JOURNAL OF BUSINESS AND SOCIAL SCIENCES
eISSN:2805-5187 | Vol.2025, Issue 3, No.8

Geospatial Assessment of Road Pavement Distress at Jahangirnagar University Campus

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Abstract

This study assesses the types, causes, and spatial distribution of pavement distress across six key road segments of the JU campus, aligning with the objectives of SDG 9 (Industry, Innovation, and Infrastructure) and SDG 11 (Sustainable Cities and Communities) to promote resilient and sustainable infrastructure systems. A mixed-method approach was employed, integrating direct field observation, photographic documentation, literature review, and geospatial mapping. Pavement distresses were classified into eight major categories: thermal cracking, warping cracking, longitudinal cracking, bleeding, stripping, raveling, pumping, and blistering. GPS coordinates were recorded using handheld devices to create georeferenced maps illustrating the spatial distribution of distress points. Data from six road sections—covering a total of 987.3 square meters—revealed 206 distress cases, with stripping (47), thermal cracking (39), and raveling (37) as the most prevalent types. These conditions were primarily influenced by temperature fluctuations, drainage inefficiencies, and material aging. Findings emphasize the necessity of regular pavement monitoring, improved drainage design, and the use of durable construction materials to enhance the resilience and longevity of campus road infrastructure. The study contributes to the national and institutional pursuit of sustainable transport and infrastructure management in line with SDG 9 and SDG 11**,** supporting safer, more sustainable, and inclusive mobility within educational environments.

Keywords

Pavement Distress, Road Surface Deterioration, Geospatial Mapping, Sustainable Infrastructure, SDG 9, SDG 11

Submission: 15 October 2025; **Acceptance:** 24 December 2025 **Available online:** December 2025

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Introduction

Road pavement distress is a critical issue affecting transportation infrastructure worldwide. In developing nations such as Bangladesh, pavement deterioration can undermine user safety, increase vehicle operating costs, and lead to inefficient maintenance spending (World Bank, 2020). Pavement distress manifests as observable disruptions or structural changes on the pavement surface and subsurface, caused by mechanical, environmental, or material degradation (ASCE, 2021; Huang, 2004). The disparities between flexible (asphalt) and rigid (concrete) pavements create distinctive distress typologies: a. *Flexible pavement distresses* include cracking (transverse, longitudinal, fatigue), raveling, stripping, bleeding, and potholes. These often result from binder aging, poor compaction, moisture intrusion, and traffic stress (Roberts et al., 1996; FHWA, 2003). And b. *Rigid pavement distresses* include thermal and warping cracks, joint deterioration, spalling, and faulting, due to temperature cycles, concrete shrinkage, subbase weakness, and construction lapses (ASCE, 2021; Papagiannakis & Masad, 2008).

However, like all transport infrastructure, pavements undergo gradual deterioration caused by a combination of environmental stress, repeated traffic loads, poor construction practices, and inadequate maintenance. One of the major factors of pavement deterioration is- *Temperature fluctuation* that leads to expansion and contraction cycles that cause thermal and warping cracks in pavement slabs (Papagiannakis & Masad, 2008). Another reason be, *Moisture Intrusion*, especially in monsoon seasons, that weakens asphalt-binder adhesion (stripping), softens bitumen (bleeding), and accelerates binder aging (Mahmud, S. M. N., Islam, M. T., & Rabbi, M. F. 2015).These include the Environmental and climatic cause of pavement deterioration. On the other hand, structural and foundational weakness also causes deterioration. Those includes- *Weak or variable subgrade soils*, like expansive clays, result in settlement, pumping, and cracking due to insufficient compaction or drainage (Papagiannakis & Masad, 2008). And *Thin pavement layers*, inadequate joint spacing, and subgrade deficiencies in JU roads exacerbate crack propagation and warping. Material used to construct roads and practices followed can create deterioration. *Material mixing errors*, use of locally aggregates lacking anti-stripping additives, and low-quality bitumen are major contributors to deterioration (Ministry of Transport, Bangladesh, 2021). And *Substandard compaction* or curing practices heighten susceptibility to blisters, bleeding, and swift binder degradation (Ahmed et al., 2020). Another reason be Traffic Load and usage of road traffic, which create deterioration. Buses, delivery trucks, and rickshaws contribute to *high-cycle loading*, which leads to wheel-path fatigue and longitudinal cracking (ASCE, 2021). This deterioration is collectively referred to as *pavement distress*, which includes visible damage such as *cracking, bleeding, stripping, blistering, raveling, and pumping*. These not only reduce riding comfort and structural performance but also increase safety risks, maintenance costs, and travel delays. In the context of academic institutions, deteriorated pavements also harm the aesthetic appeal and functional harmony of the campus environment.

Jahangirnagar University, located in Savar, Dhaka, covers 697 acres of land and is one of the country’s leading higher education institutions (JU, 2025). Despite its importance, many of the internal roads within the campus have shown significant distress in recent years. Factors contributing to this degradation include frequent movement of heavy vehicles such as buses and supply trucks, extensive use of motorcycles and bicycles, poor drainage conditions, waterlogging during the rainy season, and extreme temperature variations. Environmental factors such as intense solar radiation and heavy monsoonal rainfall further exacerbate the problem by accelerating fatigue and weakening pavement materials. In Jahangirnagar University's case, where roads are indispensable for connecting academic, residential, administrative, and recreational spaces, facilitate the daily movement of students, faculty members, staff, and visitors, as well as the delivery of goods and services, evidence points to a hybrid pavement infrastructure where both flexible and rigid distress mechanisms are at play particularly thermal, warping, longitudinal cracks, and surface issues such as bleeding, stripping, and blisters can be assessed. Thus, the overall functionality and image of the campus are closely tied to the quality of its road network. The study identifies multiple causal categories contributing to pavement distress. Understanding these determinants within JU's environment is essential for targeted maintenance.

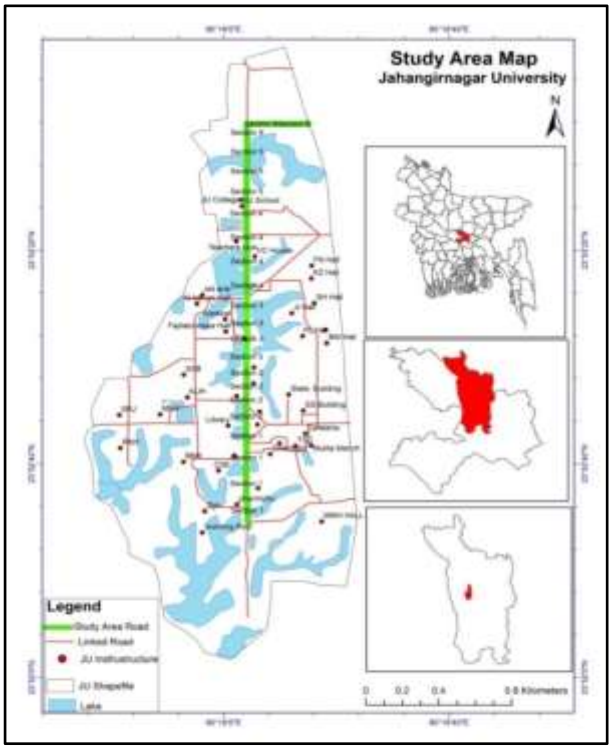
The importance of systematic pavement condition assessment has been emphasized globally. The (World Bank, 2020) notes that road infrastructure quality reflects a nation's development status, while the American Society of Civil Engineers (ASCE, 2021) highlights the need for evaluating distress types, severity, and spatial distribution as a foundation for effective pavement management. Such studies help in prioritizing repairs, optimizing maintenance budgets, and ensuring long-term durability. The present research aims to conduct a scientific assessment of pavement distress within selected sections of Jahangirnagar University. Using field observations, photographic documentation, measurements, and spatial analysis, the study identifies eight major distress types: thermal cracking, warping cracking, longitudinal cracking, bleeding, stripping, raveling, pumping, and blistering. Their frequency, severity, and coverage across key campus locations are systematically examined. By linking these conditions to local climate, soil properties, construction materials, and maintenance practices, the study seeks to provide a comprehensive understanding of pavement deterioration.

