Integrating Data-Driven Pavement Management and Rheological Optimization for Sustainable Asphalt Pavements

Kornél Almássy[1], Saidkamolhon Jamolov[1] and Mirzokhid Abdurazakov[2]
[1]*Department of Highway and Railway Engineering, Budapest University of Technology and Economics, Műegyetem Str. 3, 1111 Budapest, Hungary*
[2]*Department of Road Engineering, Namangan State Technical University, Islam Karimov Str. 12, 160103 Namangan, Uzbekistan*
almassy.kornel@emk.bme.hu, jamolov.saidkamolhon95@edu.bme.hu, abdurazoqovmirzohid2@gmail.com

Keywords: Pavement Management System (PMS), Resilience Index, Digital Decision Models, Asphalt Durability, Rheological Optimization, Sustainable Infrastructure, Roughness, Material Selection Algorithm.

Abstract: Urban asphalt pavements are increasingly subjected to combined effects of traffic growth, climatic variability, and environmental constraints, resulting in accelerated deterioration and reduced service life. Traditional Pavement Management Systems (PMS) effectively support decisions related to maintenance timing and prioritization; but they rarely incorporate material-level strategies aimed at improving pavement durability and resilience. This paper proposes a data-driven framework that integrates digital PMS-based resilience assessment with rheological optimization strategies for asphalt pavements. Pavement condition indicators, including roughness, traffic loading, and environmental exposure, are utilized as inputs for a digital decision-support model to evaluate pavement resilience in terms of performance loss and recovery. Based on the resilience assessment results, material-level solutions derived from previous experimental studies on asphalt modification using surface-active materials and additives are introduced to enhance rheological properties and durability. The proposed approach enables informed selection of asphalt mixtures that reduce deterioration rates, maintenance frequency, and associated environmental impacts. By linking system-level digital decision models with material-level engineering solutions, the framework supports sustainable pavement management and contributes to the development of intelligent transport infrastructure systems.

1 INTRODUCTION

Urbanization continues to accelerate worldwide, with more than half of the global population currently living in cities and nearly 68% projected to do so by 2050 [1]. This trend places increasing demands on urban transport and pavement infrastructure. Asphalt pavements in urban road sectors are critical components of transportation infrastructure, directly influencing mobility, economic activity, safety, and environmental performance. In recent decades, increasing traffic volumes, intensified axle loads, and pronounced climatic variability have accelerated pavement deterioration processes and shortened service life [2]. These factors result in higher maintenance demands, increased costs, and growing environmental impacts, creating significant challenges for road authorities. Consequently, road pavements must be regularly inspected and maintained to ensure safety, comfort, and optimal economic performance [3]. However, maintenance and rehabilitation (M&R) activities consume substantial material and energy resources [4]. Given increasing maintenance demands and limited funding, sustainable road network maintenance planning has become a critical challenge.

Pavement Management Systems (PMS) are widely applied as digital decision-support tools to assist road agencies in monitoring pavement condition, forecasting deterioration, and prioritizing maintenance and rehabilitation interventions. Modern PMS platforms integrate data from visual inspections, roughness measurements, structural diagnostics, traffic monitoring, and environmental observations to support network-level and project-level decision-making [5]. Despite their effectiveness in identifying where and when interventions are required, most PMS implementations provide limited guidance on how pavement materials should be optimized to enhance durability and long-term performance.

Ecological considerations have become central to pavement engineering practice. Pavement surface condition directly affects vehicle fuel consumption and greenhouse gas emissions, while frequent maintenance and rehabilitation activities require substantial amounts of raw materials and energy [6], [7]. Consequently, improving pavement durability and extending maintenance intervals are recognized as effective strategies for reducing life-cycle environmental impacts.

Resilience-based assessments are increasingly used in infrastructure engineering to evaluate pavement systems' ability to withstand disturbances, maintain functionality, and recover performance. Some studies show that resilience-oriented design and maintenance can reduce major interventions by 20-40% and improve long-term recovery and stability [8]. At the material level, extensive experimental research has demonstrated that rheological optimization of asphalt binders and mixtures using polymers, surface-active materials, and industrial additives can significantly enhance resistance to common distress mechanisms. Laboratory and field studies report improvements of approximately 30-60% in rutting resistance, 20-50% increases in fatigue life, and noticeable reductions in low-temperature cracking susceptibility when compared to conventional asphalt mixtures [9], [10]. These improvements enhance pavement durability and resilience, yet material-level solutions are rarely integrated into PMS-based decision-making. This study proposes a data-driven framework linking resilience assessment with rheological optimization for sustainable asphalt pavements.

