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Comparative Evaluation of IRI Predictions Using MEPDG 2015 with New Mexico and Virginia Local Calibrations in Indonesia

Gita Yuliani[1], Eri Susanto Hariyadi[1] and Ade Sjafruddin[1].

[1] *Highway Engineering and Development Master Program, Faculty of Civil and Environmental Engineering, Institut Teknologi Bandung, Indonesia,*

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CORRESPONDING AUTHOR

*E-mail: gitayuliani297@gmail.com

A B S T R A C T

This study aims to evaluate the accuracy of IRI prediction using the MEPDG 2015 method with two different local calibration parameters—New Mexico and Virginia—by comparing them against actual field conditions in Indonesia. The analysis was conducted on six segments of the North Coast National Road (Pantura), totaling 55.87 km, using input data from 2020 and field measurements from 2021 to 2023. Pavement responses were analyzed using ELMOD 6 and KENPAVE, and predictions were made for rutting, fatigue cracking, and IRI. The results showed that MEPDG 2015 with Virginia calibration produced the smallest relative deviation (−15.66%) compared to the field data, indicating better alignment with actual pavement performance than the New Mexico calibration. The findings confirm the importance of selecting calibration parameters appropriate to local climate and structural conditions. MEPDG 2015 with Virginia calibration is recommended for future IRI prediction in areas with similar environmental characteristics to western Indonesia.

Contribution to Sustainable Development Goals (SDGs):
SDG 9: Industry, Innovation and Infrastructure
SDG 11: Sustainable Cities and Communities
SDG 12: Responsible Consumption and Production

1. INTRODUCTION

1.1. *Research Background*

Improving pavement quality in Indonesia is a critical issue, considering the essential role of roads as the backbone of national transportation. According to the Directorate General of Highways, the national road condition rating reached only 94.18% [1] by the end of 2023, falling short of the 95% target due to budget constraints [2]. Under limited funding, accurate pavement performance prediction is essential to determine the right timing and method of maintenance interventions.

In Indonesia, the current network-level pavement management system for national roads is IRMS V.3. This system forecasts the deterioration of the International Roughness Index (IRI) using empirical equations [3]. However, pavement analysis has globally evolved towards mechanistic-empirical approaches, which combine mechanistic pavement responses and performance observations from field experiments. The mechanistic-empirical approach is considered superior to purely empirical models. The 2015 Mechanistic-Empirical Pavement Design Guide (MEPDG) is regarded as the most advanced standard for mechanistic-empirical pavement analysis and design [4]. MEPDG relies on predictive models developed initially from Long-Term Pavement Performance (LTPP) data, making them global and not immediately applicable to local conditions [5].

To bridge this gap, local calibration is required—namely, the process of adjusting MEPDG model parameters to reflect better the actual performance conditions observed in a specific region. This enhances the prediction accuracy of pavement distresses such as IRI, cracking, and rutting [6]. Among these, the International Roughness Index (IRI) is a key focus, as it also serves as a standard performance indicator in Indonesia's road management system.

This study utilizes two sets of local MEPDG calibration parameters from the U.S. states of New Mexico and Virginia, both of which provide complete documentation and validated methodologies using field data. New Mexico represents a semi-arid region characterized by low rainfall and high temperatures [6], conditions that are comparable to eastern Indonesian regions such as East Nusa Tenggara and Maluku, which also experience prolonged dry seasons and limited precipitation [7]. In contrast, Virginia, with its humid subtropical climate [8] and relatively evenly distributed annual rainfall, is considered representative of western Indonesia's climate conditions, such as in Java and Sumatra [9].

Calibrations in both states have shown significant improvements in IRI prediction accuracy compared to the global default models. Therefore, it is essential to assess how well the New Mexico and Virginia calibration parameters can represent IRI predictions under Indonesian conditions. This study aims to compare IRI prediction results using the 2015 MEPDG with those two sets of local calibration parameters against actual field data in Indonesia, in order to evaluate their suitability and reliability in a local context.

1.2. *Literature Review*

1.2.1. MEPDG 2015 Method

The Mechanistic-Empirical Pavement Design Guide (MEPDG) 2015 is a pavement structural design method that combines mechanistic and empirical approaches. It integrates knowledge of materials, climate, and structural responses of pavement such as stress, strain, and deflection [5]. MEPDG 2015 is a development from the earlier empirical design method, namely the AASHTO 1993 guide [10]

1.2.1.1. Back-calculation

Back-calculation is a method used to estimate the mechanical properties of pavement structures, such as elastic modulus, and can be performed using software such as ELMOD 6 [11].