The findings aim to support initiative-taking, data-driven, and cost-effective management strategies, enhancing safety and sustainability of the campus road network. Moreover, the results are expected to serve as a reference for other educational institutions in Bangladesh facing similar infrastructure challenges. The research aims not only to document the types and severity of road surface damage but also to identify their spatial patterns and potential causes. This will help inform policy recommendations and maintenance strategies that are cost-effective, sustainable, and adapted to the specific environmental and usage context of Jahangirnagar University. This study aims to identify the pavement distress, analyze the types and distributional patterns of pavement distress at Jahangirnagar University. To achieve the goal several objectives are identified to accomplish this research:

1. To identify and create a geodatabase of the road pavement distress of the study area, and
2. to analyze the distributional pattern of road pavement distress.

Study area

Jahangirnagar University is situated in Savar Upazila of Dhaka District, approximately 32 kilometers northwest of Dhaka city. Geographically positioned between 23°52′–23°53′N latitude and 90°16′–90°18′E longitude, the campus lies adjacent to the Dhaka–Aricha Highway. which includes academic buildings, residential facilities, and recreational areas. The campus roads serve as a primary means of transportation for students, faculty, and staff. These roads experience significant wear and tear due to heavy pedestrian and vehicular traffic, necessitating a detailed assessment of pavement conditions.



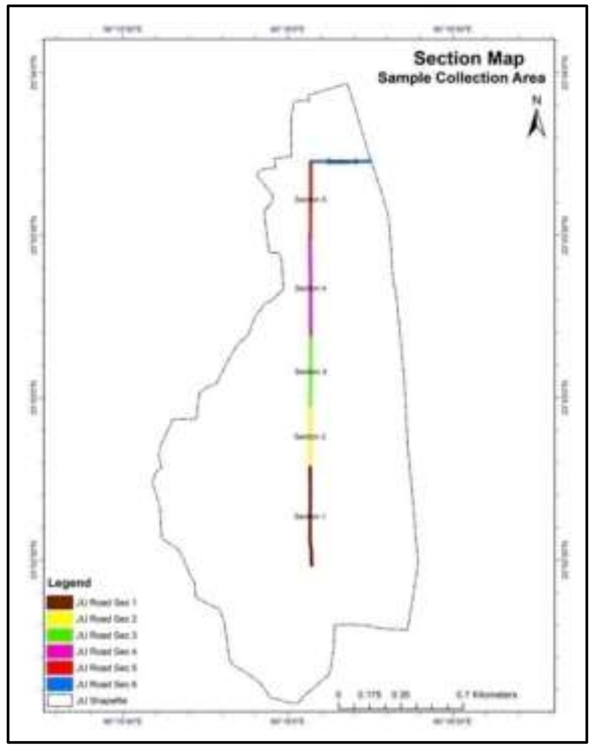


Figure 1. Study Area Map

Figure 2. Section Map of Study Area

Source: Compiled by Authors, 2025

Methodology

The methodology of this research outlines the strategic and technical steps undertaken to assess nature, causes, classification, and spatial distribution of road pavement distress at Jahangirnagar University. Given the increased concerns over deteriorating road infrastructure on campus evidenced by visible cracks, potholes, and surface unevenness, a systematic and multi-layered methodological framework was essential. The overall research approach is grounded in empirical, field-based investigations, combined with geospatial analysis and theoretical understanding obtained through literature review. A mixed-method strategy was adopted to integrate both qualitative and quantitative techniques, ensuring a holistic view of pavement distress conditions (Chen & Khan 2025). The adopted methodology bridges engineering observation, spatial science, and field research to generate a comprehensive and actionable dataset.

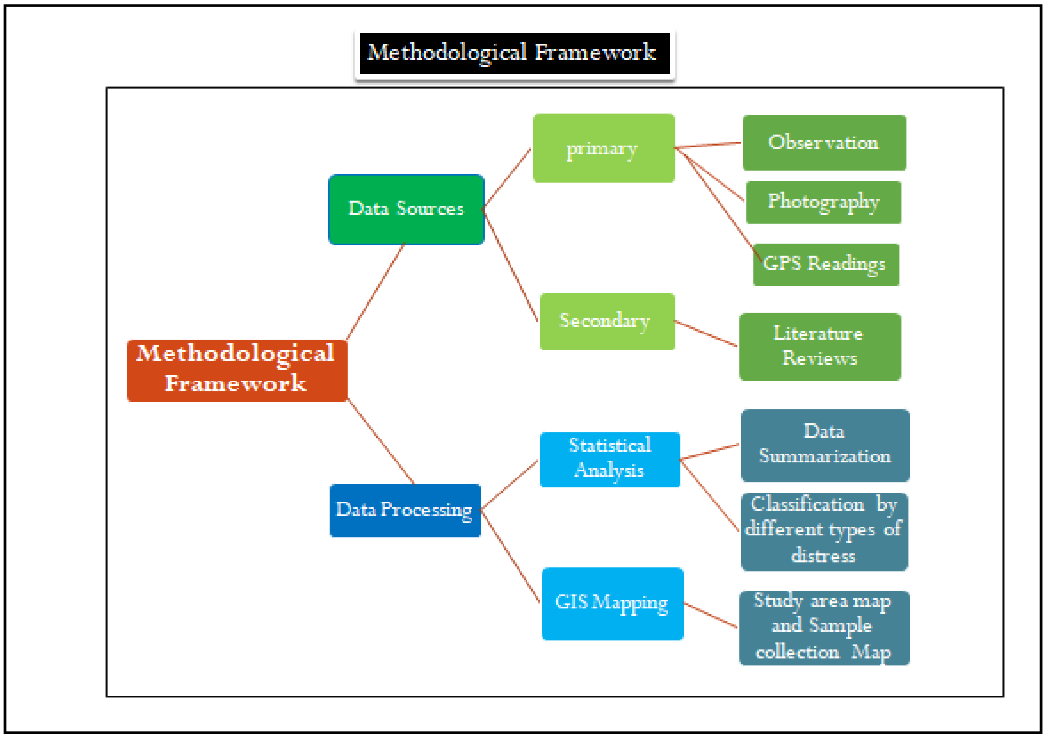


Figure 4. Methodological framework of the research.

