**DOI:** https://doi.org/10.46296/ig.v8i16.0293

# DIAGNÓSTICO DE FALLAS EN PAVIMENTOS URBANOS MEDIANTE EL MÉTODO PCI: EL CASO DE LA CALLE ELOY ALFARO EN JIPIJAPA

# DIAGNOSIS OF URBAN PAVEMENT FAILURES USING THE PCI METHOD: THE CASE OF ELOY ALFARO STREET IN JIPIJAPA

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## Resumen

Se evaluó el estado del pavimento urbano en la calle Eloy Alfaro (Jipijapa, Ecuador), entre Febres Cordero y Villamil, para informar la gestión de la movilidad urbana y la seguridad vial. El objetivo fue determinar el estado de la superficie utilizando el Índice de Estado del Pavimento (PCI; ASTM D6433-07) mediante la identificación de los tipos de deterioro, el cálculo del PCI para cada unidad de muestreo (SU) y el establecimiento del estado general de la sección. Se realizó un estudio observacional transversal con inspección visual estandarizada en ocho SU de 228 m². Las densidades de deterioro se calcularon mediante métricas (área, longitud, conteo), se obtuvieron valores de deducción (DV) y se corrigieron iterativamente (DV → CDV), y el PCI por SU se derivó como 100 − máx. (CDV). Los deterioros registrados comprendieron agrietamiento por fatiga, agrietamiento longitudinal/transversal, baches, desprendimiento/meteorización y ahuellamiento. El PCI medio del tramo fue de 24,5 (muy deficiente), con una distribución heterogénea: 50 % de los casos fueron reprobados (PCI 0-8), 25 % deficientes, 12,5 % regulares y 12,5 % buenos (máximo 64). Se concluyó que el tramo presentaba un deterioro avanzado, con una concentración de problemas estructurales y funcionales en los tramos centrales, y que el PCI proporcionaba un indicador válido y orientado a la toma de decisiones para respaldar la priorización del mantenimiento en la gestión del pavimento urbano.

**Palabras clave:** pavimento urbano, PCI, deterioro de la superficie, seguridad vial; priorización del mantenimiento.

## Abstract

Urban pavement condition on Eloy Alfaro Street (Jipijapa, Ecuador), between Febres Cordero and Villamil, was assessed to inform urban mobility and road-safety management. The objective was to determine surface condition using the Pavement Condition Index (PCI; ASTM D6433-07) by identifying distress types, computing PCI for each sampling unit (SU) and establishing the section's overall state. An observational, cross-sectional survey with standardised visual inspection was conducted on eight SUs of 228 m². Distress densities were calculated by metric (area, length, count), deduct values (DV) were obtained and iteratively corrected (DV→CDV), and PCI per SU was derived as 100 − max (CDV). Recorded distresses comprised alligator (fatigue) cracking, longitudinal/transverse cracking, potholes, ravelling/weathering and rutting. The section's mean PCI was 24.5 ("very poor"), with a heterogeneous distribution: 50% failed (PCI 0–8), 25% poor, 12.5% fair and 12.5% good (maximum 64). It was concluded that the section

**Información del manuscrito:**
**Fecha de recepción:** 09 de junio de 2025.
**Fecha de aceptación:** 29 de agosto de 2025.
**Fecha de publicación:** 29 de septiembre de 2025.

exhibited advanced deterioration with a concentration of structural and functional distresses in the central subsections, and that PCI provided a valid, decision-oriented indicator to support maintenance prioritisation within urban pavement management.

**Keywords:** urban pavement, PCI, surface distress, road safety, maintenance prioritisation.

## 1. Introduction

Adequate maintenance of urban pavements is fundamental to ensuring efficient mobility and road safety in cities. The condition of road surfaces directly influences comfort, accessibility and the protection of all users, including pedestrians, cyclists and drivers.

Pavement deterioration such as potholes, cracking and deformation adversely affects traffic flow and travel comfort. Irregular surfaces oblige drivers to reduce speed and perform evasive manoeuvres, which increases congestion and journey times. Moreover, pedestrians and cyclists tend to avoid damaged footways or cycle lanes, shifting into spaces not designed for them, which aggravates mobility problems and compromises their safety (Beketov & Khalimova, 2023; Cafiso et al., 2022).

Road safety largely depends on pavement quality. Deteriorated surfaces increase the likelihood of crashes, especially under adverse weather conditions, by reducing tyre–pavement adhesion and vehicle control. Low friction or high roughness raises crash frequency in both dry and wet conditions and disproportionately affects vulnerable users such as pedestrians and cyclists (Ragnoli et al., 2018). Evidence also indicates that preventive maintenance and timely repair can reduce serious and fatal injuries on urban networks by up to 60%.

In the Ecuadorian context, Eloy Alfaro Street in the canton of Jipijapa exemplifies the progressive deterioration of urban road infrastructure. Accelerated urban growth and land-use changes driven by commercial and service activities have exerted pressure on traditional streets, affecting both their heritage value and daily functionality. The absence of conservation and rehabilitation has allowed physical wear to advance, undermining urban quality and hindering pedestrian and vehicular mobility on one of the central arteries of Jipijapa (Regalado, 2023; Samaniego & Calero, 2021).

