microtexture of the aggregates with a wavelength of 1μm~0.5mm, and has a certain control effect on the low-speed skid resistance. The latter is related to the overall structure of a pavement with a wavelength of 0.5mm~50 mm, which affects the high-speed skid resistance of the pavement [5-7].

The three-zone concept of Moore's law, namely the front "squeezed-film zone", the middle "transition zone" and the "traction area" in the rear, is used to explain the change of the skid resistance with the velocity. When the tire sliding speed is high, the effective skid resistance decreases with the decrease of the "traction zone". On the other hand, with the slower speed of the tire, the larger the contacted area of the tire surface is, the greater the "traction area" becomes, and the friction between tire surface and pavement increases [8].

III. Review of BPT and DFT

BPT and DFT have been widely used in laboratory and field tests. However, previous studies have found that BPT and DFT have many limitations in the test of skid resistance:

(1) BPT is a pendulum impact test machine. Its rectangular rubber slider impacted the test surface at an angle during the test. DFT measures the friction force by the circular motion of the rotary rubber pad. The contact modes and mechanisms of the two devices are different from those of the vehicle tire and pavement surface. This makes the test result of the sliding mode unreliable when testing on coarse texture road surface [9, 10].

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Development of a Highway Performance Index for Upgrading Decision Making – Case Study for a Provincial Road Network in a Developing Country

H. R. Pasindu, Lalith Sirisumana, and D. N. D. Jayaratne

***Abstract*—Provincial level and Local roads comprise nearly 50% of the road network in mileage in Sri Lanka. They play a pivotal role in providing access to the local communities especially in rural areas and an essential component of the economic development of those areas. These roads are under the purview of Local Councils and Provincial Road Development Authorities. Most of these roads do not conform to the design guidelines as they were often developed from local foot paths or gravel roads. Therefore, the travel speeds are very low and safety issues have arisen with the increase in travel demand and the use of motorized vehicles. Therefore, there is need to upgrade these roads to the appropriate design standards to ensure safe and efficient mobility to the road users. However, the road agencies have limited funding to implement upgrading projects on the entire network. Thus, it is pertinent that there is a methodology to prioritize the roads based on the current operational performance so that the funding allocation can be done in the most effective manner. Road upgrading in the context of the study is focused on roadway improvements such as alignment, road width, shoulder etc. In addition to the limited funding, the agencies also lack the technical capacity to carryout detailed investigation and surveys on highway performance that are typically carried out in other road agencies at national level. Therefore, the study proposes a simplified methodology to evaluate the performance index of the road based on its roadway and operational characteristics, to be used to assess road network condition and identify upgrading needs for a highway agency of a low volume road network.**

***Index Terms*— Highway performance index, provincial roads, developing country, level of service.**

I. Introduction

Low volume roads in Sri Lanka are generally under the purview of the Local Government or the Provincial Councils. These are categorized as 'C' Class and 'D' Class roads which form more that 50% of the road network in the country in terms of road-kilometers [1]. The government has invested heavily on improving the road condition of these roads and has upgraded them to asphalt concreting or concrete pavement roads in the recent years [2] under World Bank, Asian Development Bank and other monetary institution loans. However, due to various reasons there has not been major improvements made to the roadway characteristics such as lane width, shoulder, radius of curvature of these roads. The improvements in road surface condition, population growth and increased use in motorization has resulted in the increase in travel demand on these roads. Thus, creating a need to upgrade these roads to conform with proper design requirements to ensure safe and efficient mobility to the road users.

In addition to the limited funding, the agencies also lack the technical capacity to carryout detailed investigations and surveys on highway performance that are typically carried out in other road agencies at national level. Therefore, any methodology used to evaluate the performance of provincial road networks should be based on data that can be easily collected during the routine network survey. This ensures the continuity in the application of the method in the decision-making process.

The study proposes a simplified methodology to calculate performance index of roads to be used for highway upgrading prioritization. Road upgrading in the context of the study is focused on roadway improvements such as alignment, road width, shoulder etc. not necessarily surface or pavement type improvements. Therefore, the study focuses on the roadway and operating characteristics rather than the pavement condition as the intention is to evaluate their performance with respect to planning level decision making where roads will be selected for upgrading. It is deemed that the maintenance management system would incorporate the pavement condition of the roads.