1.2.1.2. Mechanistic Modeling of Flexible Pavements

According to Ref. [12], mechanistic modeling aims to determine the pavement's response under load for multilayer systems. KENPAVE is a software developed by Dr. Yang H. Huang, P.E., from the University of Kentucky in 1993. It is used to compute stresses and strains within pavement layers and to predict potential pavement damage over a certain period. Inputs required in KENPAVE include modulus values, Poisson's ratio for each layer, tire pressure, and the coordinates of the stress and strain points to be analyzed.

1.2.1.3. Flexible Pavement Distress Prediction

The MEPDG method evaluates three primary pavement distress criteria: fatigue cracking, permanent deformation (rutting), and smoothness (IRI). The calculation follows the AASHTO (2015) guidelines.

1. Rut Depth

Rutting is caused by vertical permanent deformation in the Hot Mix Asphalt (HMA), unbound layers, or subgrade. In MEPDG 2015, rutting is estimated by calculating deformation in each sublayer. Rut depth is predicted at the mid-depth of each pavement layer based on vertical strain caused by traffic loading.

$$\Delta_{P(HMA)} = \beta_{1r} k_z \varepsilon_{r(HMA)} 10^{k1r} n^{k2r} T^{k3r\,\beta 3r} \quad (1)$$

Where:

$\Delta_{p(HMA)}$= Accumulated permanent deformation in HMA (in)
$\varepsilon_{r\,(HMA)}$ = Resilient strain at HMA mid-layer (in/in)
n = Number of load repetitions
T = Pavement temperature (°F)
kz = Depth confinement factor

k1r, 2r, 3r= Global calibration coefficients (k1r = -3,35412, k2r = 0,4791, k3r = 1,5606)

β1r, 2r, 3r = Local calibration coefficients

$$\Delta_{P(soil)} = \beta_{s1} k_{s1} \varepsilon_v h_{soil} \left(\frac{\varepsilon_0}{\varepsilon_r}\right) e^{-\left(\frac{\rho}{n}\right)^{\beta}} \quad (2)$$

Where:

$\Delta_{p(soil)}$ = Permanent deformation in the soil layer (in)
$\varepsilon_0, \varepsilon_r\, \beta, \rho$ = Lab test parameters
ε_v = Average vertical strain (in/in)
h_{soil} = Soil layer thickness (in)
ks1 = Global calibration coefficient (ks1 = 2,03 for granular and 1.35 for fine-grained)
βs1 = Local calibration coefficient

2. Load Related Cracking – Fatigue Cracking

Load-related cracking refers to fatigue damage predicted as alligator cracking and longitudinal cracking. In MEPDG, alligator cracking is assumed to initiate from the bottom of the HMA layer and propagate upward, while longitudinal cracking is considered to start from the pavement surface.

$$N_{F-HMA} = k_{f1}(C)(C_H)\beta_{f1}(\varepsilon_t)^{k_{f2}\,\beta_{f2}} (E_{HMA})^{k_{f3}\,\beta_{f3}} \quad (3)$$

Where:

N_{F-HMA} = Number of load repetitions until failure
ε_t = Tensile strain at critical location
E_{HMA} = HMA Modulus (psi)
$k_{f1,f2,f3}$ = Global calibration coefficient (k_{f1}= 0,007566, k_{f2}= 3,9492, k_{f3}= 1,281)
$\beta_{f1,f2,f3}$ = Local calibration coefficient

3. Smoothness

An increase in surface distress contributes to rising IRI values over time [5]. The prediction model is:

$$IRI = IRI_O + C_1(RD) + C_2(FC_{TOTAL}) + C_3(TC) + C_4(SF) \quad (4)$$

Where:

IRI_0 = Initial IRI (in/mi)
SF = Site factor
FC_{total} = Total fatigue cracking (%)
TC = Length of transverse cracking (ft/mi)
RD = Average rut depth (in)
$C_{1,2,3,4}$ = Global calibration coefficients ($C_1 = 40{,}00, C_2 = 0.400, C_3 = 0{,}008, C_4 = 0{,}015$)

1.2.1.4. Local Calibration

Calibration factors are adjustments in mechanistic-empirical models to better match real-world conditions. The adjustment of predictive models based on region-specific input data is referred to as local calibration. According to AASHTO (2015), local calibration aims to improve prediction accuracy and reduce model bias. In this study, calibration parameters from New Mexico and Virginia are used, as presented in Tables 1, 2, and 3 [6]; [13].

