A Review of the Philippine Visual Condition Index by Experts' Validation

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***Abstract*—The pavement performance indices were developed to address the challenge of quantifying the condition or performance of existing road networks. They are crucial to national resource programming and prioritization in asset preservation. Pavement Condition Index (PCI) is one of these metrics measured by observing the surface road defects of a road network. This index is referred to as the Visual Condition Index (VCI) in the Philippines and is being conducted by the Department of Public Works and Highways (DPWH). It was adopted from New South Wales, Australia, and was localized to indicate the surface condition of the national roads. Currently, the documented process of localizing the index cannot be traced. This study aims to scientifically evaluate the suitability of the localized version of VCI to the Philippines by developing and comparing it to a new rating condition based on the insights and proficiency of the local road practitioners and specialists representing all the District Engineering Offices (DEOs) of the DPWH in the Philippines. This new rating condition was developed by conducting an online survey that simulated road networks selected from historical data. On-site images of the selected roads were captured and used in the online survey evaluated by the practitioners and specialists. Correlation of the results using multiple regression and Artificial Neural Network (ANN) analyses were employed to formulate a new PCI. The comparison between the new asphalt and concrete pavement PCI models and the current VCI employed yield coefficient of determination values of 0.78 and 0.75, respectively. These findings suggest that the formulated PCI effectively reflects the VCI and confirms that it is tailored to the local condition.**

***Keywords*—PCI, VCI, pavement defects, Philippine PMS, Philippine roads**

I. Introduction

The Pavement Condition Index (PCI) is a metric that measures the condition of pavements through visual inspection of existing surface defects. It is one of the primary performance indicators used to assess existing pavement conditions [1]. Observation of defects along the surface of the existing pavement is crucial for implementing appropriate measures. These defects may signify underlying issues within the structure that, if left untreated, could accelerate pavement deterioration.

A similar parameter to quantify the condition of the Philippine major road network (national roads) is being employed by the DPWH called VCI as per the Road Condition Assessment (RoCond) Manual of DPWH, which was patterned from the Road Condition Manual of the Road and Traffic Authority of New South Wales, Australia [2]. The procedures and method of measurements focusing on improving safety and comfort are among the changes that were made to suit the conditions in the Philippines. However, documentation of the localization of VCI is untraceable.

A. Objectives

This study attempts to develop a new pavement condition rating based on the knowledge and experience of local field experts and evaluate the current VCI used in the Philippines. The specific objectives are set as follows:

- Develop a cost-effective methodology for developing an expert-driven PCI, drawing insights from related studies and the expertise of local field experts.
- Identify fundamental surface defects that significantly influence pavement condition based on ratings provided by practitioners.
- Formulate asphalt and concrete pavements PCI models that estimate the local road condition utilizing insights from local field experts, employing Artificial Neural Network (ANN) and multiple linear regression analysis.
- Conduct comparative analyses between the developed PCI models and the prevailing VCI to ensure the reliability of the results.

B. Scope and Limitations

This paper formulated the asphalt and concrete PCI model for the national roads in the Philippines employing

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two analytical approaches: ANN and multiple linear regression. One hundred forty-six practitioners from the 16 regions of DPWH-DEOs participated in the study through an online survey about pavement condition assessment. They evaluated 144 asphalt (72) and concrete (72) pavement sections.

II. Literature Review

A. The Philippines Pavement Condition Rating

The VCI is a function of the presence of defects and is presented in values ranging from 0 (worst condition) to 100 (best condition). There were different VCI models for different types of roads- whether concrete, asphalt, or gravel/earth. Each equation considered different weight values for different kinds of defects. Eq. (1) calculates the condition of the paved roads (concrete and asphalt) in the Philippines [2].

$$VCI = max\left(0, \left(100 * \left(1 - \sqrt{1 - \left(\left(100 - \left(\frac{min(300, SDWf)}{3}\right)\right) * 100\right)^2}\right)\right)\right) \quad (1)$$

where, SDWf - sum of the weighted defects

TABLE I. Defect Weight Factors for Asphalt VCI

Pavement Defects	Severity	Weight Factors
Crocodile Cracks	Narrow	3.50
	Wide	5.90
Transverse Cracks	Narrow	3.30
	Wide	5.50
Edge Breaks	Small	0.41
	Medium	0.82
	Large	1.25
Patching	-	1.25
Potholes	-	0.36
Surface Failures	-	0.18
Rutting	-	4.00
Wearing Surfaces	Minor	0.55
	Severe	1.20

The VCI for asphalt pavements considers various surface defects and weight factors, as shown in Table I [2]. Weight factors reflecting the damaged condition of the pavement are assigned to each defect and its severity. For concrete pavements, the surface defects encompassed in the VCI are shown in Table II [2].