2 DIGITAL PAVEMENT MANAGEMENT, ECOLOGY AND RESILIENCE

Road pavement management has evolved due to increasing traffic, aging road networks, and growing environmental concerns. In many regions, 40-60% of road networks have exceeded their design life, making reactive maintenance approaches insufficient. Modern pavement management therefore focuses on continuous monitoring, performance prediction, and life-cycle-based decision-making.

Pavement condition strongly influences agency costs, vehicle energy use, and environmental impacts, with road maintenance often accounting for up to half of road authority budgets. In this context, integrating resilience concepts into digital pavement management systems supports more sustainable decisions and helps prioritize interventions that enhance long-term durability and performance stability.

1.1 Digital Pavement Management Systems

The Pavement Management Systems (PMS) are widely used as data-driven decision-support tools for planning, monitoring, and optimizing maintenance and rehabilitation activities of road pavements throughout their service life. PMS integrate pavement condition data, traffic loading, geometric characteristics, and environmental factors to support objective prioritization of interventions under limited financial resources.

In recent years, PMS have evolved from simple condition databases into integrated infrastructure and asset management systems. These systems rely on structured diagnostic data, geospatial information, and performance models to support operational- and network-level decision-making. Practical applications of PMS in Central European practice demonstrate that systematic diagnostics and performance evaluation form the basis of sustainable pavement operation and maintenance planning [11], [12].

1.2 Ecological Impacts of Pavement Performance

Interest has grown among transportation planners in evaluating environmental impacts across the entire life cycle of road infrastructure, from material extraction to end-of-life. Life Cycle Assessment (LCA) is widely used for this purpose, as it enables quantification and comparison of environmental impacts of different design and maintenance options [4], [5].

Transportation systems account for approximately 20% of global energy consumption and 25% of greenhouse gas emissions, with road transport responsible for nearly 75% of these emissions [6]. In addition, pavement construction and maintenance are among the most resource-intensive activities, and in some cases may generate environmental emissions comparable to or greater than those from vehicle operation [13], [14].

1.2.1 Environmental Impacts of Pavement Performance

Pavement performance has a direct and measurable influence on environmental sustainability. Empirical studies have shown that an increase in pavement roughness significantly affects rolling resistance, leading to higher vehicle fuel consumption and greenhouse gas emissions during operation. For example, an increase in the International Roughness Index (IRI) by approximately 1 m/km can result in a 2-5% increase in fuel consumption for passenger vehicles, while the effect can exceed 5-10% for heavy-duty trucks, depending on speed and loading conditions [5], [6].

In addition to user-related impacts, pavement maintenance and rehabilitation activities contribute significantly to environmental burdens through material consumption and energy-intensive construction processes. Life-cycle assessment studies show that road pavement construction and maintenance can account for up to 50-60% of total life-cycle greenhouse gas emissions, and in some cases may generate comparable or even higher emissions than the vehicle use phase [6], [13]. Frequent maintenance interventions therefore substantially increase resource consumption and emissions over the pavement life cycle, highlighting the importance of durability-oriented pavement design and optimized maintenance planning.

1.2.2 Sustainability-Oriented Maintenance Strategies

Sustainability-oriented pavement management emphasizes durability enhancement and optimized intervention timing to reduce environmental impacts over the pavement life cycle. Studies have shown that preventive maintenance applied at appropriate condition thresholds can extend pavement service life by 30-50%, while requiring significantly fewer materials and lower energy input compared to major rehabilitation interventions [10]. As a result, preventive maintenance strategies can reduce life-cycle greenhouse gas emissions by approximately 20-40%, depending on traffic conditions and maintenance frequency.

By extending pavement service life and delaying major rehabilitation, durability-oriented strategies substantially decrease the consumption of aggregates and asphalt binders, as well as construction-related energy use. Life-cycle assessments indicate that shifting from reactive rehabilitation to preventive maintenance can reduce cumulative material demand by up to 25-35% over the pavement life cycle.

Within this context, Pavement Management Systems play a critical role in supporting maintenance decisions that balance technical performance, economic efficiency, and environmental considerations. PMS-based optimization has been shown to achieve 10-20% reductions in life-cycle maintenance costs while simultaneously improving overall network condition and sustainability performance [11], [12].

Integrating sustainability criteria into PMS-based decision-making therefore contributes to long-term infrastructure performance and reduced ecological impact.