Source: Compiled by Authors, 2025

The study employed both primary and secondary data sources to ensure a comprehensive assessment of pavement distress at Jahangirnagar University. Direct fieldwork was conducted by walking and driving along each road segment to evaluate surface conditions for specific sections Table 1. A structured checklist was used to identify visible symptoms such as cracks, raveling, stripping, bleeding, blistering, and pumping. This non-destructive technique was chosen for its efficiency, cost-effectiveness, and suitability for pavement evaluation. High-resolution photographs were taken for every observed distress from multiple perspectives (top-down, side, and close-up). Each image was annotated with field notes and distress classifications to ensure accuracy in later interpretation and reporting. Geospatial data were collected using handheld GPS devices and smartphone applications. Coordinates (latitude and longitude) were recorded for each distress instance, which were later integrated into a geodatabase for spatial analysis. This enabled location-based mapping of pavement problems across the campus. To determine severity, the affected areas were measured using tape measures and digital planimeters. Distress dimensions were converted into square meters, allowing comparisons of severity levels between different road sections. Collected data were digitized in spreadsheets and analyzed using descriptive statistics. Key outputs included the number of distress cases, area affected, and frequency distributions. Bar charts, pie diagrams, and frequency tables highlighted the most common and severe forms of distress—such as stripping and thermal cracking—which were used to identify critical hotspots for intervention. ArcGIS software was used to visualize and analyze the spatial distribution of distresses. Multiple layers were generated showing distress type, severity, and contributing environmental factors (e.g., drainage, slope, vegetation). Heatmaps and overlays revealed priority zones requiring maintenance. Reliability was ensured through repeated observations, cross-checking GPS points, peer review, and triangulation with photographs and field notes. Ethical considerations included non-invasive survey methods, minimal disturbance during data collection, and respect for ecological sensitivity and academic integrity.

Table 1. The selected road segments to be considered.

Section 1: JU Botanical Garden to Shaheed Minar	Section 4: Chourongi to JU School and College
Section 2: Shaheed Minar to Old Administration Building	Section 5: JU School and College to Pandoya Bazar Road Moor
Section 3: Old Administration Building to Chourongi	Section 6: Pandoya Bazar Road Moor to Bishmail Gate JU

Road pavement distress is a critical issue affecting transportation infrastructure worldwide. In developing nations such as Bangladesh, pavement deterioration can substantially undermine user safety, increase vehicle operating costs, and lead to inefficient maintenance spending (World Bank, 2020). Standardized distress categorization enables objective assessment. The Federal Highway Administration (FHWA, 2003) and (ASCE, 2021) divide distresses into:

1. **Cracking Distress** (e.g., thermal, fatigue, longitudinal, transverse)
2. **Surface Deformation** (e.g. rutting, bleeding)
3. **Disintegration** (e.g. raveling, stripping, potholes)
4. **Surface Anomalies** (e.g. blisters, pumping)

Table 2. JU's road distress types that cumulatively align with these categories

Distress Type	Classification	Description
Thermal Cracking	Cracking Distress	Expansion/contraction cracks from temperature variation
Warping Cracking	Cracking Distress	Caused by moisture or temperature gradients through slab thickness
Longitudinal Cracking	Cracking Distress	Cracks parallel to traffic, especially in wheel paths
Bleeding	Surface Deformation	Excess binder at the surface, causing a slippery film
Stripping	Disintegration	Aggregate–binder bond failure due to moisture
Raveling	Disintegration	Loss of surface aggregate via binder aging
Pumping	Surface Anomalies	Ejection of fines/water under load from the subbase
Blisters	Surface Anomalies	Air or moisture trapped causing surface bubbles

Source: Compiled by Authors, 2025.

Mapping these types across the six JU segments enables comparative severity analysis and context-aware interpretation. GIS is critical in visualizing and analyzing spatially distributed infrastructure problems. Literature shows GIS applications ranging from municipal route mapping to asset management (Al-Omari & Darter, 1994; Rahman & Ahmed, 2020). GIS benefits include: *Spatial Inventory*: Each GPS-marked distress becomes a database entry with location, type, and size, *Thematic Mapping:* Mapping allows the identification of hotspots, vulnerable areas, and patterns, *Overlay Analysis:* File layers can examine influences of drainage structure, slope, or usage intensity and *Maintenance Planning:* Spatial clustering evidences priority zones. In this study, ArcGIS is used to build a geodatabase and produce section-by-section thematic distributions, Heat maps of distress concentrations and finally Spatial overlays for recommending interventions.

Results and Discussion

Distress instances were classified into eight broad categories, adapted from internationally accepted systems such as the Pavement Condition Index (PCI) and ASTM D6433-11 standards. Figure 5 represents holistic classification of pavement distress of the study area.

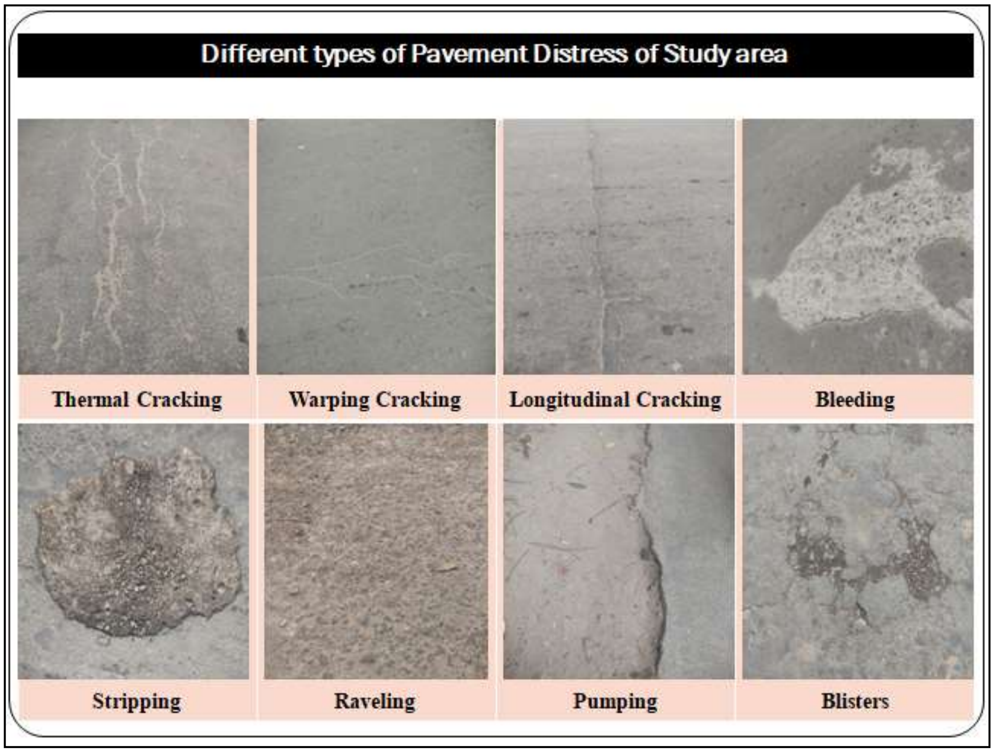


Figure 5. Types of Pavement Distress of study area

Source: Fieldwork, 2025

Types of Pavement Distresses found in Jahangirnagar University Campus from fieldwork, 2025.

A. Cracking Distress:

Type	Causes	Image
Thermal Cracking	**Extreme Temperature Fluctuations**: JU experiences significant temperature variations between day and night, causing expansion and contraction of pavement materials leading to cracks. **Insufficient Temperature Control Joints**: Lack of proper joints or spacing in rigid pavements fails to accommodate thermal movements. **Low-Quality Bitumen**: Use of bitumen with low temperature susceptibility causes it to become brittle in colder conditions.	
Warping Cracking	**Moisture Gradient**: The clayey soils found in parts of JU create uneven moisture profiles beneath pavements, leading to slab warping. **Temperature Differential**: Slabs expand on the top due to heat but stay cool at the bottom, inducing stresses that cause warping cracks. **Inadequate Slab Thickness**: Thin concrete slabs are more susceptible to warping under thermal and moisture gradients.	
Longitudinal Cracking	**Subgrade Settlement**: Weak or poorly compacted subgrade layers in JU’s older roads cause differential settlement along wheel paths. **Poor Construction Practices**: Inadequate joint construction or improper compaction leads to cracking along the pavement's centerline or wheel paths. **Heavy Traffic Loads**: Continuous movement of heavy vehicles like	

campus buses and supply trucks exacerbates stress along the pavement length.