TABLE II. Defect Weight Factors For Concrete VCI

Pavement Defects	Severity	Weight Factors
Multiple Cracks	Narrow	3.60
	Wide	-
Transverse Cracks	Narrow	3.50
	Wide	5.50
Spalling	-	3.00
Faulting	-	4.20
Shattered Slabs	-	1.36
Scaling	Minor	0.55
	Severe	1.20
Joint Sealant Deterioration	-	0.13

B. Foreign Pavement Condition Rating

The relevant experience of the practitioners and specialists are critical component in formulating pavement condition ratings. Several existing indices, such as the Present Serviceability Index (PSI) in America, the Maintenance Control Index (MCI) in Japan, and the National Highway Pavement Condition Index (NHPCI) and Highway Pavement Condition Index (HPCI) in South Korea, have been developed using this particular methodology. The methodology for creating these indices typically consists of two primary components: physical measurement of pavement defects and field-based rating of pavement sections.

1) Present Serviceability Index (PSI)

The PSI emerged during the American Association of State Highway Officials (AASHO) 's development of pavement design. Various stakeholders in the highway were gathered to rate the serviceability of selected road segments. The panel raters comprised material suppliers, maintenance workers, and automotive manufacturers. They were asked to traverse a road segment by driving or walking and to rate their perceived serviceability using a 5-point scale. The transverse and longitudinal profiles of the same road segments were measured by identifying defects such as cracks, spalls, patches, and ruts [3].

During the road test, 74 asphalt pavement sections and 49 concrete pavements were assessed. Eqs. 2 and 3 show the PSI for asphalt and concrete pavements formulated using multiple linear regression analysis of the measured defects and panel ratings.

$$PSI_{asphalt} = 5.03 - 1.91\log(1 + SV) - 1.38RD^2 - 0.01\sqrt{C + P} \quad (2)$$

$$PSI_{concrete} = 5.41 - 1.78\log(1 + SV) - 0.09\sqrt{C + P} \quad (3)$$

2) Maintenance Control Index (MCI)

Similar to the PSI, Japan's MCI (see Eq. 4) was developed based on the input of road pavement authorities. They used a 10-point rating scale to rate the condition of 1808 asphalt pavements. In addition to the visual inspections, data on maintenance and rehabilitation costs and strategies were also considered [3, 4]

$$MCI = \min\begin{pmatrix} 10 - 1.48C^{0.3} - 0.29D^{0.7} - 0.47\sigma^{0.2} \\ 10 - 1.51C^{0.3} - 0.3D^{0.7} \\ 10 - 2.23C^{0.3} \\ 10 - 0.54D^{0.7} \end{pmatrix} \quad (4)$$

where: percentage of cracking (C), the average rut depth (*D*), and the standard deviation of the longitudinal profile (σ)

3) National Highway Pavement Condition Index (NHPCI) & Highway Pavement Condition Index (HPCI)

South Korea designed the NHPCI to enhance their asphalt national highways network-level Pavement Management System (PMS). Its development involved applying multiple regression analysis between the measured defects of selected road segments and the corresponding ratings provided by pavement practitioners. Ten pavement expert members from different sectors, academe, research, government, industry, and government, were also invited to rate 40 selected road segments. The datasets of the defects (cracks, ruts, roughness, patches, etc.) measured using the Automated Road Analyzer (ARAN), together with the ratings, were used to develop the index. Given by Eq. 5 [4, 5].

$$NHPCI = (0.33 + 0.003C + 0.004RD + 0.0183IRI)^{-2} \quad (5)$$

where crack ratio (C), the rut depth (RD), and the international roughness index (IRI) are identified and set as the independent variables.