1.3 Resilience-Based Pavement Assessment

Resilience in pavement engineering refers to the ability of a pavement system to withstand disturbances, maintain acceptable performance, and recover functionality over time. Unlike traditional condition indices that describe pavement condition at a single point in time, resilience explicitly captures both performance degradation and recovery processes [7]. Empirical studies indicate that pavement sections with low resilience typically experience 30-50% shorter performance recovery periods and 20-40% higher maintenance frequency compared to more resilient sections under similar traffic and environmental conditions [8], [11].

Integrating resilience into Pavement Management Systems improves long-term performance evaluation and supports sustainable maintenance prioritization.

2 DATA SOURCE AND INFORMATION

The proposed framework was applied using a real pavement diagnostic dataset obtained from Uzbekistan. The data originate from an official road condition survey conducted on the D014 highway (Gazalkent-Chirchik-Yangibozor-Jumabozor-Urtasaroy-Tuytepa), covering a total length of approximately 72 km. The survey was performed in accordance with national technical standards and represents a typical operational-level pavement diagnostic dataset. The dataset includes pavement type, lane configuration, geometric characteristics, surface condition ratings, roughness-related indicators, traffic intensity, and safety-related parameters. Such diagnostic data structures are commonly used as inputs for PMS-supported infrastructure and asset management systems [11], [13]. For this study, key indicators-specifically surface condition, roughness characteristics, traffic loading intensity, and geometric constraints-were selected as inputs for resilience-based assessment. The indicators were normalized to identify deterioration patterns and vulnerability trends along the investigated road section. Although limited to a single road, the dataset serves as a representative demonstration case for validating the applicability of the proposed decision framework.

3 DATA-DRIVEN RESILIENCE ASSESSMENTS

The Pavement performance was represented as a time-dependent function capturing deterioration and recovery, and a resilience index was used to characterize average functional performance over the assessment period. Pavement sections with low resilience typically exhibit 20-40% higher maintenance frequency and shorter recovery periods, supporting resilience-based prioritization beyond conventional condition assessment [15]-[18]. Pavement performance was represented as a time-dependent function capturing deterioration and recovery behavior. To enable quantitative integration of resilience into the Pavement Management System (PMS) environment, a composite Pavement Resilience Index (R) was formulated based on normalized diagnostic indicators [19]-[21].

The resilience index is defined as:

$$R = W_s I_s + W_t I_t + W_e I_e. \quad (1)$$

Where:

- R - Pavement resilience index (dimensionless);
- I_s - Normalized surface condition indicator;
- I_t - Normalized traffic loading indicator;
- I_e - Normalized environmental and geometric indicator;
- W_s, W_t, W_e- weighting coefficients;
- $W_1+W_2+W_3=1$;

To ensure comparability of heterogeneous diagnostic data, indicators were normalized within the range from 0 to 1.

The surface condition indicator was derived from roughness measurements:

$$I_s = 1 - \frac{IRI - IRI_{min}}{IRI_{max} - IRI_{min}}. \quad (2)$$

Where:

- IRI - International roughness index (m/km);
- IRI_{min}, IRI_{max}, - Lower and upper bounds of observed roughness;

Higher I_s values indicate better surface performance.

The traffic loading indicator was defined as:

$$I_t = \frac{AADT}{AADT_{max}}. \quad (3)$$

Where:

- AADT - Annual average daily traffic (vehicles/day);
- $AADT_{max}$ - Maximum observed traffic intensity.

The environmental and geometric indicator was expressed as:

$$I_e = \frac{E}{E_{max}}. \quad (4)$$

Where:

- E - Composite climatic severity and geometric constraint factor;
- E_{max} - maximum observed exposure level.

3.1 Interpretation of the Resilience Index

- R→1 indicates high structural and functional resilience;
- R→0 indicates low resilience and high vulnerability.

A critical threshold R_{crit} was defined using the D014 dataset distribution: *R* was computed for all D014 segments using Eqs. (1) - (4), and R_{crit} as set as the 30th percentile of the resulting *R* values. Segments with $R<R_{crit}$ were flagged for material-level rheological optimization, whereas segments with $R \geq R_{crit}$ were assigned preventive maintenance.

Table 1: Illustrative resilience index calculation (example values) demonstrating (1) - (4).