Despite the historical and social relevance of Eloy Alfaro Street, there are no conservation plans or systematic maintenance strategies to reverse deterioration. This lack of management has exacerbated structural and surface problems over time, affecting the urban image and user safety. The situation calls for an urgent rehabilitation masterplan that prioritises recovery of critical segments and integrates cultural, social and environmental aspects in corridor management.

Within this framework, the Pavement Condition Index (PCI; ASTM D6433-07) was an appropriate standardised visual diagnostic tool owing to its objectivity, simplicity and effectiveness for assessing the surface state of urban pavements. The PCI quantifies deterioration by identifying and classifying distress types, severities and extents, generating a numerical index from 0 to 100 that supports decisions on maintenance and rehabilitation priorities. Its visual and systematic application has been validated internationally, proving reliable and cost-effective for network monitoring, particularly where maintenance resources are limited (Azam et al., 2023; Karim et al., 2016; Temimi et al., 2021).

Comparative studies have shown that the PCI's ASTM-based visual approach enables comprehensive and repeatable assessment across urban and rural settings. Investigations in Yemen, Brazil and Indonesia reported that the PCI is suitable for identifying maintenance needs, prioritising interventions and optimising budgets, and that it integrates readily with road asset management systems and technologies such as GIS and artificial intelligence (Ibragimov et al., 2024; Loprencipe, Pantuso, Simone, et al., 2017). The use of PCI fosters consistent and comparable diagnoses, which are essential for efficient and transparent management of road infrastructure.

The central purpose of this study was to evaluate the pavement condition of Eloy Alfaro Street, between Febres Cordero and Villamil in Jipijapa, through application of the PCI method (ASTM D6433-07). Three specific objectives were set: to identify surface distresses and classify them by type and severity, to quantify deterioration by computing PCI in sampling units and to determine the overall condition of the section so as to inform technical criteria for maintenance and rehabilitation prioritisation.

This article presented the theoretical and methodological framework underpinning the PCI application, followed by the description of materials, procedures and technical criteria used for data collection. It then reported the results of distress diagnosis and PCI computation for the study corridor, and finally offered the discussion and conclusions, where the findings were interpreted and recommendations were outlined for the management and conservation of urban road infrastructure. In doing so, the study contributed to the technical diagnosis of urban pavement and to the formulation of rehabilitation guidelines applicable to the Jipijapa context.

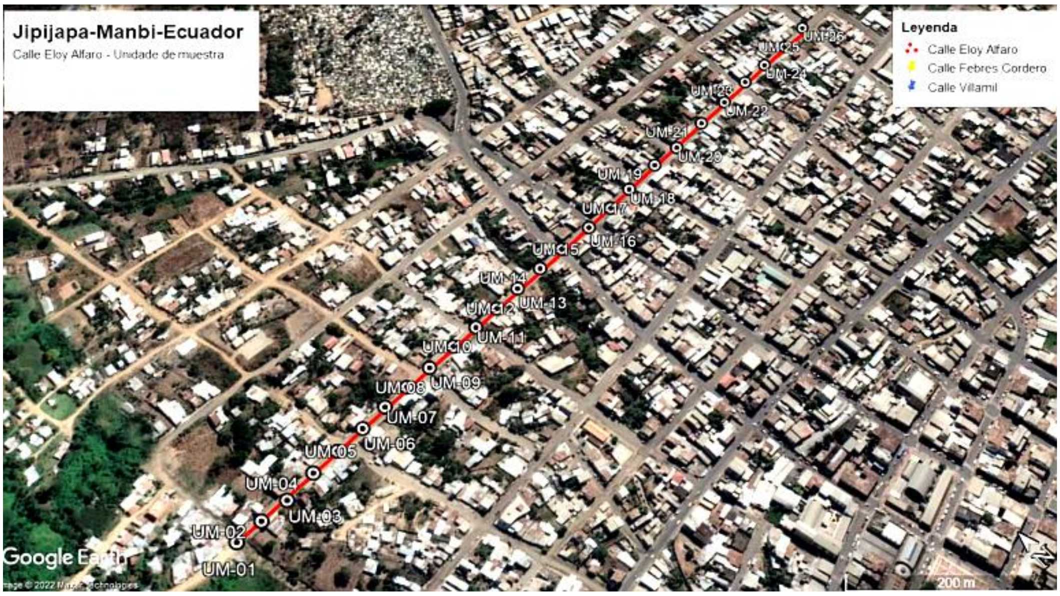
## 2. Materials and metods

### 2.1 Study area and scope

The study was conducted on Eloy Alfaro Street in Jipijapa (Manabí, Ecuador), along the section between Febres Cordero and Villamil. This is an urban corridor with commercial and service functions whose selection responded to its functional relevance and documented evidence of progressive surface deterioration. The diagnosis was framed as an observational, cross-sectional assessment of pavement condition using standardised visual inspection in accordance with the PCI method (ASTM D6433-07), for the purposes of maintenance management and intervention prioritisation.

The evaluable population was defined as the set of sampling units (SU) within the paved section; 26 SUs were identified, and a representative sampling design was applied with 95 % confidence and ±5% sampling error, assuming a standard deviation of 8 PCI points for a first survey. As a result, eight georeferenced SUs were selected and assessed. See Figure 1 for the location of the section and the sequence of SUs along the carriageway.