Table 1 Local Calibration for Rut Depth

Calibration	***Rut Depth***		
	β1r	**β2r**	**β3r**
New Mexico	1.10	1.10	0.80
Virginia	0.687	1.00	1.00

Table 2 Local Calibration for Alligator Cracking

Calibration	***Bottom – Up / Alligator Cracking***					
	βf1	**βf2**	**βf3**	**c1**	**c2**	**c4**
New Mexico	1.00	1.00	1.00	0.625	0.25	6.000
Virginia	42.87	1.00	1.00	0.319	0.319	6.000

Table 3 Local Calibration for Longitudinal Cracking

Calibration	***Top – Down / Longitudinal Cracking***					
	βf1	**βf2**	**βf3**	**c1**	**c2**	**c4**
New Mexico	1.00	1.00	1.00	3.00	3.00	1.000
Virginia	1.00	1.00	1.00	7.00	3.50	1.000

1.3. *Research Objective*

The research object focuses on analyzing IRI prediction using the MEPDG 2015 mthod with different calibration settings compared to actual field conditions. The analysis aims to determine which method best approximates real-world deterioration. The analysis was conducted on 13 STA points that received no treatment from 2020 to 2022, allowing natural IRI deterioration to be observed.

2. MATERIALS AND METHODS

The study was carried out on six sections of the North Coast National Road (Pantura) in Java, covering a total length of 55.87 km. The road sections include: 22016 – Lohbener – Bts. Kota Indramayu, 2201611 – Jln. Soekarno – Hatta (Indramayu), 22017 – Lingkar Indramayu (Indramayu) – Karangampel, 2201711 – Jln. Mulia Asri (Indramayu), 22018 – Karangampel – Bts. Kab. Cirebon/Indramayu (Singakerta), and 22019 – Bts. Kab.Cirebon/Indramayu (Singakerta) – Bts. Kota Cirebon.

The research was conducted through a structured sequence of stages to ensure a systematic and well-planned process. These stages are illustrated in the flowchart in Figure 1.