II. Evaluation of Highway Functional Performance

Highway performance relates to the structural and functional performance of the road. Functional performance is represented by the mobility, rider comfort and safety. These are predominately affected by the roadway characteristics such as alignment, gradient, curvature, road width, shoulder condition, surface condition; and operating characteristics such as traffic volume, heavy vehicle composition, presence of non- motorized traffic etc. Most studies represent highway functional performance via level of service which mainly addresses the mobility aspect of the road.

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Digital sieving of pervious concrete air voids using X-ray computed tomography

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***Abstract*— The design and quality assessment of the pervious concrete mixtures based on its structural and functional performance are greatly influenced by the microstructural properties of the internal pore structure. The main objective of this study is to investigate the internal pore structure properties of two different pervious concrete mixtures (gap graded mixtures with nominal maximum aggregate sizes including 9.5mm and 12.5mm) using X-Ray computed tomography and digital image processing. Image segmentation algorithms based on the histogram and laboratory volumetric characteristics of the pervious concrete mixtures have been utilised for the CT scan images. The key microstructural parameters of the air voids such as effective porosity, pore volume distribution, surface area distribution, elongation, flatness and shape factor distributions of the two different mixtures. It is expected that the developed procedure will serve as a valuable tool with potential applications in the current design methods of the pervious concrete pavements.**

***Index Terms*— pervious concrete, x-ray computed tomography, volumetric segmentation, air voids, digital sieving.**

I. Introduction

The increased concern in the recent years toward reducing the pollutants and the environment resulted in the usage of pervious concrete as the pavement surface layers[1]. Pervious pavement is defined as the special class of pavement comprising materials with sufficient interconnected voids different mixtures were analysed and the results were compared for the ranging from 15 to 35% to allow water to pass through. The benefits of using the pervious pavement include the increase in the skid resistance and reduction in hydroplaning, storm water run-off and tire/road noise. The size and shape characteristics of the pervious concrete air voids have a significant influence on the water permeability and acoustic absorption characteristics [1].

In recent years, significant efforts have been made in analysing the infrastructure materials using CT scanning and digital image processing. Yun et al. [2] and Kim et al. [3] studied the equivalent pore diameters and paste void spacing of the hardened cement paste using CT scanning. Gruber et al. [4] examined the anisotropic permeability, pore size distribution, ice formation in the internal pore network of hot mix asphalt using CT scanning. Gao et al. [5] investigated the size, shape and distribution characteristics of the coarse aggregates in the cold recycling mixes using CT scanning. Kuang et al. [6] investigated the pore network properties of pervious concrete such as pore size distribution, porosity, tortuosity and specific surface area using X-Ray computed tomography. Shaheen et al. [7] developed a framework for evaluated the fatigue characteristics of hot mix asphalt using the pore volume distributions obtained from CT scanning. Abera et al., [8] investigated the effectiveness of global thresholding algorithms for different porous media including pervious concrete using void ratio. Zhang et al. [9] studied the pore size distributions of the various pervious concrete mixtures using watershed segmentation algorithm. Jagadeesh et al. [10] studied the effect of global thresholding algorithms on discharge and volumetric characteristics of the pervious concrete samples. The current paper analyses the effect of different segmentation algorithms on the digital sieving of pervious concrete air voids based on size and shape characteristics using CT scanning and digital image processing.

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II. Materials

To analyse the internal pore characteristics of the different mixtures, two pervious concrete mixtures P1 and P2 with the nominal maximum aggregate size of 9.5mm and 12.5mm respectively and the design porosity of 26.5% were produced. The siliceous aggregates of specific gravity 2.64 and percent absorption 1.35% and the binding agent ASTM Type I cement was used for the mixtures P1 and P2. The water-cement, cement-aggregate and superplasticizer-cement ratio used for the mixtures are 0.300, 0.222 and 0.006 respectively. Pervious concrete samples of 150mm diameter and 250mm height were casted in the laboratory and cured for 28 days in the limewater tank.