***Figure 1.*** *Location of the study section and sequence of sampling units.*




*Note.* The satellite image served as the cartographic base to delineate SUs on the carriageway and to document the visual survey; the analysis was performed with representative sampling (n = 8, 95 % confidence, ± 5% error). Source: Google Earth; authors' elaboration.

The Pavement Condition Index (PCI) quantifies surface condition on a 0–100 scale based on the identification, severity and extent of distresses within sampling units. The method has been formalised by ASTM D6433 for roads and car parks, and its use has been consolidated in pavement management manuals and in the scientific literature for urban networks (ASTM International, 2007).

### 2.2. PCI methodological design and sampling scheme

The study adopted the PCI procedure as specified in ASTM D6433, using the thesis version (D6433-07) and consulting the 2016/2018 and 2023 editions for normative reference without altering the reported computations. The practice comprises: delimiting homogeneous sections; partitioning into sampling units (SUs) (typically 230 ± 93 m² for asphalt carriageways with width < 7.30 m); conducting a standardised visual survey with distress classification by type and severity (low, medium, high); computing distress densities and deduct values (VD); applying the PCI correction to obtain the corrected deduct value (CDV); and deriving the

PCI per SU and the section-level PCI as the (weighted) mean.

Sample size and selection. For project-level evaluation (not full-network surveys), ASTM/Shahin recommend estimating n for a target error (±5 PCI) with an initial σ = 8 for a first survey; if n < 5, all units should be inspected. In this case, the paved section comprised N = 26 SUs; a representative design with 95% confidence and ±5% sampling error (σ assumed = 8 PCI points) was adopted, and eight georeferenced SUs were ultimately selected and surveyed (Shahin, 2005).

The choice of PCI for urban roads was supported by experience in urban pavement management systems (PMS) and international applications that employ PCI to prioritise maintenance and optimise budgets (e.g., Italy, Yemen, Iraq), facilitating methodological comparability and transferability (Loprencipe et al., 2017).

### 2.3. Instruments and material

A basic set of instruments was used for the standardised visual inspection and recording of distresses in accordance with the PCI method: a 5 m tape (for small-dimension distresses), a 50 m tape (for SU lengths and extensive distresses), a 1 m aluminium straightedge (for level differences), a field notebook, a digital camera for photographic evidence, and a standardised recording form adapted from ASTM D6433-07 to consolidate roadway data and, for each distress, its type, severity and measurement unit. The use of standardised forms was consistent with the practice defined by ASTM D6433-07, which formalises the Pavement Condition Index for roads and car parks.

### 2.4. Survey procedure and quality control

The field and office procedure was structured in stages in accordance with ASTM D6433-07:

1. Segmentation and sampling units (SUs). The carriageway was divided into one homogeneous section and into SUs according to the ranges indicated for asphalt pavements (approximately 230 ± 93 m² when width is < 7.30 m). For project-level evaluation, SU selection was performed using

representative sampling, applying the sampling interval $i = N/n$as per the methodology (project example: N = 26, n = 10, $i \approx 3$).

2. Visual inspection and recording. In each SU, distresses were identified and classified by type and severity (low, medium, high), noting the corresponding measurement unit (area, length or number) on the standardised PCI field form.
3. Computation of distress densities. Density was calculated according to the measurement unit:

   - Area-type distresses: $\text{Density} = \frac{\text{Damage area}}{\text{SU area}} \times 100.$
   - Length-type distresses: $\text{Density} = \frac{\text{Damage length} \times 0.60\ \text{m}}{\text{SU area}} \times 100.$
   - Count-type distresses (e.g., potholes): $\text{Density} = \frac{\text{Total pothole area}}{\text{SU area}} \times 100.$

These expressions were applied in accordance with the PCI procedure.

4. Deduct values and correction (VD and CDV). For each SU, distresses by type and severity were totalled and the Deduct Value (VD) was obtained from the PCI deduction curves. The maximum admissible number of VDs $m$was then determined and, by iteration, the maximum Corrected Deduct Value (CDV) was obtained, accounting for the number $q$of VD > 2, as specified by the PCI correction procedure.
5. PCI calculation. The PCI for each SU was computed as $\text{PCI} = 100 - \max(\text{CDV})$. The section PCI corresponded to the mean of the SU PCIs (weighted where applicable).
6. Quality control. Consistency checks included: (i) cross-checking forms and photographs for 100% of surveyed SUs; (ii) verification of severities against the ASTM catalogue prior to VD computation; (iii) repeat measurements in 10% of SUs

to verify reproducibility; and (iv) an audit of the computational chain (densities–VD–CDV–PCI) prior to closure. These practices align with PCI guidance in pavement management manuals and technical literature.