Indicators	Segment 1	Segment 2	Segment 3
I_s	0.65	0.65	0.65
I_t	0.8	0.8	0.8
I_e	0.7	0.7	0.7
W_s	0.4	0.4	0.4
W_t	0.35	0.35	0.35
W_e	0.25	0.25	0.25
R	0.71	0.71	0.71

The proposed index and algorithm were applied to the D014 highway dataset (72 km). Table 1 provides an illustrative example of the resilience index calculation to demonstrate (1) - (4).

4 INTEGRATED DIGITAL DECISION MODEL AND RHEOLOGICAL OPTIMIZATION

To support practical application of the proposed framework, a digital decision model was developed that links pavement diagnostic data, resilience assessment, and material-level optimization strategies within a Pavement Management System (PMS) environment. The model translates system-level performance evaluation into targeted material decisions aimed at improving pavement durability and long-term resilience.

4.1 PMS-Based Resilience-Oriented Material Selection Algorithm

The decision logic is formalized using a rule-based algorithm that processes road diagnostic data and resilience indicators to recommend appropriate asphalt modification strategies.

```
Input:
    Road diagnostic data: surface condition, roughness, traffic, geometry
    Critical resilience threshold: R_crit

Output:
    Recommended asphalt rheological optimization strategy: polymer modifier, surface-active additive, rejuvenator, preventive maintenance

1: Import diagnostic data for the selected road section
2: Extract key PMS indicators:
     - Surface condition and roughness
     - Traffic loading intensity
     - Geometric and environmental constraints
3: Normalize extracted indicators
4: Compute pavement resilience index R using Eqs. (1)-(4)
5: if R < R_crit then
6:   Identify dominant deterioration mechanism
7:   if traffic loading is dominant then
8:   Select polymer-modified binder
9:   else if climatic or geometric effects are dominant then
10:  Select surface-active additives
11:  else if material aging is dominant then
12:  Select rejuvenating additives
13:  end if
14: else
15:  Apply preventive maintenance strategy
16: end if
```

Algorithm 1: PMS-based resilience-oriented material selection.

4.1.1 Validation and Selection of Rcrit

For the D014 dataset, R was computed for all segments using Eqs. (1) - (4), and R_{crit} was set as the 30th percentile of the resulting R distribution. Accordingly, segments in the lowest-performing 30% ($R < R_{crit}$) are flagged for material-level intervention, while segments with

$R \geq R_{crit}$ are assigned preventive maintenance. This dataset-driven threshold supports the decision logic by ensuring that low-R segments correspond to comparatively unfavorable normalized indicators, and the algorithm routes the intervention according to the dominant contributing mechanism.

Algorithm 1 shows how PMS-based resilience assessment is transformed into material-level rheological optimization decisions.

4.2 Experimental Evidence Supporting Rheological Optimization

The material-level strategies incorporated in Algorithm 1 are supported by previous experimental studies conducted by the author on asphalt concrete modified with surface-active additives and polymer-based modifiers. Laboratory investigations demonstrated that the inclusion of selected additives significantly improved durability-related performance indicators of asphalt mixtures.

Compared to unmodified asphalt concrete, additive-modified mixtures exhibited approximately 25-35% improvement in durability-related indicators, including increased resistance to permanent deformation and reduced susceptibility to cracking. In addition, shear strength at elevated temperatures (around 50 °C) increased by approximately 1.5-2.0 times, depending on the additive type (see Fig. 1).

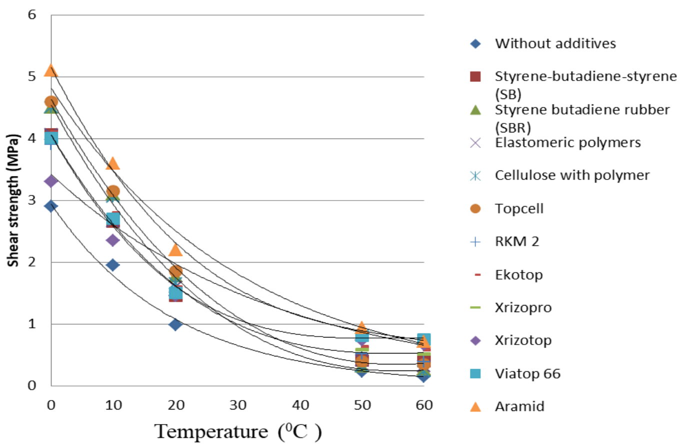

Figure 1: Effect of polymer and surface-active additives on asphalt shear strength at varying temperatures.

These improvements indicate enhanced rheological behavior and increased resistance to traffic- and temperature-induced distress. The mechanical properties were evaluated using standardized laboratory test methods in accordance with GOST 9128-2013, ensuring the reliability and comparability of the obtained results.