B. Surface Deformation

Type	**Causes**	**Image**
Bleeding	**Excess Asphalt Binder**: Over-application of asphalt during construction or maintenance results in asphalt binder migrating to the surface. **Hot Weather Conditions**: High temperatures soften the binder, causing it to bleed to the surface, especially in summer months. **Low Air Voids in Pavement**: Dense mix designs with inadequate voids prevent binder absorption, increasing bleeding risk.	

C. Disintegration

Type	Causes	Image
Stripping	**Poor Drainage Conditions**: JU roads often have waterlogging issues during the rainy season, leading to water intrusion that weakens the bond between aggregate and binder. **Inadequate Compaction**: Poor compaction allows moisture infiltration, promoting stripping. **Use of Non-Stripping Resistant Aggregates**: Some locally sourced aggregates may lack anti-stripping agents, worsening the problem.	

Raveling	**Aging of Asphalt Binder**: Oxidation of the asphalt binder over time leads to loss of adhesion, causing aggregates to dislodge. **Low-Quality Mix or Workmanship**: Poorly designed asphalt mixtures or improper laying techniques lead to weak surface bonding. **Heavy Traffic Wear**: Constant movement of heavy vehicles around the main gates and dormitory areas causes surface deterioration.	

D. Surface Anomalies

Type	Causes	Image
Pumping	**Inadequate Sealing of Joints and Cracks**: Open cracks allow water infiltration, which mixes with fine particles and is ejected under heavy loads. **Poor Subbase Conditions**: Weak or erodible subbase layers common in some parts of JU's internal roads contribute to pumping. **Repeated Loading**: Repeated bus and truck traffic cycles force water and fines to the surface.	
Blisters	**Entrapped Moisture or Air**: During construction, trapped moisture or air beneath the surface layer expands when heated by the sun, causing blisters. **Improper Surface Preparation**: Lack of surface cleaning or priming before laying overlays traps moisture. **High Pavement Temperatures**: Hot weather conditions on exposed	

roads contribute to blister formation.

N.B: All the images are captured by the authors during fieldwork conducted in 2025.

Section-Wise Pavement Distress Analysis

Section 1: Section 1 includes roads connecting JU Botanical Garden and Shaheed Minar. Figure 6 displays the overall pavement distresses traced along "JU Road Sec 1," identifying several types of distress namely, Raveling, Thermal Cracking, Warping Cracking, and Pumping, and their corresponding areas in square meters unit, as detailed in Table 3. Figure 7 illustrates the spatial distribution of different pavement distress categories. For more visualization (represented by distinct colored areas in columns a, b, c, and d) along Section 1, specifically the segment from the JU Botanical Garden to Shaheed Minar.

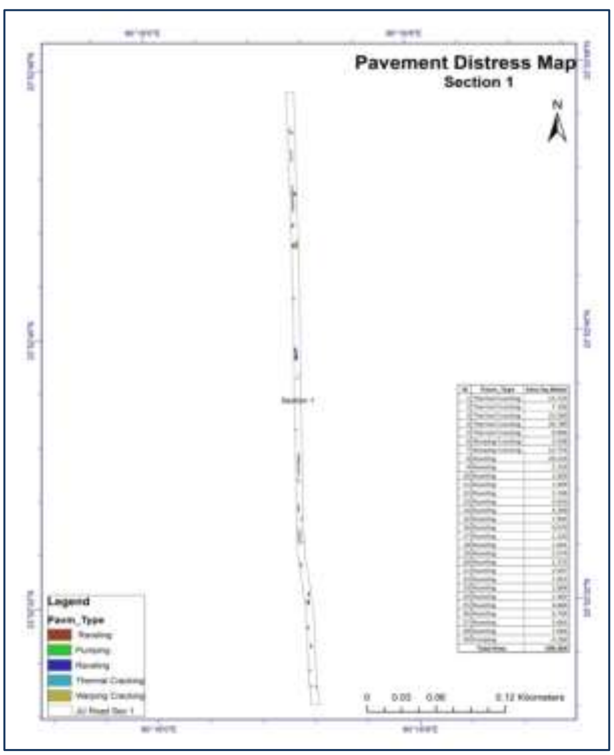


Figure 6. Pavement Distress Map - Section 1

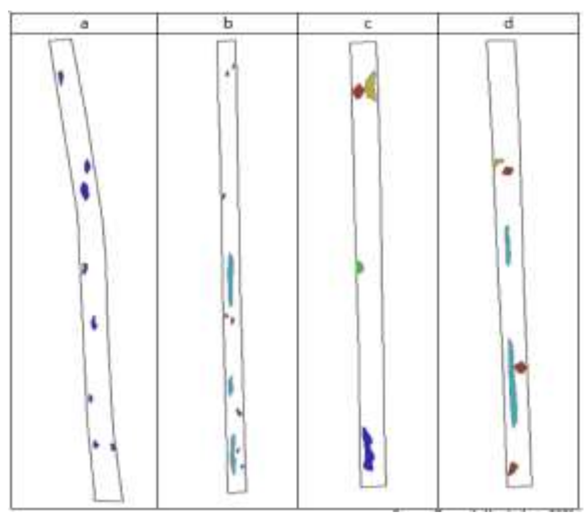


Figure 7. Segmented pavement distresses in section 1, Botanical Garden to Shaheed Minar

Source: Authors, 2025

In Table 3, numbers of each type of pavement distresses identified, and their corresponding area is tabulated. It is mentionable that Raveling pavement distresses are maximum in number for this section. It denotes that in this section the dominant process that influences pavement distress is disintegration.

Table 3. Statistical Representation of Section 1, JU Botanical Garden to Shaheed Minar

Pavement Type	Number of Distress	Area Sq. Meter
Thermal Cracking	5	83.093
Warping Cracking	2	16.191
Raveling	21	86.798
Pumping	1	4.182
Total	29	190.264

Source: Authors, 2025.

Section 2: Section 2 includes roads connecting Shaheed Minar to Old Administration Building. Figure 8 displays the overall pavement distress along "JU Road Sec 2," identifying various types of distress (Longitudinal Cracking, Raveling, Pumping, Thermal Cracking, and Warping Cracking) and their corresponding areas in square meters, as detailed in Table 4. Figure 9 illustrates the spatial distribution of different pavement distress categories. For more visualization (represented by distinct colored areas in columns a, b, c, and d) along Section 2, specifically the segment from the Shaheed Minar to the Old Administration Building.