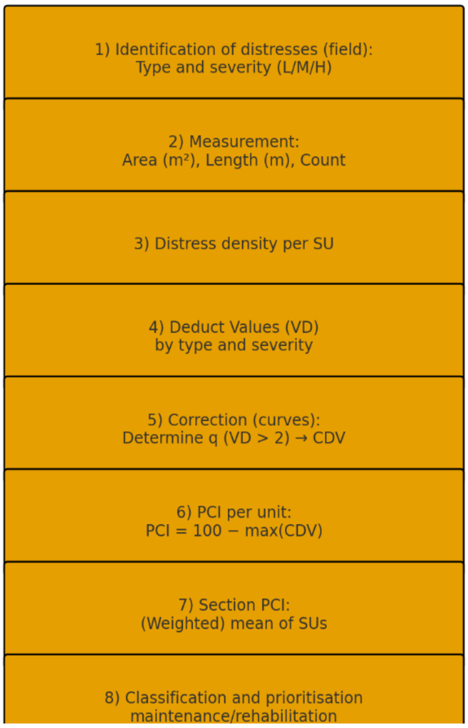
## 2.5. Data processing and analysis

Field records were transcribed to a spreadsheet per SU including SU area, distress type, severity (low/medium/high), measurement unit (area, length or number) and photographic evidence. Distress density was obtained following the PCI method:

- Area-type: $\text{Density} = \frac{\text{Damage area}}{\text{SU area}} \times 100.$
- Length-type: $\text{Density} = \frac{\text{Damage length} \times 0.60\ \text{m}}{\text{SU area}} \times 100.$
- Count-type (e.g., potholes): $\text{Density} = \frac{\text{Total pothole area}}{\text{SU area}} \times 100.$

From the densities, VDs for each distress type/severity were derived using the PCI tables. The maximum admissible number of VDs was estimated as $m_i = 1.00 + \frac{9}{98}(100 - HDV_i)$, where $HDV_i$ is the highest VD in SU $i$. Iteratively, the smallest VD > 2.0 was reduced to 2.0, VD $_{\text{total}}$ and $q$ (number of VD > 2) were recalculated, and the CDV was obtained from the correction curve. The PCI for each SU was then computed as $\text{PCI} = 100 - \max(\text{CDV})$ (see Figure 2).

***Figure 2.*** *Stages of the PCI method (calculation flow).*




*Note.* Sequence applied in the study: identification and measurement of distresses → calculation of densities → derivation of VD → correction (q → CDV) → PCI per unit → section-level PCI → classification and prioritisation of interventions.

The section PCI corresponded to the mean of the unit PCIs (weighted where applicable). For classification, the following ranges were used: 100–85 (Excellent), 85–70 (Very good), 70–55 (Good), 55–40 (Fair), 40–25 (Poor), 25–10 (Very poor) and 10–0 (Failed).

Data handling included automated range and unit checks in the spreadsheet, double verification against field forms and photographs, and an audit of the density → VD → CDV → PCI processing chain, ensuring traceability and reproducibility.

### 2.6 Ethical and operational safety consideration

The inspection was conducted from public and safe areas, without interfering with traffic and without collecting personal data; images were restricted to pavement condition, avoiding the identification of individuals or vehicle plates. As it did not involve intervention with human subjects or destructive sampling, the study was considered minimal risk with negligible environmental impact.

During fieldwork, operational road-safety practices were applied: use of high-visibility PPE, scheduling surveys during lower-flow periods, continuous communication among observers and, where necessary, temporary warning signage in accordance with international guidelines for road safety inspections/audits and temporary traffic control. These measures are consistent with PIARC and FHWA manuals and guidance to safeguard both the survey team and road users during evaluation activities.

Finally, primary records (forms, photographs and spreadsheets) were safeguarded, and the processing workflow was documented to secure traceability and reproducibility of the diagnosis, following good data-quality management practices for PMS.

## 3. Results and discussion

### 3.1 Typology of identified distresses

In the standardised visual survey, the following distresses were documented: (i) alligator (fatigue) cracking; (ii) longitudinal and transverse cracking; (iii) potholes; (iv) weathering and ravelling; and (v) rutting. The identification and measurement of each distress followed ASTM D6433-07, applying the corresponding measurement unit (area, length or count) and the severity classification (low, medium, high) defined in the method catalogue.

***Table 1.*** *Observed surface distresses and quantification metric (ASTM D6433-07).*

| Distress type | Operational description (summary) | Measurement unit | Severity criterion (L/M/H) |
|---|---|---|---|
| Alligator (fatigue) cracking | Interconnected crack mesh in the asphalt surface (wheel paths). | Affected area (m²) | Crack width, opening and extent of the mesh. |
| Longitudinal/transverse cracking | Cracks parallel or perpendicular to the road axis. | Length (m) | Opening, continuity and presence of exudation/ravelling. |
| Potholes | Localised loss of asphalt mixture forming cavities. | Count and area (m²) | Diameter/depth and edges ravelled or well defined. |
| Weathering / ravelling | Binder ageing, micro-cracking and particle loss. | Area (m²) | Percentage of affected surface and presence of loose material. |
| Rutting | Permanent depressions in wheel paths due to repeated loading. | Area (m²) and depth | Measured depth and continuity along the wheel path. |

*Note.* These metrics were used on the field forms to compute densities, derive deduct values (VD) and subsequently the corrected deduct value (CDV) and PCI for each sampling unit.

The observed set of distresses indicated a mixed deterioration pattern with a dominant structural component: alligator cracking and rutting evidenced fatigue and plastic deformation under repeated loading, whereas weathering and ravelling indicated binder ageing and deficits in micro-drainage. Longitudinal and transverse cracks likely facilitated water ingress, accelerating degradation. This pattern was consistent with the Materials and Methods regarding the applied metrics (area/length/count) and the computation scheme from densities to VD, CDV and PCI in each sampling unit.