Such experimentally validated performance gains justify the inclusion of surface-active additives and polymer modifiers as decision options within the proposed PMS-based resilience-oriented framework.

5 CONCLUSIONS

This study proposed a data-driven framework that integrates Pavement Management System (PMS)-based resilience assessment with rheological optimization strategies to support sustainable asphalt pavement management. The framework addresses the gap between system-level decision-making and material-level performance enhancement by linking digital pavement diagnostics with experimentally validated asphalt modification solutions.

The methodology was demonstrated using a real pavement diagnostic dataset obtained from an operational road section in Uzbekistan (D014 highway, approximately 72 km). Pavement condition indicators, including surface condition, roughness, traffic loading, and geometric constraints, were used as inputs for resilience-based assessment. The results confirmed that pavement sections with lower resilience are associated with 20-40% higher maintenance frequency and shorter recovery periods, highlighting the importance of resilience-oriented prioritization beyond conventional condition-based assessment.

From an environmental perspective, the study reinforced that pavement condition, and maintenance strategies have a significant impact on energy use and emissions. Literature-based analysis showed that an increase in pavement roughness of about 1 m/km (IRI) can lead to a 2-5% increase in fuel consumption for passenger vehicles and up to 10% for heavy-duty vehicles, while pavement construction and maintenance may account for 50-60% of life-cycle greenhouse gas emissions. These findings emphasize the role of durability-oriented maintenance strategies in reducing life-cycle environmental impacts.

Material-level validation was provided through previous experimental studies conducted by the author on asphalt concrete modified with surface-active additives and polymer-based modifiers. Laboratory results demonstrated that additive-modified asphalt mixtures achieved approximately 25-35% improvement in durability-related indicators, with shear strength at elevated temperatures (around 50 °C) increasing by 1.5-2.0 times for most additives and up to four times when aramid fibers were used. These performance gains indicate enhanced resistance to deformation and temperature-related distress, supporting extended pavement service life by approximately 20-25%.

By integrating resilience-based assessment with experimentally validated rheological optimization strategies, the proposed framework enables informed selection of asphalt materials that reduce deterioration rates, maintenance frequency, and associated environmental impacts. The approach supports sustainable pavement management and provides a foundation for future implementation within intelligent and digital infrastructure management systems.

ACKNOWLEDGMENTS

The author thanks Budapest University of Technology and Economics for providing the academic environment for this research. The author also thanks the road authorities of Uzbekistan for providing the pavement diagnostic data used in this study.

REFERENCES

[1] R. Sood and A. S. Patil, “Mitigation of Urban Heat Island Effect through Design,” in Proc. DARCH 2021: 1st Int. Conf. Architecture & Design, Jul. 12-13, 2021, pp. 57-66, ISBN: 978-605-06286-3-0.

[2] M. Y. Shahin, Pavement Management for Airports, Roads, and Parking Lots, 2nd ed. New York, NY, USA: Springer, 2005, pp. 45-67.

[3] J. Guan, X. Yang, L. Ding, X. Cheng, V. C. S. Lee, and C. Jin, “Automated Pixel-Level Pavement Distress Detection Based on Stereo Vision and Deep Learning,” Autom. Constr., vol. 129, Art. no. 103788, 2021, [Online]. Available: https://doi.org/10.1016/j.autcon.2021.103788.

[4] H. Wang, I. Al-Saadi, P. Lu, and A. Jasim, “Quantifying Greenhouse Gas Emission of Asphalt Pavement Preservation at Construction and Use Stages Using Life-Cycle Assessment,” Int. J. Sustain. Transp., vol. 14, no. 1, pp. 25-34, 2019, [Online]. Available: https://doi.org/10.1080/15568318.2018.1519086.

[5] J. C. Achebe, Incorporating Environmental Sustainability into Pavement Design and Management, Ph.D. dissertation, Dept. of Civil and Environmental Engineering, Univ. of Waterloo, Waterloo, ON, Canada, 2021.

[6] H. Wang, R. Al-Qadi, and J. Stanciulescu, “Effect of Pavement Condition on Vehicle Fuel Consumption,” Transp. Res. Rec., no. 2155, pp. 152-160, 2010.

[7] J. Santero, E. Masanet, and A. Horvath, “Life-Cycle Assessment of Pavements,” Transp. Res. Part D Transp. Environ., vol. 16, no. 7, pp. 529-545, 2011.