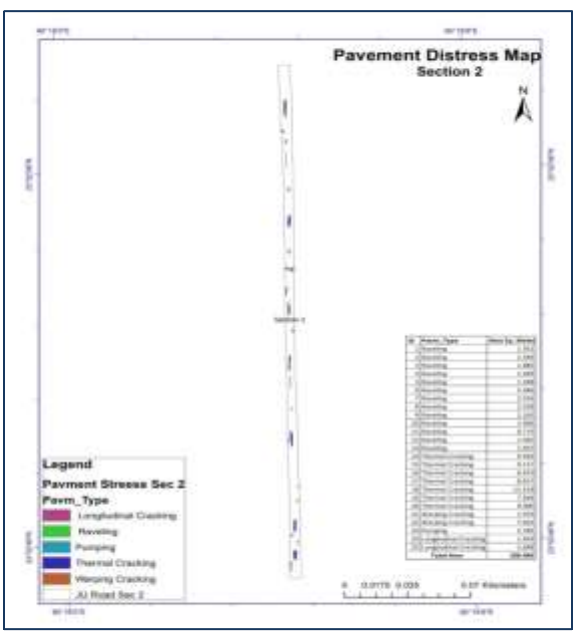


Figure 8. Pavement Distress Map Section 2

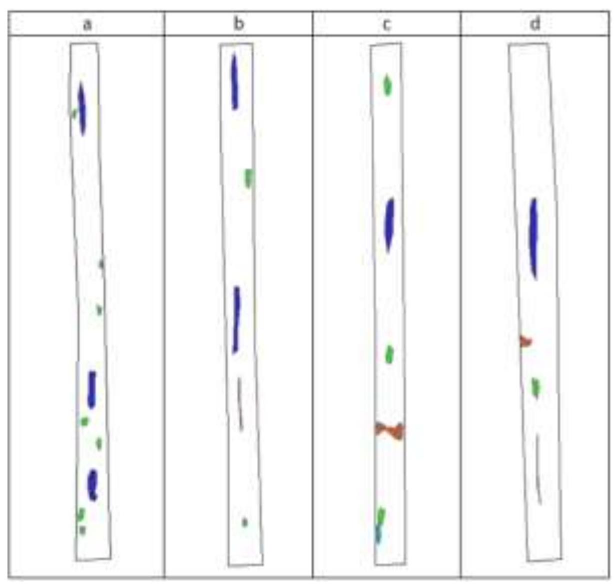


Figure 9. Segmented pavement distresses in section 2, Shaheed Minar to Old Administration Building

Source: Authors, 2025

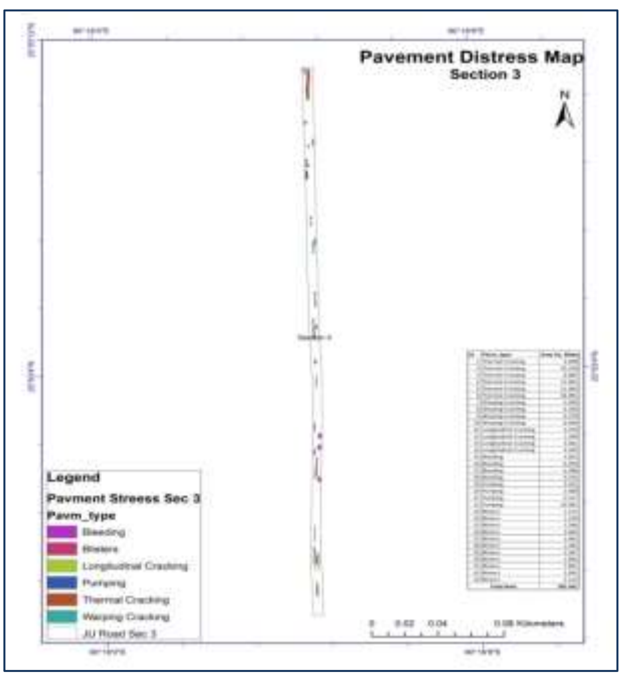
In Table 4, numbers of each type of pavement distresses are identified, and their corresponding area is tabulated. It is mentionable that Raveling pavement distresses are maximum in number for this section. It denotes that in this section the dominant process that influences pavement distress is disintegration.

Table 4: Statistical Representation of Section 2, Shaheed Minar to Old Administration Building

Pavement Type	**Number of Distress**	**Area Sq. Meter**
Thermal Cracking	7	63.022
Warping Cracking	2	8.991
Longitudinal Cracking	2	3.107
Raveling	13	23.141
Pumping	1	2.185
Total	25	100.446

Source: Compiled by Authors, 2025.

Section 3: Section 3 includes roads connecting Old Administration Building to Chourongi. Figure 10 displays the overall pavement distress along "JU Road Sec 3," identifying various types of distress (Bleeding, Blisters, Longitudinal Cracking, Pumping, Thermal Cracking, and Warping Cracking) and their corresponding areas in square meters, as detailed in the accompanying table. Figure 11 illustrates the spatial distribution of different pavement distress categories. For more visualization (represented by distinct colored areas in columns a, b, c, and d) along Section 3, specifically the segment from the Administration Building to Chourongi.



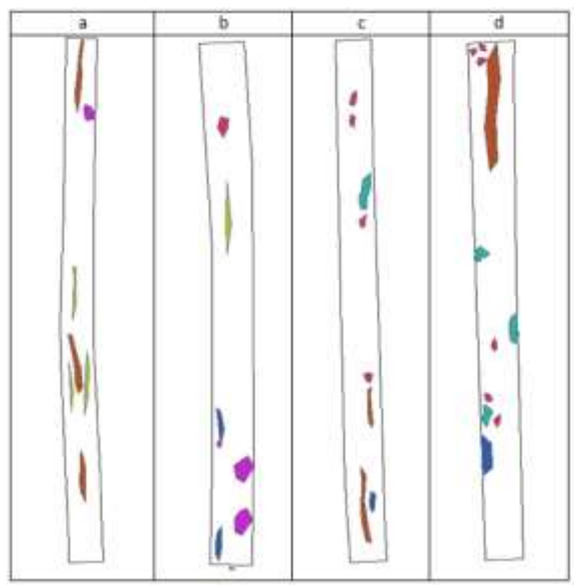


Figure 10. Pavement Distress Map - Section 3

Figure 11. Segmented pavement distress of section 3, Administration Building to Chourongi

Source: Authors, 2025

In Table 5, numbers of each type of pavement distresses identified, and their corresponding area is tabulated. It is mentionable that Blister pavement distresses are maximum in number for this section. It denotes that in this section the dominant process that influences pavement distress is surface anomalies.

Table 5: Statistical Representation of section 3, Old Administration Building to Chourongi

Pavement Type	**Number of Distress**	**Area Sq. Meter**
Thermal Cracking	6	83.710
Warping Cracking	4	23.012
Longitudinal Cracking	4	16.676
Bleeding	4	19.466
Pumping	4	19.209
Blisters	11	19.558
Total	33	181.631

Source: Compiled by Authors, 2025.

Section 4: Section 4 includes roads connecting Chourongi to JU School and College. Figure 12 displays the overall pavement distress along "JU Road Sec 4," identifying various types of distress (Bleeding, Stripping, Blisters, Raveling, Thermal Cracking, and Warping Cracking) and their corresponding areas in square meters, as detailed in Table 6. Figure 13 illustrates the spatial distribution of different pavement distress categories. For more visualization (represented by distinct colored areas in columns a, b, c, and d) along Section 4, specifically the segment from Chourongi to JU School and College.