### 3.2 PCI index per sampling unit

The PCI was calculated for eight sampling units (SUs), each 228 m², distributed between chainages 0+105 and 0+875. Table 2 reports the exact values and their classification according to the adopted scale.

***Table 2.*** *PCI by sampling unit*

| SU | Chainage (start–end) | Area (m²) | PCI | Classification |
|---|---|---|---|---|
| 1 | 0+105–0+140 | 228 | 38 | Poor |
| 2 | 0+210–0+245 | 228 | 8 | Failed |
| 3 | 0+315–0+350 | 228 | 54 | Fair |
| 4 | 0+420–0+455 | 228 | 29 | Poor |
| 5 | 0+525–0+560 | 228 | 0 | Failed |
| 6 | 0+630–0+665 | 228 | 0 | Failed |
| 7 | 0+735–0+770 | 228 | 3 | Failed |
| 8 | 0+840–0+875 | 228 | 64 | Good |

*Note.* Classification used: Excellent (100–85), Very good (85–70), Good (70–55), Fair (55–40), Poor (40–25), Very poor (25–10), Failed (10–0). Each SU had area = 228 m².

The class distribution showed 50.0% of the section as Failed (SU-2, SU-5, SU-6, SU-7), 25.0% Poor (SU-1, SU-4), 12.5% Fair (SU-3) and 12.5% Good (SU-8). The mean PCI = 24.5 confirmed an overall "very poor" condition and a compromised level of service. The median was 18.5 (ordered values: 0, 0, 3, 8, 29, 38, 54, 64), evidencing skew towards degraded states. Variability was high (minimum = 0, maximum = 64), which justified prioritisation by subsections:

- Reconstruction/deep recycling in SU-5, SU-6 and SU-7 (PCI 0–3).
- Major rehabilitation in SU-2 (PCI 8) and in SU-1/SU-4 (PCI 38 and 29).
- Preservation in SU-8 (PCI 64) and targeted major maintenance in SU-3 (PCI 54) to prevent downgrading to "Poor".

### 3.3 Operational and road-safety implications

Based on the exact PCI values for each sampling unit (SU), the operational and road-safety criticality was characterised by subsection. The categorisation drew on the probability of loss of functionality, the presence of surface irregularities (potholes, active cracking and rutting) and the impact on ride comfort, in accordance with the PCI classes. Table 3 summarises the surface criticality level by SU and the distress patterns observed in the field.

***Table 3.*** *Operational and road-safety criticality level by sampling unit*

| SU | PCI | Class | Criticality level | Observations (dominant distresses; descriptive only) |
|---|---|---|---|---|
| 1 | 38 | Poor | Medium–high | Longitudinal/transverse cracking and ravelling; localised unevenness. |
| 2 | 8 | Failed | High | Severe alligator cracking and potholes; loss of surface integrity. |
| 3 | 54 | Fair | Medium | Concentrated damage; moderate cracking and ravelling. |
| 4 | 29 | Poor | Medium–high | Connected cracking and ravelling; active progression. |
| 5 | 0 | Failed | Very high | Functional collapse; multiple concurrent distress modes. |
| 6 | 0 | Failed | Very high | Functional collapse; probable loss of support. |
| 7 | 3 | Failed | Very high | Potholes and severe cracking; high surface unevenness. |
| 8 | 64 | Good | Low | Localised deterioration; dispersed low–medium-severity cracking. |

*Note.* "Criticality level" describes the operational severity derived from the surface condition (PCI class) and the observed distress pattern. It does not include recommended actions.

The concentration of failed subsections (SU-2, SU-5, SU-6, SU-7) in the central sector implied high–very high operational risk due to deep potholes, connected cracking and rutting, which forced abrupt speed reductions and evasive manoeuvres with potential for vehicle–pedestrian conflict and loss of stability for two-wheelers. The Poor subsections (SU-1 and SU-4) showed conditions consistent with structural degradation trending towards failure, while SU-3 (Fair) presented a state susceptible to deterioration if not preserved. SU-8 (Good) exhibited a preservable condition with routine sealing and monitoring needs.

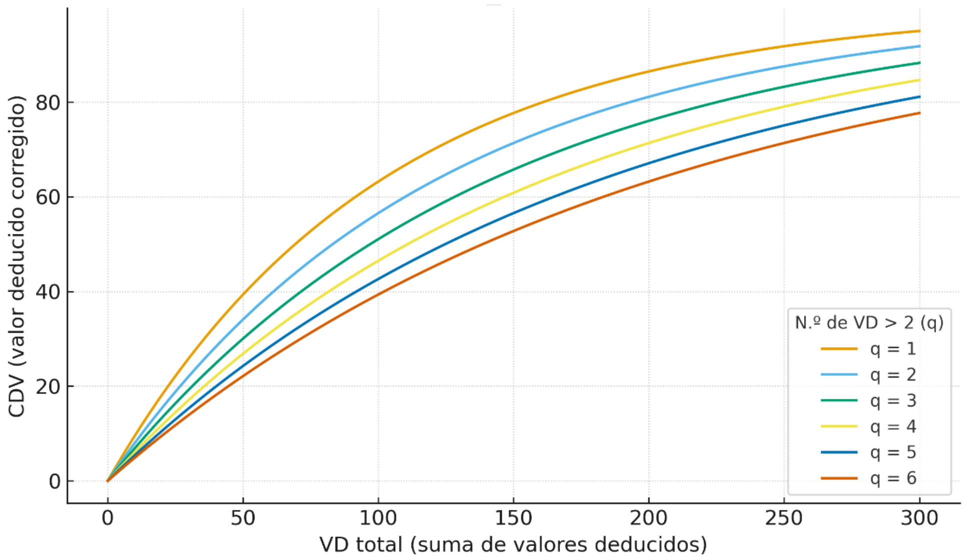
### 3.4. Correction of deduct values (VD → CDV) and computation of PCI per unit