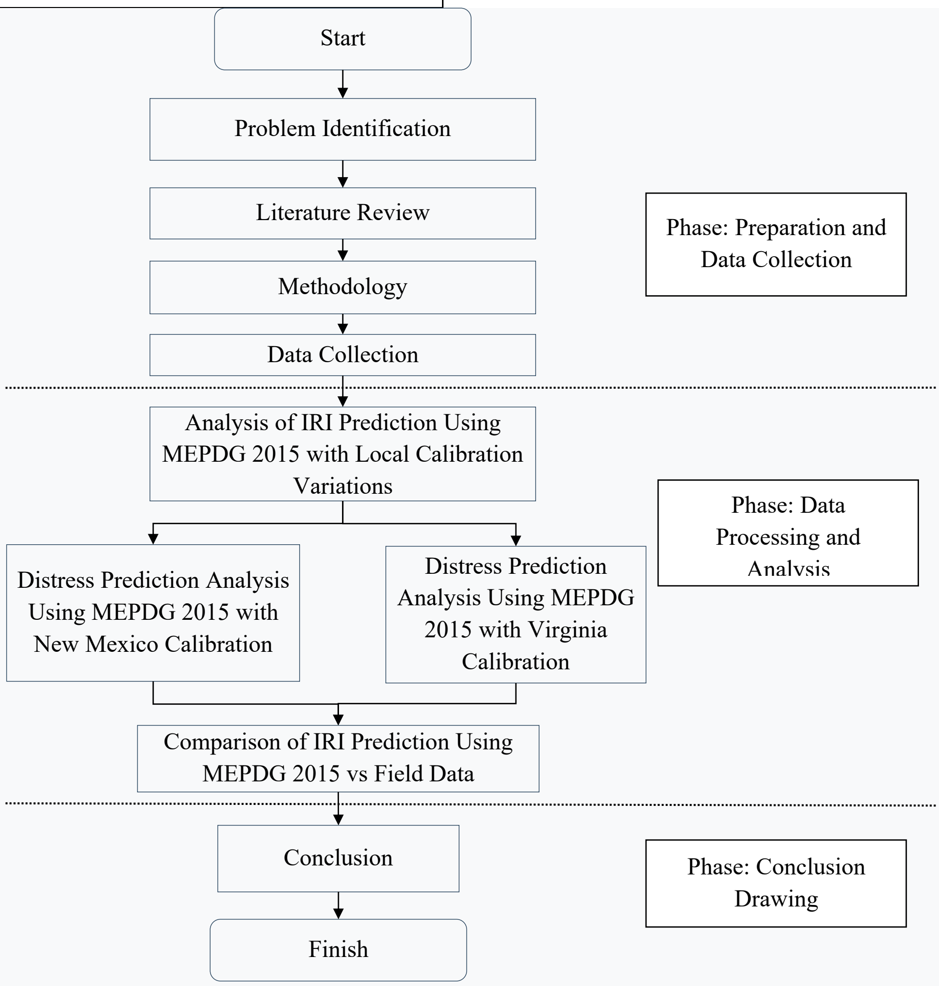

Fig. 1. Flowchart

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The preparation and data collection phase include identifying the research problem, composing the background, selecting the study location, and designing the research methodology. Literature review activities were also conducted at this stage.

This study used secondary data, which includes:

1. Traffic Data
   Average Daily Traffic (ADT) data from 2018 to 2023 was used to compute cumulative traffic loading and growth factors. Lane and directional distribution factors and Vehicle Damage Factor (VDF) were obtained from Bina Marga Manual 2024.
2. IRI Data
   Functional condition data in the form of IRI, measured every 100 m using a Hawkeye Roughometer. This data was used to compare with predicted IRI values.
3. Deflection Data
   Falling Weight Deflectometer (FWD) data from BBPJN DKI Jakarta – West Java was used to segment road sections and obtain representative deflection values.
4. Temperature Data
   Air and asphalt surface temperature data collected during FWD surveys were used to correct field deflection results.

Fundamental analysis included traffic analysis to compute the cumulative equivalent standard axle load (CESAL), used in the IRI prediction process. The prediction of International Roughness Index (IRI) using the MEPDG 2015 method was conducted by considering potential pavement distresses, specifically rut depth and fatigue cracking, based on modulus values obtained from deflection data. The calculations were performed using Microsoft Access, ELMOD 6, and KENPAVE software. The analysis aimed to predict IRI values for the years 2021 to 2023 using input data from 2020, and the results were then compared to actual field data collected between 2021 and 2023. ELMOD 6 was used to determine material modulus values, while KENPAVE was employed to analyze pavement structural responses. Subsequently, rut depth, fatigue cracking, and smoothness predictions were calculated.

3. RESULT AND DISCUSSION

3.1. Rut Depth Analysis

Rutting analysis refers to the evaluation of permanent surface deformation on pavements that results in the formation of wheel path depressions. Several studies have approached rut depth analysis differently. For example, a research study used the average rut depth of both asphalt and unbound layers over the evaluation year [14], whereas Wiraprakoso (2024) considered only the rut depth in the asphalt layer for that year [15]. In this study, cumulative rut depth values were used exclusively from the asphalt layer [16], following the approach of Suwanda (2022), as shown in Figure 2. This method was chosen because using the average rut depth tends to yield lower values and deviates further from field conditions. Moreover, research by Wassem A. et al. (2013) also supports the use of cumulative rut depth in the DARWin-ME™ software for MEPDG analysis [17].

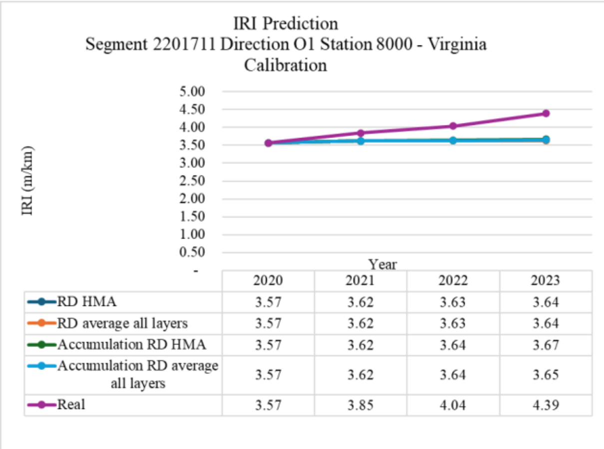

Fig. 2. IRI prediction with different rut depth calculation methods

Subsequently, rut depth analysis was conducted using Equations (1) and (2). Based on the analysis, the rut depth values for the Virginia local calibration were higher than those for the New Mexico calibration, as shown in Figure 3.