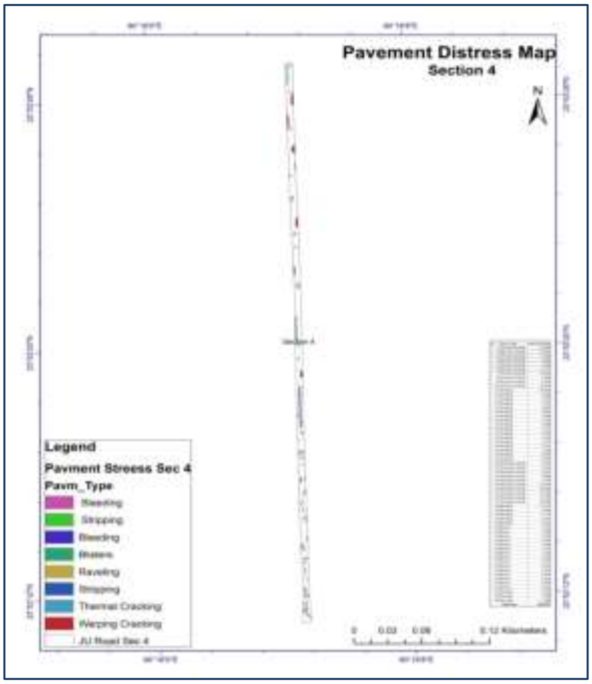


Figure 12: Pavement Distress Map - Section 4

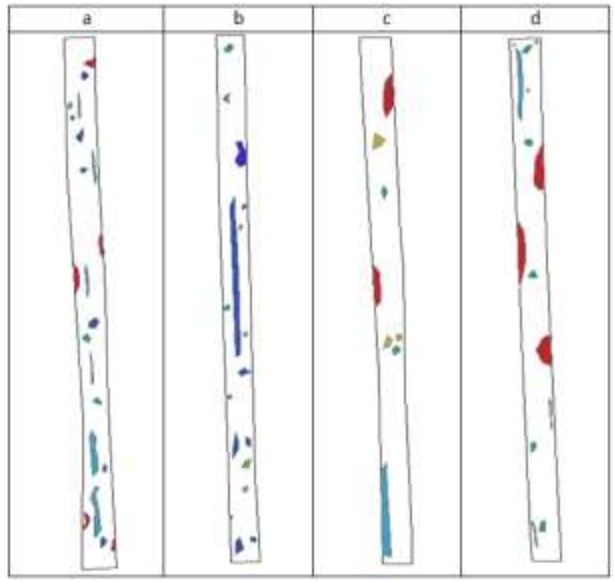


Figure 13: Segmented pavement distress of section 4, Chourongi to JU School and College

Source: Authors, 2025

In Table 6, numbers of each type of pavement distresses identified, and their corresponding area is tabulated. It is mentionable that Stripping pavement distresses are maximum in number for this section. It denotes that in this section the dominant process that influences pavement distress is disintegration.

Table 6. Statistical Representation of Section 2, Chourongi to JU School and College

Pavement Type	**Number of Distress**	**Area Sq. Meter**
Thermal Cracking	10	85.006
Stripping	17	82.439
Warping Cracking	10	105.076
Bleeding	5	3.119
Blisters	15	26.945
Raveling	3	9.135
Total	60	226.714

Source: Compiled by Authors, 2025.

Section 4: Section 5 includes roads connecting JU School and College to Pandoya Bazar Road Moor. Figure 14 displays the overall pavement distress along "JU Road Sec 5," identifying various types of distress (Bleeding, Blisters, Longitudinal Cracking, Pumping, Stripping, and Thermal Cracking,) and their corresponding areas in square meters, as detailed in Table 7. Figure 15 illustrates the spatial distribution of different pavement distress. For more visualization (represented by distinct colored areas in columns a, b, c, and d) along Section 5, specifically the segment from JU School and College to Pandoya Bazar Road Moor.

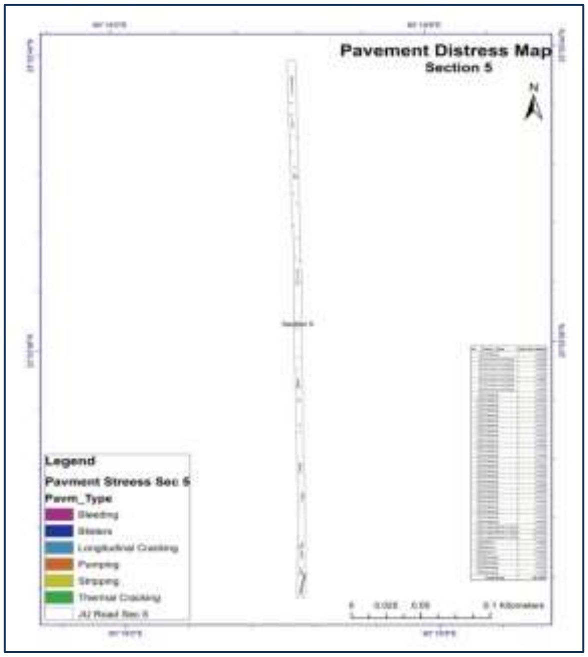


Figure 14: Pavement Distress Map Section 5

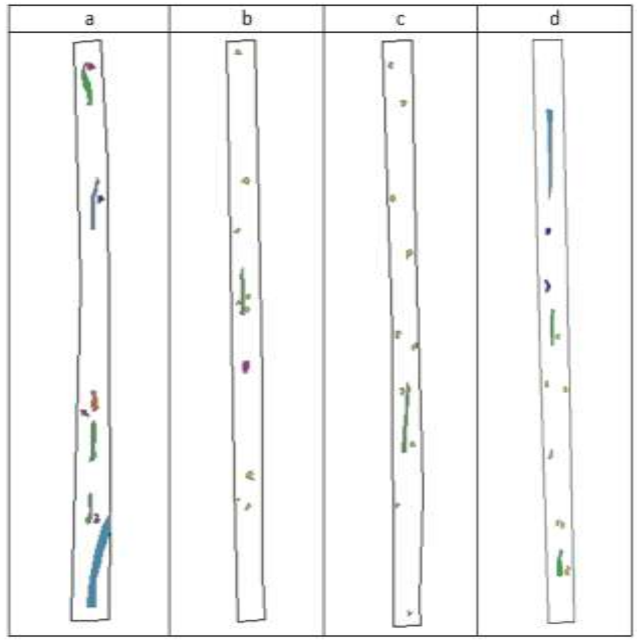


Figure 15: Segmented pavement distress of section 5, JU School and College to Pandoya Bazar Road Moor

Source: Authors, 2025

In Table 7, numbers of each type of pavement distresses identified, and their corresponding area is tabulated. It is mentionable that Stripping pavement distresses are maximum in number for this section. It denotes that in this section the dominant process that influences pavement distress is disintegration.

Table 7: Statistical Representation of Section 4, JU School and College to Pandoya Bazar Road Moor

Pavement Type	**Number of Distress**	**Area Sq. Meter**
Thermal Cracking	7	30.153
Stripping	26	16.153
Longitudinal Cracking	3	35.376
Blisters	3	3.367
Bleeding	4	5.389
Pumping	1	3.333
Total	44	93.769

Source: Compiled by Authors, 2025.

Section 6: Section 6 includes roads connecting Pandoya Bazar Road Moor to Bishmail Gate Moor. Figure 16 displays the overall pavement distress along "JU Road Sec 6. This section runs west to east only, identifying various types of distress (bleeding, blisters, stripping, thermal cracking, and warping cracking) and their corresponding areas in square meters, as detailed in the accompanying table. Figure 17 illustrates the spatial distribution of different pavement distress categories. For more visualization (represented by distinct colored areas in columns a, b, c, and d) along Section 6, specifically the segment from Pandoya Bazar Road Mor to Bishmail Gate.