A separate condition index HPCI was developed to evaluate the expressways in South Korea. Like NHPCI, HPCI's formulation employs multiple regression analysis of panel ratings and measured defects. The HPCI models for asphalt and concrete pavements are shown in Eqs. (6) and (7), respectively [6].

$$HPCI_{asphalt} = 5 - 0.54(IRI^{0.8}) - 0.75(RD^{1.2}) - 0.9\log(1 + SD) \quad (6)$$

$$HPCI_{concrete} = 5 - 0.8(IRI^{0.7}) - 0.85\log(1 + 2.5SD) \quad (7)$$

where: international roughness index (IRI), the rut depth (RD), and the surface distress or crack quantity (SD).

Moreover, various recent studies attempted to develop indices to assess the condition of specific pavement structures such as national roads [7, 8], local streets [9], airport pavements [10, 11], urban road networks [12–14], highways [15], sidewalk [16], composite pavements [17]. Most of these studies utilized deduct value curves, multi-linear regression analysis, and machine learning.

III. Methodology

Like existing indices, developing a new pavement condition index requires two primary components: measured defects from selected road segments and experts' ratings of the pavement section. Typically, the conventional method incurs significant costs when gathering the dataset and requires transporting the practitioners and specialists to the road segments. However, due to the transportation restrictions imposed during COVID-19, the online survey was created to simulate the segments and bring them to the practitioners and specialists when the study was implemented. The historical condition of road networks and online survey platforms are utilized to reduce the cost of PCI development. The methodology comprises two main components: road segment section selection and pavement condition assessment.

A. Road Segment Selection

Selected road segments were chosen based on the DPWH road condition datasets, which depict the road conditions across the Philippines for the last two years. Given that this historical data includes pavement defects, the necessity for physical defect measurements can be circumvented. The types, measurements, and units of defects from the data on paved roads (asphalt and concrete pavement) are summarized in Table III. Figure 1 shows the online survey that simulates the image of a 1 km stretch of a two-lane pavement section containing defects.

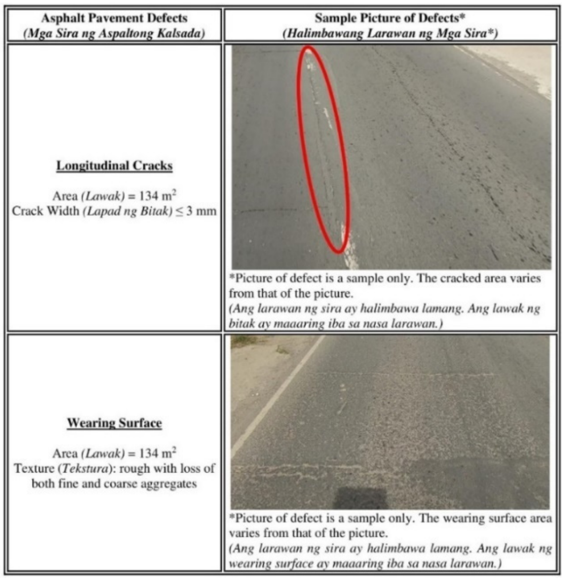

Fig. 1. Sample of pavement section representation.

TABLE III. Defects Considered in the Asphalt and Concrete Pavement Section

ASPHALT			CONCRETE		
Defects	Measurement	Unit	Defects	Measurement	Unit
Crocodile Cracks	Area	m^2	Multiple Cracks	Area	m^2
	Crack Width	mm		Crack Width	mm
Longitudinal Cracks	Area	m^2	Longitudinal Cracks	Area	m^2
	Crack Width	mm		Crack Width	mm
Transverse Cracks	Area	m^2	Transverse Cracks	Area	m^2
	Crack Width	mm		Crack Width	mm
Edge Breaks	Length	m	Spalling	Length	m
	Average Width	mm		Average Width	mm
Patching	Area	m^2	Faulting at Transverse Joint	Average Faulting	mm
Potholes	Count	-			
Surface Failures	Count	-	Shattered Slabs	Count	-
Rutting	Mean Rut Depth	mm	Scaling	Area	m^2
Wearing Surface	Area	m^2		Texture	-
	Texture	-	Joint Sealant Deterioration	Length	m

B. Pavement Condition Assessment

The road pavement sections were brought to the practitioners through the images in the online survey, unlike the traditional evaluation method. In the online survey, they were asked to evaluate the overall surface condition of the road segments based on their best judgment. The 0 (worst possible condition) to 10 (best possible condition) point scale was adopted. The portion of the electronic survey is illustrated in Fig. 2.