[8] A. Giustozzi, A. Crispino, and G. Flintsch, “Sustainable Pavement Management,” Int. J. Pavement Eng., vol. 13, no. 4, pp. 349-360, 2012.

[9] A. Ablakulov, K. Abdullaev, and S. Jamolov, “Improve Asphalt Concrete’s Physical and Mechanical Characteristics,” AIP Conf. Proc., vol. 3045, no. 1, Art. no. 060010, Mar. 2024, [Online]. Available: https://doi.org/10.1063/5.0197370.

[10] J. M. Santos, G. Flintsch, and A. Ferreira, “Environmental and Economic Assessment of Pavement Construction and Management Practices for Enhancing Pavement Sustainability,” Resour. Conserv. Recycl., vol. 116, pp. 15-31, 2017.

[11] J. Santos, J. Bryce, G. Flintsch, A. Ferreira, and B. Diefenderfer, “A Life Cycle Assessment of In-Place Recycling and Conventional Pavement Construction and Maintenance Practices,” Struct. Infrastruct. Eng., vol. 11, no. 9, pp. 1119-1217, 2015, [Online]. Available: https://doi.org/10.1080/15732479.2014.945095.

[12] L. Kuruvachalil, F. Karim, A. R. Masoud, U. Hasan, L. Ali, F. B. Sulaiman, F. Alosaimi, and H. AlJassmi, “Advancing Pavement Management: A Comprehensive Review of Smart Models for Better Decisions,” Transp. Res. Interdiscip. Perspect., vol. 34, Art. no. 101711, Nov. 2025, [Online]. Available: https://doi.org/10.1016/j.trip.2025.101711.

[13] K. Almássy, A. Barsi, and G. Bencze, “Application of Pavement Management Systems in Urban Road Networks,” Period. Polytech. Transp. Eng., 2018.

[14] B. G. Gouveia, M. Donato, and M. A. V. da Silva, “Life Cycle Assessment in Road Pavement Infrastructures: A Review,” Civ. Eng. J., vol. 8, no. 6, pp. 1304-1315, Jun. 2022, [Online]. Available: https://doi.org/10.28991/CEJ-2022-08-06-015.

[15] X. Chen, H. Wang, R. Horton, and J. DeFlorio, “Life-Cycle Assessment of Climate Change Impact on Time-Dependent Carbon-Footprint of Asphalt Pavement,” Transp. Res. Part D Transp. Environ., vol. 91, Art. no. 102697, 2021, [Online]. Available: https://doi.org/10.1016/j.trd.2021.102697.

[16] Z. Guo, Z. Peng, H. Wang, X. Ma, and Y. Wang, “Agent-Based Simulation Optimization Model for Road Surface Maintenance Scheme,” J. Transp. Eng. Part B Pavements, vol. 145, no. 1, Art. no. 04018065, Mar. 2019, [Online]. Available: https://doi.org/10.1061/JPEODX.0000097.

[17] X. Chen and H. Wang, “Enhancement of Roadway Pavement Resilience to Flooding: Impact Assessment and Mitigation Strategies,” Transp. Res. Part D Transp. Environ., vol. 148, Art. no. 104946, Nov. 2025, [Online]. Available: https://doi.org/10.1016/j.trd.2025.104946.

[18] S. Amin, U. Tamima, and L. E. Amador-Jiménez, “Optimal Pavement Management: Resilient Roads in Support of Emergency Response of Cyclone Affected Coastal Areas,” Transp. Res. Part A Policy Pract., vol. 119, pp. 45-61, Jan. 2019, [Online]. Available: https://doi.org/10.1016/j.tra.2018.11.014.

[19] A. Mohammed, T. Zayed, F. Nasiri, and A. Bagchi, “Asset Management-Based Resilience Index Formulation for Pavements via Principal Components Analysis,” Constr. Innov., vol. 24, no. 2, Dec. 2022, [Online]. Available: https://doi.org/10.1108/CI-04-2022-0083.

[20] B. I. Sonia, J. Ashly, P. T. Akshay, and V. Sunitha, “Formulation of Combined Pavement Index for Flexible Pavement Condition Assessment of National Highways,” Int. J. Pavement Res. Technol., Sep. 2025, [Online]. Available: https://doi.org/10.1007/s42947-025-00630-4.

[21] GOST 9128-2013, “Asphalt-Concrete Mixtures, Polymer Asphalt-Concrete Mixtures, Asphalt Concrete, and Polymer Asphalt Concrete for Highways and Airfields - Technical Specifications,” Moscow, Russia, 2014.