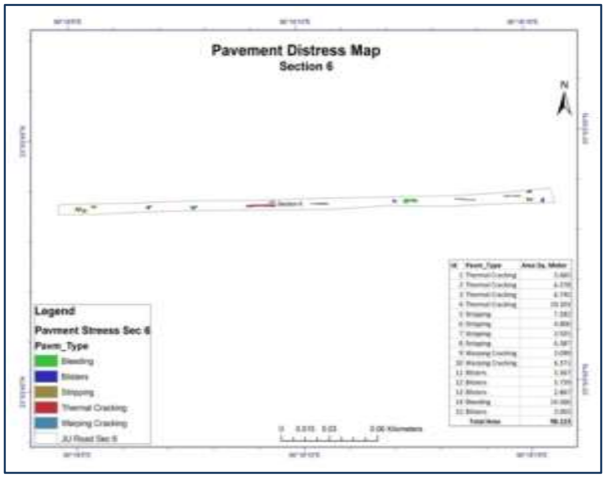


Figure 16: Pavement Distress Map - Section 6

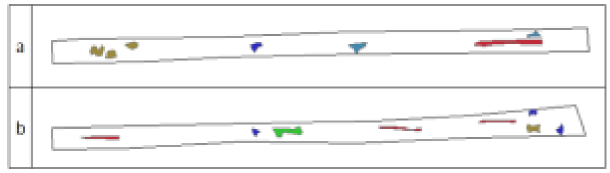


Figure 17. Segmented pavement distress in section 6, Pandoya Bazar Road Moor to Bishmail Gate

Source: Authors, 2025.

In Table 8, numbers of each type of pavement distresses identified, and their corresponding area is tabulated. It is mentionable that Thermal Cracking, Stripping and Blisters pavement distresses are maximum in number for this section. It denotes that in this section multiple process influence pavement distress is disintegration.

Table 8: Statistical Representation of section 6, Pandoya Bazar Road Moor to Bishmail Gate

Pavement Type	Number of Distress	Area Sq. Meter
Thermal Cracking	4	37.991
Stripping	4	22.400
Warping Cracking	2	9.471
Blisters	4	13.896
Bleeding	1	14.366
Total	15	98.123

Source: Compiled by Authors, 2025.

Spatial Distribution of Pavement Distresses:

Distress clusters are dense in areas with: High vehicular traffic (near dormitories, admin, and college gates), Poor drainage and moisture retention zones and Weak or degraded sub-base materials. Section wise quantitative analysis of distresses is tabulated in Table 9.

Table 9. Section wise quantitative analysis of Pavement Distresses:

Section	Total Distress	Dominant Type	Affected Area In Sq. m	Description
1	29	Raveling (21cases)	190.264	This section, shaded by trees and exposed to pedestrian and light-vehicle traffic, showed moderate signs of thermal cracking and surface raveling. The degradation is likely due to material aging and inadequate maintenance.
2	25	Thermal Cracking (7 cases)	100.446	This moderately trafficked area reveals thermal cracking and some longitudinal cracks, which suggests temperature stress and subgrade settlement beneath older road layers.
3	33	Blisters (11 cases), Thermal Cracking (6 cases)	181.631	This part of the campus exhibits significant blistering and bleeding. The proximity to administrative and vehicular-heavy zones likely contributed to repetitive loading and surface heating effects.
4	60	Stripping (17), Warping Cracking (10), Blisters (15)	323.067	This section recorded the highest number of distress events. Poor drainage and structural failures due to high traffic flow likely contribute to the observed distresses. Moisture-related issues are predominant here.
5	44	Stripping (26 cases)	93.769	Stripping and longitudinal cracking are prominent, due to continuous rainfall infiltration and weak aggregate-binder bonding.
6	15	Blisters (4), Stripping (4), Thermal Cracking (4)	98.123	Although relatively less distress is observed, the presence of thermal cracking and blistering signals underlying structural deficiencies.

Source: Compiled by Authors, 2025.

Hotspot areas, where the intensity of pavement distress is found concentrated are identified and mapped Figure 18. It provides an insight that Section 4 (Road connecting Chourongi to JU School and College), Section 3 (Road connecting Old Admin to Chourongi) and Section 5 (JU School to Pandoya Bazar Road Moor) have high concentration. These spatial patterns provide crucial input for prioritizing maintenance and funding allocation. A comprehensive assessment of pavement conditions across six sections of the road of the study area Botanical Garden to Bishmile Gate revealed varying levels of distress. A total of 206 distress cases were identified, covering an overall distressed area of 790.947 square meters. Among the different types of distresses recorded, Stripping was the most frequent with 47 cases, followed by Raveling (37 cases), Thermal Cracking (39 cases), and Blisters (33 cases).

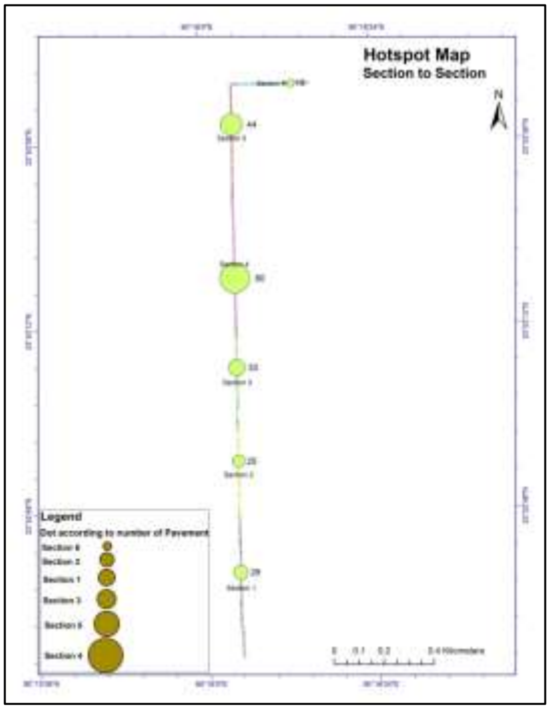


Figure 18: Hotspot map according to number of pavement distress

Source: Authors, 2025

Other notable distress types included Warping Cracking (20 cases), Bleeding (14 cases), Longitudinal Cracking (9 cases), and Pumping (7 cases). Section 1 recorded 29 cases with the highest being Raveling (21 cases) and a total affected area of 190.264 sqm. Whereas Section 2 reported 25 distress cases, dominated by Thermal Cracking (7 cases) and Raveling (13 cases), covering 100.446 sqm. In case of Section 3, it showed 33 distress cases, with a combination of Thermal Cracking (6 cases), Blisters (11 cases), and Pumping (4 cases), affecting 181.631 sqm. Whereas Section 4 had the highest number of distresses (60 cases) and the largest damaged area (226.714 sqm). Major issues were Stripping (17 cases), Warping Cracking (10 cases), and Blisters (15 cases). But Section 5 showed 44 cases of distress, particularly Stripping (26 cases) and Thermal Cracking (7 cases), with an affected area of 93.769 sqm and Section 6 had the least number of cases (15) but notable occurrences of Thermal Cracking, Stripping, and Blisters, contributing to a total damaged area of 98.123 sqm. Thermal Cracking was observed in all sections, indicating temperature-related pavement stress. Stripping, Raveling, and Blisters were significant in multiple sections, suggesting both moisture-related and material-based failures. Section 4 is the most critically affected, requiring immediate attention in both repair and design reassessment.

These findings highlight a significant presence of both moisture-induced and temperature-related pavement failures, indicating underlying structural weaknesses and poor maintenance conditions. Pavement distress at Jahangirnagar University is influenced by both environmental and structural factors. Those includes *Moisture-related issues* (e.g., stripping, blistering, pumping) occur mainly post-monsoon due to poor drainage, *Temperature changes* lead to widespread thermal cracking, especially on exposed surfaces, *Construction defects* like warping and longitudinal cracking arise from poor joint spacing and subgrade settlement and finally *High traffic loads* near gates and academic areas cause surface fatigue and binder failure.