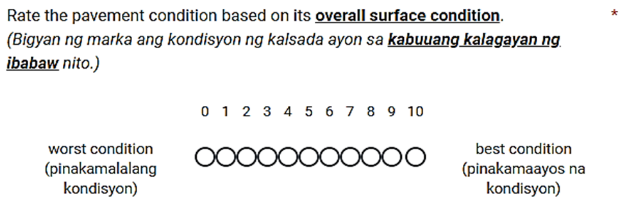

Fig. 2. A portion of the online survey on pavement condition assessment.

The DPWH Bureau of Maintenance personnel assisted in successfully deploying the online survey to the different DPWH DEOs. The field experts who participated in the assessment were pavement maintenance and management officers. 146 field experts from 16 out of 17 DPWH DEOs in the Philippines participated in the pavement condition assessment survey. Most respondents have an average of 6-10 years of experience and hold bachelor's degrees, with 12% conferring postgraduate degrees.

The data from the assessment was then used to establish the relationship between the pavement defects and the pavement condition (PCI). A comparative analysis between the developed PCI and VCI that is currently employed by the VCI of DPWH.

IV. Result and Discussion

A. Development of Expert-based PCI

The practitioners were able to evaluate a total of 144 road segments divided into two different pavement materials: asphalt and concrete pavement. Each of these road segments were evaluated by an average of 7 practitioners. The average rating in a section was utilized for the development of PCI. Table IV provides the summary of the average PCI for the 72 asphalt pavement sections and 72 concrete pavement sections.

To establish the independent variables in the development of PCI models, surface defects were analyzed using Pearson's correlation. Variables with significant correlations were chosen as independent variables. The strength of the correlations was assessed through the correlation coefficient, while significance is determined by the p-value [18].

The summary of the Pearson correlation between the pavement defects and the rating of the practitioner is shown in Table V. The correlation of asphalt pavement defects, e.g., crocodile cracks, longitudinal cracks, edge breaks, patching, surface failures, rutting, potholes, and wearing surfaces are significant, given that their calculated p-values are less than 0.200. For concrete pavements, all calculated p-values were less than 0.200 and were identified to have a significant correlation with practitioners' ratings. As such, the surface defects considered for concrete are multiple cracks, longitudinal cracks, transverse cracks, spalling, faulting, shattered slabs, scaling, and joint sealant deterioration. Hence, these defects were considered in developing the PCI model (see Table V).

TABLE IV. Average Field expert's Ratings for Asphalt and Concrete Pavement Sections

ASPHALT					
Section ID	**Ave. Rating**	**Section ID**	**Ave. Rating**	**Section ID**	**Ave. Rating**
SA1	4.25	A22	3.88	A46	7.40
SA2	6.13	A23	5.67	A47	3.60
SA3	6.38	A24	4.40	A48	1.20
A1	3.25	A25	6.00	A49	1.60
A2	4.25	A26	5.00	A50	6.00
A3	5.63	A27	6.40	A51	4.89
A4	4.88	A28	5.00	A52	4.40
A5	2.38	A29	5.00	A53	4.50
A6	3.38	A30	6.43	A54	4.00
A7	5.38	A31	6.43	A55	4.60
A8	4.75	A32	3.14	A56	6.25
A9	4.38	A33	2.33	A57	4.00
A10	2.57	A34	3.86	A58	5.40
A11	4.25	A35	4.20	A59	2.40
A12	7.00	A36	2.33	A60	6.20
A13	4.75	A37	5.60	A61	4.40
A14	3.50	A38	2.78	A62	5.00
A15	3.12	A39	6.60	A63	2.38
A16	7.50	A40	4.60	A64	4.60
A17	3.13	A41	3.20	A65	5.71
A18	5.00	A42	5.60	A66	4.00
A19	4.75	A43	5.20	A67	4.40
A20	3.63	A44	4.80	A68	4.43
A21	4.78	A45	6.40	A69	6.14
CONCRETE					
SC1	3.75	C22	3.33	C46	4.40
SC2	2.88	C23	4.78	C47	1.40
SC3	2.62	C24	3.38	C48	7.80
C1	1.88	C25	6.86	C49	3.80
C2	4.50	C26	4.60	C50	3.00
C3	5.63	C27	4.20	C51	4.20
C4	9.00	C28	5.00	C52	3.56
C5	3.25	C29	3.71	C53	3.00
C6	5.25	C30	5.71	C54	2.20
C7	4.88	C31	1.86	C55	3.88
C8	4.88	C32	3.86	C56	5.40
C9	1.50	C33	4.56	C57	4.60
C10	5.00	C34	5.33	C58	3.60
C11	5.63	C35	4.78	C59	3.80
C12	7.50	C36	2.14	C60	4.75
C13	2.63	C37	6.60	C61	5.60
C14	2.13	C38	3.80	C62	4.20
C15	2.63	C39	6.80	C63	4.40
C16	5.00	C40	5.60	C64	5.40
C17	3.75	C41	3.80	C65	5.71
C18	2.50	C42	6.00	C66	2.80
C19	3.50	C43	7.00	C67	4.14
C20	5.63	C44	6.60	C68	5.00
C21	5.78	C45	4.2	C69	6.71