For each SU, deduct values (VD) by distress type/severity were summed and the correction curve was applied as a function of q (number of VD > 2 in the iteration) and VD_total. In each iteration, the smallest VD > 2 was reduced to 2.0, VD_total was recalculated, q was updated and the corresponding CDV was obtained from the correction curve. The SU PCI was determined as:

$$\mathrm{PCI} = 100 - \max\,(\mathrm{CDV})$$

The following tables present the exact iterative values and the resulting PCI for each SU (see Figure 3 for the effect of q on CDV).

***Figure 3.*** *Correction curves (CDV vs. VD_total)*




*Note.* The figure illustrates the effect of q (number of VD > 2) on CDV for a given VD_total: the higher the q, the higher the CDV and, consequently, the lower the resulting PCI.

Subsections with multiple relevant distress modes (high q) tended to exhibit elevated CDV even when no single VD was extreme, which explains low PCI in subsections with diverse deterioration.

***Table 3.*** *Correction of deduct values — SU-04 (Chainage 0+105–0+140; Area 228 m²)*

| Iteration | Individual VDs | VD_total | q | CDV |
|---|---|---|---|---|
| 1 | 33, 26, 21, 17, 16, 12 | 125 | 6 | 62 |
| 2 | 33, 26, 21, 17, 16, 2 | 115 | 5 | 55 |
| 3 | 33, 26, 21, 17, 2, 2 | 101 | 4 | 58 |
| 4 | 33, 26, 21, 2, 2, 2 | 86 | 3 | 55 |
| 5 | 33, 26, 2, 2, 2, 2 | 67 | 2 | 49 |
| 6 | 33, 2, 2, 2, 2, 2 | 43 | 1 | 43 |

*Note.* Max (CDV) = 62 ⇒ PCI = 100 − 62 = 38 (Poor).

SU-04 exhibited a broad set of distresses (initial q = 6) with moderate–high VDs. The PCI = 38 was governed by the combination of several distress modes (high q) rather than a single extreme VD. The pattern suggests accumulated deterioration consistent with the need for structural patching, local milling and thin overlays, with drainage adjustments where appropriate to prevent recurrence.

***Table 4***. *Correction of deduct values — SU-07 (Chainage 0+210–0+245; Area 228 m²)*

| Iteration | Individual VDs | VD_total | q | CDV |
|---|---|---|---|---|
| 1 | 87, 35, 28, 21 | 171 | 4 | 91 |
| 2 | 87, 35, 28, 2 | 152 | 3 | 89 |
| 3 | 87, 35, 2, 2 | 126 | 2 | 84 |
| 4 | 87, 2, 2, 2 | 93 | 1 | 92 |

*Note.* Max (CDV) = 92 ⇒ PCI = 8 (Failed).

SU-07 was dominated by a very high principal VD (87) together with two other relevant distresses (initial q = 4). Although the correction reduced q and VD_total, CDV reached 92 in the last iteration, confirming severe deterioration with functional failure of the subsection. This behaviour is typical of advanced fatigue combined with local disintegration: a single dominant high-severity mode can drive the PCI to failure even when other distresses are moderate.

***Table 5.*** *Correction of deduct values — SU-10 (Chainage 0+315–0+350; Area 228 m²)*

| Iteration | Individual VDs | VD_total | q | CDV |
|---|---|---|---|---|
| 1 | 41, 12, 11 | 64 | 3 | 41 |
| 2 | 41, 12, 2 | 55 | 2 | 40 |
| 3 | 41, 2, 2 | 45 | 1 | 46 |

*Note.* Max (CDV) = 46 ⇒ PCI = 54 (Fair).

SU-10 showed three distress modes with a dominant VD = 41 and q reduced from 3 → 1. The maximum CDV = 46 placed the subsection in Fair condition, indicating concentrated rather than generalised deterioration. The state is consistent with major maintenance needs (crack sealing, local patching and surface reinforcement) to prevent downgrading to Poor.

***Table 6.*** *Correction of deduct values — SU-13 (Chainage 0+420–0+455; Area 228 m²)*

| Iteration | Individual VDs | VD_total | q | CDV |
|---|---|---|---|---|
| 1 | 53, 30, 18 | 101 | 3 | 71 |
| 2 | 53, 30, 2 | 85 | 2 | 61 |
| 3 | 53, 2, 2 | 57 | 1 | 57 |

*Note*. Max (CDV) = 71 ⇒ PCI = 29 (Poor).