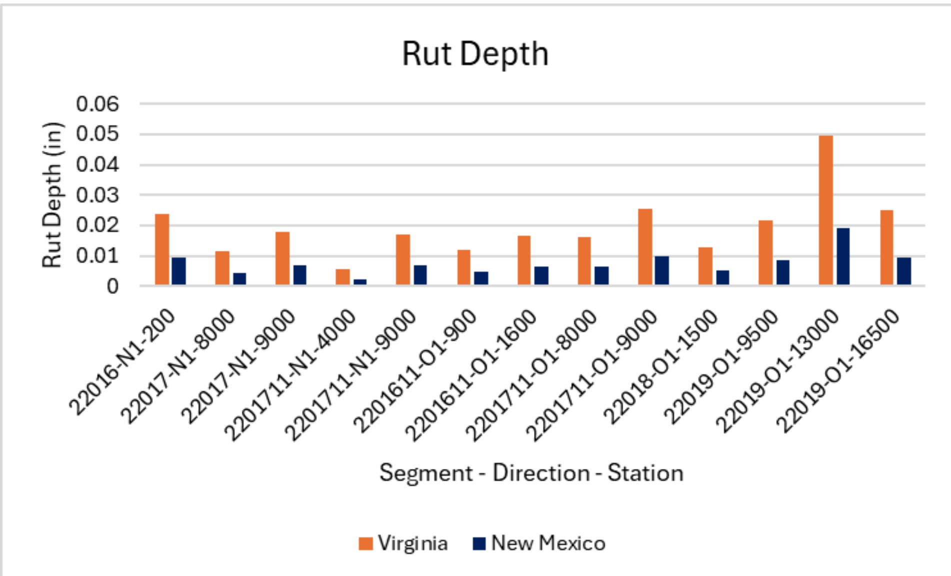

Fig. 3. Predicted Rut Depth Damage

From Figure 3, the differences between the two calibrations lie in the local calibration parameters β1r and β3r, as listed in Table 1. Higher values of β1r in both the Virginia and New Mexico calibrations resulted in greater rut depth [18]. Furthermore, the local calibration parameter β3r was found to have the most significant impact [19], as a 20% difference in β3r between the Virginia and New Mexico calibrations caused the rut depth values for Virginia to be significantly higher than those for New Mexico.

3.2. Fatigue Cracking Analysis

Fatigue cracking analysis involves the evaluation of cracking that appears in pavement layers due to repeated tensile stresses, which are typically caused by continuous traffic loading. Based on the analysis using Equation (3), the predicted fatigue cracking values from the New Mexico calibration were higher than those from the Virginia calibration, as illustrated in Figures 4 and 5.