The models developed for the Philippine national roads were formulated using multiple linear regression and ANN analysis. The range of 0 to 100 and road condition values were adopted. The intercept is set to 100 to represent the perfect condition of the pavement. The developed PCI estimation models using the two analysis methods are then compared based on the adjusted coefficient of determination (R^2). Table VI summarizes the comparison for asphalt and concrete pavements, respectively. It can be observed from the table that the highest values of R^2 were attained using multiple linear regression analysis. As such, the PCI models developed using the said method will be considered the final results of this study and utilized in the comparisons with the current VCI of the DPWH.

The PCI model (Eq. 8) obtained an adjusted R2 of 0.624 for asphalt pavements, while the PCI model (Eq. 9) for concrete pavement obtained an adjusted R2 of 0.706. The result implies that the developed PCI estimation model captures 62.4% and 70.6% of the variability of the expert-based dataset for both asphalt and concrete pavements respectively.

$$PCI_{asphalt} = \max(0, 100 - 0.808x_{CC} - 1.727x_{LC} - 0.308x_{EB} - 0.561x_{PA} - 0.248x_{SF} - 2.306x_{RD} - 0.028x_{PO} - 0.584x_{WS}) \quad (8)$$

TABLE V. PEARSON CORRELATION BETWEEN ASPHALT PAVEMENT DEFECTS AND FIELD EXPERTS' RATINGS

Asphalt	Field Experts' Rating	Concrete	Field Experts' Rating
Pavement Defects	P-value	Pavement Defects	P-value
Crocodile Crack Percentage (%)	9.47E-05	Multiple Crack Percentage (%)	1.84E-04
Longitudinal Crack Percentage (%)	0.01	Longitudinal Crack Percentage (%)	0.038
Transverse Crack Percentage (%)	0.296	Transverse Crack Percentage (%)	0.162
Edge Break Percentage (%)	0.16	Average Width of Spalling (mm)	0.031
Patching Percentage (%)	0.071	Average Faulting (mm)	0.075
Number of Surface Failures	0.023	Number of Shattered Slabs	1.41E-06
Mean Rut Depth (mm)	0.033	Scaling Percentage (%)	5.45E-05
Number of Potholes	0.186	Joint Sealant Deterioration Percentage (%)	0.08
Wearing Surface Percentage (%)	7.65E-05		

The PCI for asphalt pavements is calculated based on the crocodile cracking in percent (x_{CC}), the longitudinal cracking in percent (x_{LC}), the edge break in percent (x_{EB}), the patching in percent (x_{PA}), the number of surface failures (x_{SF}), the mean rut depth in millimeter (x_{RD}), the number of potholes (x_{PO}), and the wearing surface in percent (x_{WS}) of the pavement section.

$$PCI_{concrete} = \max(0, 100 - 0.762x_{MC} - 1.312x_{LC} - 1.296x_{TC} - 0.381x_{SP} - 2.210x_{FA} - 0.716x_{SS} - 0.570x_{SC} - 0.196x_{JS}) \quad (9)$$

The PCI for concrete pavements is calculated based on multiple cracking in percent (x_{MC}), the longitudinal cracking in percent (x_{LC}), the transverse cracking in percent (x_{TC}), the average width of spalling in millimeters (x_{SP}), the average faulting in millimeters (x_{FA}), the number of shattered slabs (x_{SS}), the scaling in percent (x_{SC}), and the joint sealant deterioration in percent (x_{JS}).