SU-13 was governed by two principal VDs (53 and 30) and a third relevant distress (initial q = 3). Although the correction reduced q and VD_total, CDV remained high (71), placing the subsection in Poor condition. The pattern indicates advanced fatigue with localised disintegration unlikely to be resolved by superficial treatments alone.

***Table 7.*** *Correction of deduct values — SU-16 (Chainage 0+525–0+560; Area 228 m²)*

| Iteration | Individual VDs | VD_total | q | CDV |
|---|---|---|---|---|
| 1 | 65, 55, 54, 51, 20, 9 | 254 | 6 | 100 |
| 2 | 65, 55, 54, 51, 20, 2 | 247 | 5 | 100 |
| 3 | 65, 55, 54, 51, 2, 2 | 229 | 4 | 100 |
| 4 | 65, 55, 54, 2, 2, 2 | 180 | 3 | 100 |
| 5 | 65, 55, 2, 2, 2, 2 | 128 | 2 | 86 |
| 6 | 65, 2, 2, 2, 2, 2 | 75 | 1 | 75 |

*Note.* Max (CDV) = 100 ⇒ PCI = 0 (Failed).

SU-16 exhibited very high VDs and multiple distress modes (initial q = 6), with an exceptional VD_total > 250. CDV reached the maximum (100) in several iterations, confirming generalised structural failure.

***Table 8.*** *Correction of deduct values — SU-19 (Chainage 0+630–0+665; Area 228 m²)*

| Iteration | Individual VDs | VD_total | q | CDV |
|---|---|---|---|---|
| 1 | 58, 56, 39, 25, 16, 11, 7.70 | 212.70 | 7 | 100 |
| 2 | 58, 56, 39, 25, 16, 11, 2 | 207 | 6 | 100 |
| 3 | 58, 56, 39, 25, 16, 2, 2 | 198 | 5 | 97 |
| 4 | 58, 56, 39, 25, 2, 2, 2 | 184 | 4 | 100 |
| 5 | 58, 56, 39, 2, 2, 2, 2 | 161 | 3 | 93 |
| 6 | 58, 56, 2, 2, 2, 2, 2 | 124 | 2 | 83 |
| 7 | 58, 2, 2, 2, 2, 2, 2 | 70 | 1 | 70 |

*Note.* Max (CDV) = 100 ⇒ PCI = 0 (Failed).

SU-19 displayed numerous relevant distress modes (initial q = 7) and a very high VD_total from the first iteration (212.70), which drove CDV to its maximum (100). Even as q and VD_total decreased through correction, the subsection remained in functional collapse (PCI = 0). This pattern is consistent with generalised structural fatigue, disintegration and probable loss of support (base/subgrade), exacerbated by water ingress through cracks.

***Table 9.*** *Correction of deduct values — SU-22 (Chainage 0+735–0+770; Area 228 m²)*

| Iteration | Individual VDs | VD_total | q | CDV |
|---|---|---|---|---|
| 1 | 69, 68, 20, 10 | 167 | 4 | 95 |
| 2 | 69, 68, 20, 2 | 159 | 3 | 97 |
| 3 | 69, 68, 2, 2 | 141 | 2 | 91 |
| 4 | 69, 2, 2, 2 | 75 | 1 | 75 |

*Note*. Max (CDV) = 97 ⇒ PCI = 3 (Failed).

SU-22 was dominated by two very high VDs (69 and 68). Even with relatively few distress modes (initial q = 4), CDV reached 97, placing the subsection in Failed condition. The pattern suggests severe cracking and localised disintegration that compromise operational safety (potholes, frayed edges).

***Table 10.*** *Correction of deduct values — SU-25 (Chainage 0+840–0+875; Area 228 m²)*

| Iteration | Individual VDs | VD_total | q | CDV |
|---|---|---|---|---|
| 1 | 32, 12, 11 | 55 | 3 | 35 |
| 2 | 32, 12, 2 | 46 | 2 | 34 |
| 3 | 32, 2, 2 | 36 | 1 | 36 |

*Note.* Max (CDV) = 36 ⇒ PCI = 64 (Good).

SU-25 presented moderate VDs and low q, keeping CDV contained (≤ 36) and the subsection in good condition. Deterioration was limited and preservable, consistent with crack sealing, micro or ultra-thin surfacing and routine maintenance (e.g., gutter cleaning), prioritising prevention to avoid downgrading to Fair/Poor.

### 3.5 Consolidation of PCI by unit and overall section condition

Based on the VD → CDV iterations presented above, the PCI values per sampling unit (SU) and the overall condition of the section were consolidated. For each SU, the exact chainage and a constant area = 228 m² were reported; condition classes followed the adopted scale (Excellent, very good, Good, Fair, Poor, very poor, Failed).