Conclusion

This research comprehensively assessed the condition and types of road pavement distress across six key road segments at Jahangirnagar University (JU), employing direct field observation, photography, GPS mapping, and literature review. The findings reveal a significant presence of various types of pavement distress, including alligator cracking, longitudinal and transverse cracking, potholes, raveling, and surface depression. These distresses vary in severity across the campus and are largely influenced by environmental exposure, poor drainage, subgrade weaknesses, lack of timely maintenance, and repetitive vehicular loading, especially from heavy service vehicles. The study applied a classification framework that helped categorize and map each type of distress according to its visual characteristics and probable causes. Data collected through GPS readings and photographic documentation were instrumental in generating spatial insights, particularly in identifying distress-prone zones and understanding their distribution patterns. The integration of maps and field data allowed for detailed spatial interpretation, emphasizing critical segments where maintenance is urgently needed. The study highlights the urgent requirement for proactive pavement maintenance planning and the incorporation of sustainable road design principles at JU. Moreover, the findings underscore the importance of routine inspection, quality construction materials, proper drainage systems, and budgetary allocation to avoid further deterioration and enhance the campus' transportation safety and infrastructure longevity. Overall, this research not only documents the existing physical condition of JU's internal roads but also establishes a practical framework for future monitoring, decision-making, and rehabilitation strategies. It serves as a foundational study for policy recommendations and offers a replicable methodology for similar institutional or urban environments experiencing pavement distress.

Acknowledgement

There is no grant or funding bodies to be acknowledged for preparing this paper.

References

Bensalem, A., Brown, A. J., Nunn, M. E., Merrill, D. B., & Lloyd, W. G. (2000). Finite element modeling of fully flexible pavement: Surface cracking and wheel interaction. *Proceedings of the 2nd International Symposium on 3D Finite Element for Pavement Analysis, Design, and Research*, 103–113.

Chen, C., & Khan, S. A. (2025). Advancing Sustainable Innovation: The Role of Transformational Leadership and Organizational Innovation Climate in Shaping the Innovative Behavior of Knowledge-Based Employees in High-Tech Enterprises in China. *Sustainability*, *17*(17), 7931. https://doi.org/10.3390/su17177931

Collop, A., & Cebon, D. (1995). A theoretical analysis of fatigue cracking in flexible pavements. *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, 209*(5), 345–361. https://doi.org/10.1243/PIME_PROC_1995_209_163_02

Dauzats, M., & Rampal, A. (1987). Mechanism of surface cracking in wearing courses. In *Proceedings of the 6th International Conference on Structural Design of Asphalt Pavements* (pp. 232–247). https://trid.trb.org/View/242527

Draper, N. R., & Smith, H. (1998). *Applied regression analysis* (Vol. 326). John Wiley & Sons.

Du, Z., Yuan, J., Xiao, F., & Hettiarachchi, C. (2021). Application of image technology on pavement distress detection: A review. *Measurement, 184*, 109900. https://doi.org/10.1016/j.measurement.2021.109900

Georgopoulos, A., Loizos, A., & Flouda, A. (1995). Digital image processing as a tool for pavement distress evaluation. *ISPRS Journal of Photogrammetry and Remote Sensing*. Elsevier Science B.V. https://doi.org/10.1016/0924-2716(95)91844-A

Gerritsen, A., Van Gurp, C., Van der Heide, J., Molenaar, A., & Pronk, A. (1987). Prediction and prevention of surface cracking in asphaltic pavements. In *Proceedings of the 6th International Conference on Structural Design of Asphalt Pavements* (pp. 378–392). https://trid.trb.org/View/302940

Gransberg, D. D., Tighe, S. L., Pittenger, D., & Miller, M. C. (2014). Sustainable pavement preservation and maintenance practices. In *Climate change, energy, sustainability and pavements* (pp. 393–418). https://doi.org/10.1007/978-3-662-44719-2_14

Hosmer, D. W., Jr., Lemeshow, S., & Sturdivant, R. X. (2013). *Applied logistic regression* (Vol. 398). John Wiley & Sons.

Huhtala, M., Pihlajamäki, J., & Pienimäki, M. (1989). Effects of tires and tire pressure on road pavements. *Transportation Research Record, 1227*, 107–114. https://onlinepubs.trb.org/Onlinepubs/trr/1989/1227/1227-011.pdf

Indian Roads Congress. (2001). *Guidelines for the design of flexible pavements*. Jamnagar House, Shahjahan Road, New Delhi, India. https://law.resource.org/pub/in/bis/irc/irc.gov.in.037.2019.pdf

Indian Roads Congress. (2001). *Specification for road and bridge works* (4th rev.). Ministry of Road Transport and Highways, Government of India.

Jacobs, M. M. J. (1995). *Crack growth in asphaltic mixes* (Doctoral dissertation). Delft University of Technology, The Netherlands.

Jahangirnagar University (JU). (2025). *At a glance*. JU Website. https://juniv.edu/custom/slug/about-ju

Khanna, S. K., & Justo, C. E. G. (2001). *Highway engineering*. Nem Chand & Bros.

Kumar, R. S. (2011). *Textbook of highway engineering*. Universities Press Private Limited.

Lippmann, S. A. (1985). Effects of tire structure and operating conditions on the distribution of stress between the tread and the road: The tire–pavement interface. In *ASTM Special Technical Publication* (pp. 91–109). ASTM International. https://doi.org/10.1520/STP20004S

Marcelino, P., Antunes, M. D. L., & Fortunato, E. (2018). Comprehensive performance indicators for road pavement condition assessment. *Structure and Infrastructure Engineering, 14*(11), 1433–1445. https://doi.org/10.1080/15732479.2018.1446179

Markwick, A. H. D., & Starks, J. H. (1941). Stresses between tire and road. *Journal of the Institution of Civil Engineers, 16*, 309–325. https://doi.org/10.1680/ijoti.1941.13663

Matsuno, S., & Nishizawa, T. (1992). Mechanism of longitudinal surface cracking in asphalt pavement. In *Proceedings of the 7th International Conference on Asphalt Pavements* (Vol. 2, pp. 277–291).

Myers, L. A., Roque, R., & Ruth, B. (1998). Mechanisms of surface-initiated longitudinal wheel path cracks in high-type bituminous pavements. *Journal of the Association of Asphalt Paving Technologists, 67*, 401–432. https://trid.trb.org/View/542939

O'Flaherty, C. A. (2001). *Highways: The location, design, construction and maintenance of pavements*. Butterworth-Heinemann.

Perdomo, D., & Nokes, B. (1993). Theoretical analysis of the effects of wide-base tires on flexible pavement using CIRCLY. *Transportation Research Record, 1388,* 108–119. https://trid.trb.org/View/382540

Sebaaly, P., & Tabatabaee, N. (1989). Effects of tire pressure and type on response of flexible pavement. *Transportation Research Record, 1227*, 115–127. https://onlinepubs.trb.org/Onlinepubs/trr/1989/1227/1227-012.pdf

Seitz, N., & Hussmann, A. W. (1971). Forces and displacements in contact area of free rolling tires. *Society of Automotive Engineers Technical Paper* 710626, 1–7. https://www.jstor.org/stable/44650319

Surendrakumar, K., Prashant, N., & Mayuresh, P. (2013). Application of Markovian probabilistic process to develop a decision support system for pavement maintenance management. *International Journal of Scientific & Technology Research, 2*(8), 295–303.

Yoder, E. J., & Witczak, M. W. (1975). *Principles of pavement design*. John Wiley & Sons.

Zakeri, H., Nejad, F. M., & Fahimifar, A. (2017). Image-based techniques for crack detection, classification, and quantification in asphalt pavement: A review. *Archives of Computational Methods in Engineering, 24*, 935–977. https://doi.org/10.1007/s11831-016-9194-z