B. Comparisons with VCI

1) Pavement Defects Considered

The pavement defects in developing the PCI model were compared with those in the currently employed VCI. (see Tables VII and VIII).

TABLE VI. COMPARISON OF DEVELOPED PCI MODELS FOR ASPHALT PAVEMENTS

ASPHALT		
Analysis Method	**ANN Topology**	**Adjusted R^2**
Multiple Linear Regression	-	0.624
Artificial Neural Network (ANN)	8-1-1	0.345
	8-2-1	0.326
	8-3-1	0.415
	8-4-1	0.454
	8-5-1	0.535
	8-6-1	0.294
	8-7-1	0.415
	8-8-1	0.446
	8-9-1	0.559
	8-10-1	0.405
	8-11-1	0.425
	8-12-1	0.506
	8-13-1	0.431
	8-14-1	0.459
	8-15-1	0.427
Analysis Method	**ANN Topology**	**Adjusted R^2**
Multiple Linear Regression	-	0.706
Artificial Neural Network (ANN	8-1-1	0.349
	8-2-1	0.470
	8-3-1	0.420
	8-4-1	0.463
	8-5-1	0.384
	8-6-1	0.401
	8-7-1	0.402
	8-8-1	0.432
	8-9-1	0.443
	8-10-1	0.503
	8-11-1	0.484
	8-12-1	0.500
	8-13-1	0.520
	8-14-1	0.475
	8-15-1	0.451

TABLE VII. ELEMENT DEFECTS CONSIDERED IN EXPERT-BASED PCI AND VCI

Asphalt Pavement Defects	Expert-Based PCI	VCI [2]
Crocodile Cracks	O	O
Longitudinal Cracks	O	
Transverse Cracks		O
Edge Breaks	O	O
Patching	O	O
Potholes	O	O
Surface Failures	O	O
Rutting	O	O
Wearing Surface	O	O

The current formula for VCI does not account for longitudinal cracking, as shown in the comparison in Table VII. However, based on the results of this study, it has been identified that it has a significant correlation with the overall condition of asphalt pavements. Hence, longitudinal cracking is incorporated as one of the independent variables in the developed expert-based PCI model.

On the other hand, based on the Pearson correlation analysis, the defect mentioned is insignificantly correlated to the field experts' ratings. Hence, it was excluded from the expert-based PCI. However, this outcome may be attributed to the lack of historical data, as transverse cracks are seldom observed in Philippine asphalt pavements. Table VIII compares the defects considered by the expert-based PCI model and the VCI for concrete pavements.

TABLE VIII. COMPARISON OF ASPHALT PAVEMENT DEFECTS CONSIDERED IN EXPERT-BASED PCI AND VCI

Asphalt Pavement Defects	Expert-Based PCI	VCI [2]
Multiple Cracks	O	O
Longitudinal Cracks	O	
Transverse Cracks	O	O
Spalling	O	O
Faulting	O	O
Shattered Slabs	O	O
Scaling	O	O
Joint Sealant Deterioration	O	O
Multiple Cracks	O	O

Like asphalt pavements, the current VCI does not incorporate longitudinal cracks. However, this study's results indicate otherwise. The significant correlation between longitudinal cracks and the field experts' ratings was identified and considered in developing the expert-based PCI model. The confidence level in establishing a correlation's significance is set to only 80%. If additional data is acquired, this threshold is suggested to be increased to 90-95%.

2) Pavement Condition Evaluation of Historical Data

Another comparative analysis was conducted between the developed PCI and existing VCI. The surface defects data in 2019-2020 was utilized from 44,698 asphalt pavement sections and 83,101 concrete pavement sections in the country. The pavement conditions of these segments were calculated using the developed expert-based PCI from Eq. 8 and Eq. 9. The results were then compared with the corresponding VCI of the pavement sections. Given that the primary objective of this study is to provide supporting evidence on localized VCI of the Philippines, the expert-based PCI developed in this study should ideally be equal to the existing VCI. Therefore, fitting the two parameters in the equation is logical.