***Table 11.*** *Consolidation of the surface evaluation – Eloy Alfaro Street*

| SU | Chainage (start–end) | Area (m²) | PCI | Classification |
|---|---|---|---|---|
| 1 | 0+105–0+140 | 228 | 38 | Poor |
| 2 | 0+210–0+245 | 228 | 8 | Failed |
| 3 | 0+315–0+350 | 228 | 54 | Fair |
| 4 | 0+420–0+455 | 228 | 29 | Poor |
| 5 | 0+525–0+560 | 228 | 0 | Failed |
| 6 | 0+630–0+665 | 228 | 0 | Failed |
| 7 | 0+735–0+770 | 228 | 3 | Failed |
| 8 | 0+840–0+875 | 228 | 64 | Good |
| **Section means** | | | **24.5** | **Very poor** |

*Note.* Classification according to the thesis scale: Excellent (100–85); Very good (85–70); Good (70–55); Fair (55–40); Poor (40–25); Very poor (25–10); Failed (10–0).

### 3.6 Severities and densities (computational traceability)

Severities (L/M/H) assigned to each distress were converted to VD using the ASTM D6433-07 deduction curves after computing their densities according to the method metric (area, length × 0.60 m, or count). As a documented example, a high-severity edge crack (7A) of 7.00 m in length with SU area = 228 m² yielded a density = 1.84%, which was then converted into its corresponding VD using the deduction curves. This procedure was applied analogously to all distresses and SUs.

## Discussion

The mean PCI = 24.5 (Very poor) observed on Eloy Alfaro Street was consistent with urban scenarios of advanced deterioration reported for Andean and tropical cities. In Quito, a study comparing PCI–IRI on Av. Llira Ñan using ASTM D6433-07 visual surveys and Merlin roughness measurements supported the validity of the approach for urban grids; results showed segments with deficient condition and failed sections, comparable to the central portion of Jipijapa's corridor (Freire, 2024). In Guayaquil, the assessment of Calle 47 S-E using PCI reported marked heterogeneity, with samples in the "very poor/poor" ranges and others "good/very good", a pattern compatible with heavy loading and irregular maintenance, also observed on Eloy Alfaro (Figueroa & Lema, 2025).

In contrast, the Loja–Saraguro corridor (km 27+000–37+000) obtained PCI = 81.82 (Very good) and IRI = 3.83 m/km, indicating that contexts with more favourable structural and operational conditions sustain superior levels of service (Tacuri & Ortíz, 2022). Likewise, surveys in the Bogotá region confirmed institutional PCI use by the IDU and distributions with substantial presence of failed/very poor/poor classes in urban grids, supporting methodological comparability and the utility of PCI as a condition descriptor in local networks (Restrepo & Cruz, 2017). From a management and safety perspective, the findings reinforce PCI (ASTM D6433) as an input for prioritising interventions, although greater effectiveness is achieved when integrated with functional and risk indicators (e.g., IRI, friction/macrotexture). ASTM practice states that PCI objectifies surface and operational condition without directly measuring friction or roughness; therefore, it should be complemented within a PMS, and technical guidance (UCPRC/CCPIC) recommends not relying on PCI alone to select conservation strategies (ASTM International, 2020). Regarding underlying causes, the literature recognises the influence of materials, drainage and maintenance on performance: PCI-based studies have explored correlations between drainage condition and pavement state (sometimes weak when few elements are assessed), while broader analyses show combined effects of structure, climate and demand on degradation (Diniz & Melo, 2023). In terms of road safety, Federal Highway Administration (2023) documents and recent syntheses confirm statistically robust associations between friction/macrotexture and crash rates, and indicate that rutting and high roughness increase risk, particularly in wet conditions; consequently, the presence of potholes, active cracking and rutting observed on Eloy Alfaro is consistent with elevated operational risk in an urban setting.

## 4. Conclusions

1. Based on the standardised PCI visual inspection (ASTM D6433-07) and the VD → CDV treatment, Eloy Alfaro Street (Febres Cordero–Villamil section) exhibited an overall “very poor” condition with a mean PCI = 24.5. Spatial response was heterogeneous: four units were failed (PCI 0–8: SU-2, SU-5, SU-6, SU-7), two were poor (SU-1 and SU-4), one was fair (SU-3) and one was good (SU-8 = 64). This pattern confirmed a significant loss of level of service and advanced deterioration in the central portion of the section.

2. The predominant distresses were alligator cracking, longitudinal and transverse cracking, potholes, weathering/ravelling and rutting. The combination of multiple distress modes (high q) explained the elevated CDV and, consequently, low PCI in several units, consistent with structural fatigue under repeated loading and suboptimal drainage conditions. SU-25 (PCI 64) evidenced preservable subsections, whereas SU-16/SU-19/SU-22 (PCI 0–3) reflected functional collapse of the surfacing.

3. From an operational standpoint, the highly degraded surface condition implied a greater likelihood of irregularities (potholes, rutting, active cracking), affecting ride comfort, traffic flow and urban road safety, especially in wet conditions. The findings supported the use of PCI as an input for prioritisation within a pavement management system, distinguishing reconstruction/rehabilitation for failed

or poor subsections and preservation for segments in better condition.

4. Limitations and outlook: (i) the scope was visual (PCI) with n = 8 sampling units, without instrumental measurements of roughness (IRI), friction/macrotexture or structural capacity (e.g., FWD); (ii) subsurface drainage was not assessed with indirect methods (e.g., GPR). Future work should increase the sample size, integrate functional and safety indicators (PCI–IRI–friction), and verify structural capacity to refine the intervention strategy and the maintenance programme.

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