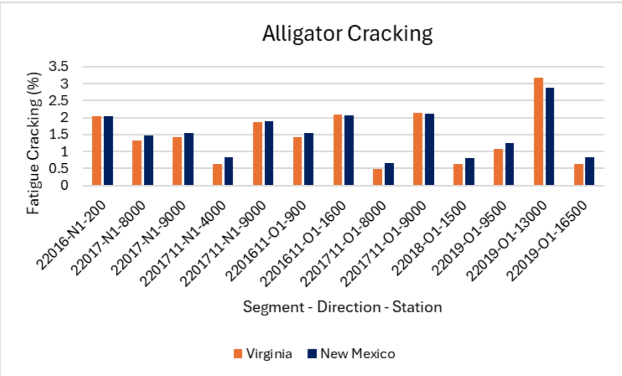

Fig. 4. Predicted Alligator Cracking Damage

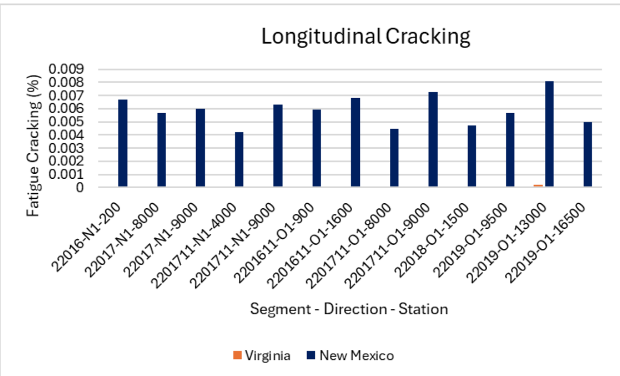

Fig. 5. Predicted Longitudinal Cracking Damage

From Figures 4 and 5, it can be observed that the fatigue cracking values for the method using the New Mexico calibration were consistently higher than those using the Virginia calibration. According to the results of the analysis, the calibration coefficients C1 and C2 had a significant influence on the prediction outcomes. This is consistent with the findings of Huang, B., et al. (2016), who stated that coefficients C1 and C2 have a substantial effect on distress prediction results [20]. In contrast, coefficient C4 was held constant in this analysis due to its comparatively lower impact.

3.3. IRI Analysis

The predicted International Roughness Index (IRI) values were obtained using Equation (4). Based on the analysis results, it was found that both calibration methods did not yield significant differences in IRI predictions for the initial year of the analysis period, as shown in Figure 6. For each calibration, the differences were minimal because in the early year, the initial IRI value (IRI0) had the most dominant influence on the overall increase in IRI, as illustrated in Figure 6.

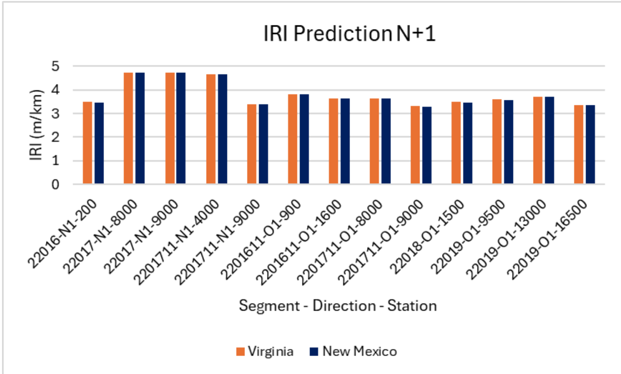

Fig. 6. IRI Prediction for the Year 2024

3.4. Influential Parameters on IRI Prediction in MEPDG 2015

The parameters that influence the predicted International Roughness Index (IRI) in the MEPDG 2015 method include the Initial IRI (IRI0), rut depth (RD), fatigue cracking (FC Total), and environmental factors such as the site factor (SF). Based on the analysis, all road segments yielded similar trends, where the initial IRI was found to be the most influential parameter, contributing up to 99% of the predicted IRI. However, as the analysis period progressed, the influence of IRI0 gradually decreased, while the contributions from rut depth and fatigue cracking increased, as shown in Figure 7.

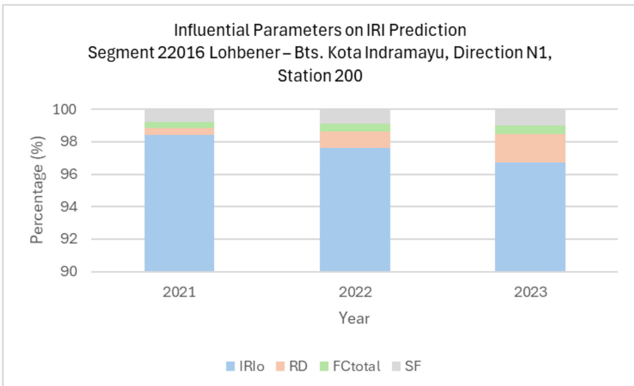

Fig. 7. Parameters Influencing IRI Prediction

This finding is consistent with the research conducted by Wiraprakoso (2024), which stated that IRI0 had an influence of nearly 100% in the initial year and gradually decreased to approximately 50% by the end of the analysis period.

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3.5. Comparative Analysis of IRI Prediction Using MEPDG 2015 Calibration Variations Against Field Conditions

A comparative analysis was conducted between the predicted International Roughness Index (IRI) values, obtained using the MEPDG 2015 method with two different calibration settings, and actual field measurements to assess the extent of deviation from real-world pavement conditions.

The analysis used data from the year 2020 to generate IRI predictions for the years 2021 through 2023. However, this comparison was not performed across all Stationing (STA) points. Instead, it was limited to STA locations that exhibited an increase in IRI values between 2021 and 2023 and had not received effective maintenance treatments during that period.

An example of the analysis results is illustrated in Figures 8 and 9 for Section 22019 – Cirebon/Indramayu Regency Border (Singakerta) to Cirebon City Border, direction Right, at STA 13000.