The correlation between the asphalt and concrete expert-based PCI with VCI is 0.781 and 0.752, respectively. These values suggest that the expert-based PCI developed in this study strongly represents the VCI. The comparison can also be visually represented by plotting the VCI against the expert-based PCI (Fig. 3 and Fig. 4). It is apparent from the figures that the relationships between the indices are not linear as expected. The discrepancy arises because the expert-based PCI developed assumes a linear relationship between pavement condition and defects, whereas the existing VCI demonstrates the exponential relationship between pavement condition defects.

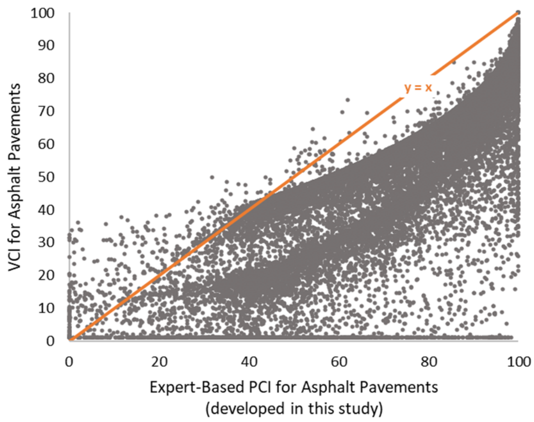

Fig. 3. Graphical representation of comparison between expert-based PCI and VCI for asphalt pavements.

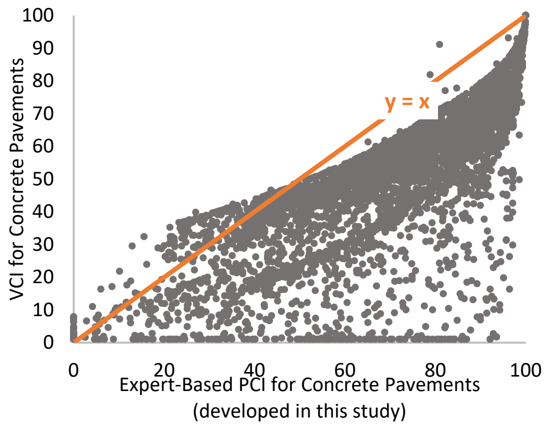

Fig. 4. Graphical representation of comparison between expert-based PCI and VCI for concrete pavements.

V. CONCLUSION

This study aims to provide a scientific evaluation for localizing the Philippine VCI by developing a new pavement condition rating.

The study successfully formulated the PCI estimation model for the Philippine asphalt concrete national roads based on the judgment and experience of field experts across the country's regions. PCI models were developed and compared to identify the best fit for the expert-based dataset generated. The PCI model developed using multiple linear regression analysis was identified to be the best fit with the corresponding values of R2 equal to 0.624 and 0.706 for asphalt and concrete pavements, respectively.

Based on the Pearson correlation analysis results, particular surface defects that significantly impact pavement conditions were identified. The formulated expert-based PCI model for asphalt pavement as a function of crocodile cracking percentage, longitudinal cracking percentage, edge break percentage, patching percentage, number of surface failures, mean rut depth, potholes, and wearing surface percentage. On the other hand, the resulting PCI model for concrete pavements is a function of multiple crack percentage, longitudinal crack percentage, transverse crack percentage, average width of spalling, average faulting, number of shattered slabs, scaling percentage, and joint sealant deterioration percentage.

Furthermore, the expert-based PCI model developed in this study has been compared with the currently employed VCI in the Philippines. The developed PCI models showed a good representation of VCI. Therefore, this study supports the claim that the currently employed VCI to assess the condition of asphalt and concrete pavements of the national roads is localized to Philippine conditions.

In addition, a cost-effective methodology using electronic survey platforms was formulated and utilized to develop the expert-based PCI model.

Including more data is recommended to enhance the results of correlation, multiple regression, and ANN analyses. Therefore, acquiring additional data through electronic surveys on pavement condition assessments is highly encouraged. Lastly, exploring alternative analysis methods, such as genetic programming, is recommended for further investigation. Conflict of Interest

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Lea B. Bronuela-Ambrocio: Funding Acquisition, Conceptualization, Methodology Writing-review and editing, Supervision.

Jamie Alea B. Ramos: Conceptualization, Methodology, Formal Analysis and investigation, Writing-original draft preparation.

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