III. X-ray Computed Tomography

The medical X-Ray CT scanner of Somatom Emotion 16-channel with an output voltage of 110kV energy was used to obtain the pore network structure of the pervious concrete samples P1 and P2. A total of 300 section images at the vertical interval of 0.7mm has been obtained for the pixel size 1024 x 1024. The Simpleware ScanIP software was used in the conversion of X-Ray absorption coefficients for the voxels to the 16-bit greyscale intensities varying from 0 to 65535, followed by image filtering using convolution kernel and segmentation into binary images using thresholding algorithms. Thresholding of air voids based on grey scale

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Surface Distress Index Updates to Improve Crack Damage Evaluation

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***Abstract*— Road pavement is one of infrastructures that is currently getting most attention due to its important role in accelerating the economic growth rate of an area, opening up isolated regions and improving the connectivity among them. A road infrastructure has a life-cycle which starts from design to reconstruction. Among all phases of road life-cycle, maintenance work plays an important role to maintain the performance of the road always in the top level. To conduct road maintenance work, it is necessary to evaluate the condition of the road, both structurally and functionally. To date, road functional condition assessment uses two indices, namely surface distress index (SDI) and international roughness index (IRI). The SDI, currently used by Directorate General of Highway (DGH), has a simple procedure and is easy to use. Talking about accuracy in estimating the functional conditions of the road, it seem that SDI is still far from satisfactory. In this study, an attempt to evaluate SDI, particular for crack damages, will be proposed by considering all types of crack damage and their corresponding dimension and severity level. Pavement condition index (PCI), the most comprehensive method for evaluating the functional conditions of the road, will be used as the reference. It looks like that PCI is the best choice as a tool to evaluate road functional conditions in Indonesia, however, the weak capability of the field personnel becomes a constraint in optimizing the potential of PCI. Therefore, updating SDI could be now considered as the best solution.**

***Index Terms*— crack damage. road functional condition, SDI,**

I. Introduction

Maintenance/rehabilitation activity is one important part of road life cycle. To be able to select and implement a maintenance/rehabilitation program, a highway agency needs to ensure the latest condition of the road segment and also available budget, so that only the most appropriate program should be processed. This highlights the importance of the road condition evaluation process. The evaluation process consists of two parts, namely evaluation of functional and structural conditions.

The evaluation of functional condition is carried out to determine whether the road still has an adequate level of performance to be able to carry out its functions. The evaluation on flexible pavement usually consists of 3 components, namely, evaluation of the type and severity level of road damage, evaluation of the road roughness and evaluation of skid resistance of the road.

For road damage evaluation, there are two types of parameters that are used to define the level of road damage in Indonesia, that is, surface distress index (SDI) and road condition index (RCI). So far, RCI is less popular due to its qualitative manner in measuring the road damage. At present, a relationship has been developed between RCI and IRI (international roughness index) [1], however, this relationship is not appropriate since the two parameters are different philosophically and not all road damage contributes to the road roughness.

On the other hand, SDI is a parameter that is more widely used. This parameter, together with IRI, could represent the functional conditions of a road pavement. The use of IRI only can represent the roughness along the trail of wheel; therefore, combining the two parameters (SDI and IRI) is more effective in representing the damage of road surface. Unfortunately, SDI parameter is too simple as it only evaluates 3 types of road damage (i.e. pothole, crack and rut), compared to 19 types of road damage identified in PCI (pavement condition index) method [2, 3].

PCI method is recognized by AASHTO [4] as one of the most comprehensive methods in estimating the functional condition of a road. However, with such a comprehensive level, the procedure for determining PCI parameter becomes too complex. This is where the advantages and disadvantages of SDI parameter can play a role. The strength of SDI is in terms of simplicity and ease of conducting measurement of functional conditions of the road by surveyors with low to middle level education. On the other hand, the weakness of SDI is that simplification can lead to inaccuracies in estimating the functional condition of the road, which in turn will affect the inaccuracy of the selection of road handling types.