Subsequently, a relative deviation calculation was performed to quantify the difference between the predicted IRI values (using MEPDG 2015 with the two calibrations) and the actual field conditions. A smaller relative deviation indicates that the prediction method more closely aligns with real field conditions. The formula for relative deviation is presented as follows [21]:

$$Relative\ Deviation\ (\%) = \frac{X - X_{ref}}{X_{ref}} x\ 100\% \quad (5)$$

Where:

X = The value being compared (MEPDG 2015 prediction) (MEPDG 2015)

Xref = Reference or actual field value

Based on Equation (5), the relative deviation results are presented in Table 4. The smallest average relative deviation was observed with the MEPDG 2015 method using Virginia calibration, at -15.66%, making it the method most closely aligned with actual field conditions. The highest average deviation occurred with the New Mexico calibration, at -16.08%.

Table 4. Relative Deviation Analysis Results

Method	Relative Deviation			
	2021	2022	2023	Average
MEPDG New Mexico Calibration	-5.68	-16.52	-26.05	-16.08
MEPDG Virginia Calibration	-5.49	-16.09	-25.38	-15.66

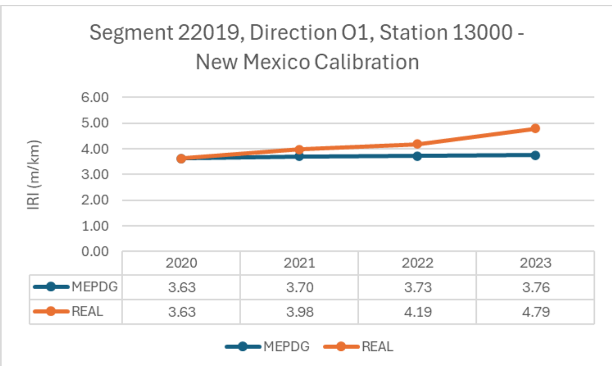

Fig.8. Comparison of IRI Prediction Using MEPDG 2015 with New Mexico Calibration Against Field Data

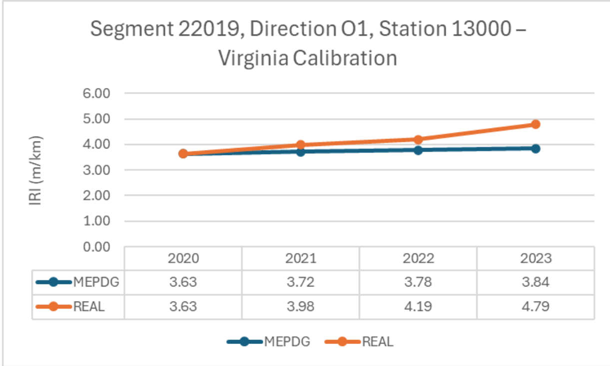

Fig.9. Comparison of IRI Prediction Using MEPDG 2015 with Virginia Calibration Against Field Data

4. CONCLUSION

This study draws several key conclusions as follows:

1) The increase in predicted International Roughness Index (IRI) values using both IRMS V.3 and MEPDG 2015 is influenced by internal and external factors, with internal factors—specifically pavement structural conditions—playing the dominant role.
2) Rut depth prediction in MEPDG 2015 was conducted by accumulating deformation in the asphalt layers throughout the design life, as these layers contributed the most to rut depth. This approach produced results that closely matched actual field conditions.
3) The IRI prediction using the MEPDG 2015 method with Virginia calibration showed the smallest relative deviation compared to field data, at -15.66%. This indicates that the Virginia calibration method is more accurate than the New Mexico calibration method in representing field conditions.

REFERENCE

[1] Bina Marga. (2024). Kemantapan Jalan Nasional. www. data.pu.go.id/dataset/kemantapan-jalan-nasional. Diakses pada 11 Februari 2024.

[2] Bina Marga. (2022). Laporan Kinerja Instansi Pemerintah Direktorat Jenderal Bina Marga tahun 2021. Direktorat Jenderal Bina Marga. Kementerian Pekerjaan Umum dan Perumahan Rakyat.

[3] Sari. (2024). Analisis Perbandingan Pemrograman Pemeliharaan Jalan dengan Tipe Perkerasan Lentur Menggunakan Metode Paterson Dan Indonesian Road Management System (IRMS V.3) (Studi Kasus: Jalan Soekarno-Hatta (Palembang)). Tesis Program Magister. Institut Teknologi Bandung.

[4] Wasanta, T., et al. (2024). Comparative Analysis Of Overlay Thickness Using The Asphalt Institute's and MEPDG With Kenlayer. GEOMATE Journal, 26(118), 57-64.

[5] AASHTO. (2015). Mechanistic-Empirical Pavement Design Guide: A Manual of Practice. United States of America: American Association of State Higway and Transportation Officials.

[6] Tarefder, R. A., & Rodriguez-Ruiz, J. (2013). Local calibration of MEPDG for flexible pavements in New Mexico. Journal of Transportation Engineering, 139(4), 345–353.

[7] FAO. 2011. AQUASTAT Country Profile – Indonesia. Food and Agriculture Organization of the United Nations (FAO). Rome, Italy.

[8] Peel, M. C., et al. (2007). Updated world map of the Köppen-Geiger climate classification. Hydrol. Earth Syst. Sci., 11, 1633–1644.

[9] BMKG. (2021). Peta Rata-rata Curah Hujan dan Hari Hujan Periode 1991-2020 Indonesia. Badan Meteorologi, Klimatologi, dan Geofisika.

[10] NCHRP. (2004). Guide for mechanistic-empirical design of new and rehabilitated pavement structures (NCHRP Project 1-37A Final Report). National Cooperative Highway Research Program. Transportation Research Board.

[11] Rahmawati, R., et al. (2022). Penentuan Nilai Modulus Elastisitas Perkerasan Lentur menggunakan Metode Perhitungan Balik. Jurnal HPJI (Himpunan Pengembangan Jalan Indonesia), 8(2), 159-172.

[12] Rachmasari. (2024). Evaluasi Faktor Kalibrasi Model Rut depth, Fatigue Cracking dan IRI pada Perkerasan Lentur menggunakan Metode MEPDG 2015 (Studi Kasus: Ruas Bts. Kab. Tasikmalaya/Ciamis-Ancol). Tesis Program Magister. Institut Teknologi Bandung.

[13] Smith, B., & Nair, H. (2015). Development of local calibration factors and design criteria values for mechanistic-empirical pavement design (No. FHWA/VCTIR 16-R1). Virginia Center for Transportation Innovation and Research.

[14] Lussy, C. (2024). Analisis Perbandingan Nilai IRI Prediksi Metode Paterson dan Metode MEPDG Serta Prediksi Umur Sisa Perkerasan Lentur (Studi Kasus: Ruas Bts. Kota Leuwiliang – Bts. Kota Bogor). Tesis Program Magister. Institut Teknologi Bandung.

[15] Wiraprakoso. (2024). Pemrograman Pemeliharaan Jalan Berdasarkan Analisis Prediksi Nilai IRI Menggunakan Metode AASHTO 2008 (MEPDG) dan IRMS (Studi Kasus: Ruas Jalan Tol Pematang Panggang – Kayu Agung Sta 294+000 S/D 304+000). Tesis Program Magister. Institut Teknologi Bandung.

[16] Suwanda M. A. (2022). Penyusunan Program Pemeliharaan Jalan serta Biaya Selama Umur Rencana Berdasarkan Prediksi Kondisi Fungsional Menggunakan Metode MEPDG (Studi Kasus: Ruas Jalan Raya Sindanglaya – Ujung Berung – Cipadung – Cibiru, Bandung). Tesis Program Magister. Institut Teknologi Bandung.

[17] Waseem, A., et al (2013). Evaluation Of Pre-Overlay Rut Depth For Local Calibration Of The Mepdg Rutting Model In Ontario. 3rd Specialty Conference on Material Engineering & Applied Mechanics.

[18] Hossain, N., et al. (2019). Performance monitoring of field test section to evaluate rutting behavior of different pavement layers. International Journal of Pavement Research and Technology, 12(5), 519-526.

[19] Li, J., et al. (2009). Calibration of flexible pavement in mechanistic–empirical pavement design guide for Washington state. Transportation Research Record, 2095(1), 73-83.

[20] Huang, B., et al. (2016). Local Calibration of Mechanistic-Empirical Pavement Design Guide in Tennessee (No. RES2013-33). Tennessee. Department of Transportation.

[21] Montgomery, D. C., & Runger, G. C. (2010). Applied statistics and probability for engineers (5th ed.). John Wiley & Sons

 https://doi.org/10.29165/ajarcde.v9i2.726