Based on the description above, this research is important to do especially for the following: (i) updating

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Regional Well-to-Wheel Carbon, Energy, and Water Footprint Analysis of Electric Vehicles

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Abstract— **Adoption of alternative vehicle technologies such as electric vehicles (EVs), plug-in hybrid electric vehicles (PHEVs), and hybrid electric vehicles (HEVs) have the potential of reducing some of the environmental impacts and reducing oil-dependency of the U.S transportation sector. However, this potential depends on the regional driving patterns and the source of the electricity generation to power PHEVs and EVs. In this study, state-specific electricity generation mix scenarios and driving patterns in Alabama, Florida, and Hawaii are considered to calculate regional impacts associated with alternative vehicle technologies (HEVs, PHEVs, EVs) compared to internal combustion vehicles (ICVs). Three electricity generation mix scenario are evaluated, which are namely; average electricity generation mix, marginal electricity generation mix, and 100% solar electricity generation mix. Well-to-wheel carbon, energy, and water footprint of these vehicles are quantified for each state and potential environmental reductions are evaluated. According to comparative evaluation for the proposed scenarios, shifting to low carbon, energy, and water intensive electricity generation mix by utilization of solar energy is crucial to achieve environmental friendly transportation in the U.S.**

***Index Terms*— carbon, energy, water, electric vehicles.**

I. Introduction

Transportation sector is one of the largest source of Greenhouse gas (GHG) emissions and energy consumption in the United States. Energy consumption and GHG emission share of the transportation sector is approximately 28% of the U.S. total [1,2]. Adoption of alternative vehicle technologies to reduce these environmental impacts has been a growing interest in the literature and industry [3,4]. In addition to environmental issues, concerns associated with rising oil prices and national energy security increased the need for sustainable and more efficient transportation systems in the U.S. The amount of petroleum consumed by the transportation sector is significantly higher than the total U.S. petroleum production (about 141% of the annual production). Light-duty vehicles consume about 63% of this immense amount and they account for 59% of the total energy consumption in the U.S. transportation sector [5]. Light-duty vehicles (LDVs) compromise about 85% of the passenger miles travelled in the United States and it is a rapidly growing transportation mode in the world as well as in the developed countries [6,7].

Adoption of alternative vehicle technologies such as electric vehicles (EVs), plug-in hybrid electric vehicles (PHEVs), and hybrid electric vehicles (HEVs) have the potential of reducing some of the environmental impacts and reduce oil-dependency of the U.S transportation sector [8–12]. However, this potential depends on the regional driving patterns and the source of the electricity generation to power PHEVs and EVs [13,14]. For instance, the electricity generation mix to power an EV might come from either a carbon-intensive source such as coal or a low-carbon source mix with high share of renewable energy such as solar power [15]. Similarly, the water withdrawal, energy use, and other environmental impacts might vary significantly based on the electricity generating mix [16–18]. Among the alternative vehicle technologies mentioned above, PHEVs have both an electric and an internal combustion engine. The electric motor is powered by a high capacity battery that is mostly charged from the grid. So, they are capable to displace some of the petroleum consumption with electric power. The portion of the distance that can be powered by electricity depends on several important factors such as all-electric range (AER), driving distance, and driving conditions [19]. AER is defined as the total miles can be driven, after the battery is fully charged, in electric mode (engine-off) before the engine turns on for the first time [20].

In this study, driving patterns in Alabama (AL), Florida (FL), and Hawaii (HI) are considered for various AER options of PHEVs (10, 20, 30, and 40) to calculate regional impacts associated with alternative vehicle technologies compared to internal combustion vehicles (ICVs). The driving patterns determine what portion of the vehicle miles travelled (VMT) can be powered by electricity for various ranges of PHEVs. For instance, vehicles travelled less than 30 miles compromise the approximately 63% of the daily VMT in the U.S. [21]. This percentage can vary from state to state and hence, associated environmental impacts might be significantly different. In this regard, AL, FL, and HI were selected to evaluate how these spatial variations influence the impacts at state level. Furthermore, comparisons between various vehicle options allows a better understanding about how state-level vehicle

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