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Identification of Influencing Factors and Development of a Quality Index for Asphalt Pavement Construction

by

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A THESIS

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DEPARTMENT OF CIVIL ENGINEERING
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I hereby declare that the thesis entitled **"Identification of Influencing Factors and Development of a Quality Index for Asphalt Pavement Construction"** submitted to the Department of Civil Engineering in partial fulfillment of the requirements for the degree of Master of Science in Construction Management, is a record of an original work done under the guidance of Asst. Prof. Mahendra Raj Dhital and Assoc. Prof. Nagendra Bahadur Amatya, Institute of Engineering, Pulchowk Campus. This thesis contains only work completed by me except for the consulted material which has been duly referenced and acknowledged.

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CERTIFICATE OF THESIS APPROVAL

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ABSTRACT

Pavement construction quality is a key factor influencing road performance, durability, service life, and maintenance demand. This study focused on Hot Mix Asphalt (HMA) flexible pavements in highways, feeder roads, and urban roads in Nepal. The research was carried out from a construction-practice perspective to identify, prioritize, and develop a quality assessment index for asphalt pavement construction.

The major factors and related sub-factors influencing pavement construction quality were obtained from previous studies and refined through expert consultation. The identified factors were validated, and their relative weightages were determined using questionnaire survey responses collected from 77 construction professionals. The questionnaire showed strong reliability, as reflected by a Cronbach's Alpha value of 0.944, which indicates excellent consistency among the survey items. Mean score analysis and normalized weight calculation were used to rank the construction-practice factors and develop the Pavement Construction Quality Index (PCQI) model.

The study identified eight main construction-practice factors affecting pavement construction quality: Subgrade Preparation, Subbase and Base Course Construction, Surface Preparation Before Paving, Prime/Tack Coat Application, Paving Practices, Compaction Practices, Execution of Joints, and Transportation of Asphalt Mixtures. Among these, Subgrade Preparation ranked first with a normalized weight of 0.1331, followed by Subbase and Base Course Construction with a weight of 0.1324. Paving Practices and Compaction Practices also ranked highly, showing the importance of proper asphalt placement, thickness control, temperature control, and field density achievement.

Based on the assigned weights, a PCQI equation was developed to quantify pavement construction quality in percentage terms. The usefulness of the proposed PCQI was assessed by applying it to two real pavement construction case study projects. The case study result indicated moderate quality performance, demonstrating that the PCQI model can identify both compliance levels and weak construction areas in pavement projects.

The developed PCQI provides a structured framework for measuring asphalt pavement construction quality from a construction-practice perspective. It can serve as a practical guideline, checklist, and decision-support tool for engineers, contractors, consultants, and client organizations to evaluate process quality, compare projects, identify weak construction activities, and support quality improvement in future pavement works.

Keywords: Pavement Construction Quality Index, PCQI, Construction Practices, Flexible Pavement, Asphalt Pavement, Quality Assessment

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List of Abbreviations

AASHTO — American Association of State Highway and Transportation Officials

AHP — Analytic Hierarchy Process

DOR — Department of Roads

HMA — Hot Mix Asphalt

ISO — International Organization for Standardization

PCQI — Pavement Construction Quality Index

QC — Quality Control

CHAPTER ONE: INTRODUCTION

1.1 Background

Quality refers to the extent to which inherent characteristics meet specified requirements (ISO, 2015). The concept was brought closer to the ground by defining quality as fitness for use (Juran & Godfrey, 1999). In construction terms this means a finished structure must meet design standards for safety and durability and function. This has been extended further by arguing that quality in construction is not just about the final product (Arditi & Gunaydin, 1997). It is also about the process.

The durability and functional life of pavement surfaces have become increasingly critical as nations expand their road networks. It has been noted that global road networks are expanding rapidly and that asphalt pavement remains the dominant surfacing material (Liu et al., 2020). Flexible pavements made from hot-mix asphalt (HMA) form the vast majority of road surfaces worldwide. In Nepal the use of flexible pavements has been increasing as road construction accelerates across the hills and terai. It has been emphasized that pavements are among the most valuable public infrastructure assets a nation can hold (Shahin, 2005). A poorly built road is not just inconvenient. It is an economic drain. Premature cracks and potholes force expensive maintenance. Rutting shortens service life. Water infiltration weakens the foundation layers below.

The service life of a flexible pavement depends on more than design equations and material specifications. It depends on what happens in the field. The performance of hot-mix asphalt is influenced by each stage, from production to laying at the site (Roberts et al., 1991). This finding was confirmed more recently by showing that compaction quality measured through intelligent compaction meter values directly predicts pavement performance (Chang et al., 2019). It has been documented that in developing countries, weak or insufficient quality-assessment systems can lead to poor construction outcomes (Lu et al., 2018).

Nepal faces a version of this problem that is particularly acute. The country has invested heavily in road construction over the past two decades. An assessment of quality management practices in Nepalese construction projects found that the performance level of construction firms is poor regarding quality delivery (Mishra, 2020). A similar conclusion was reached and argued that very few studies had been conducted on construction quality in Nepal (Kusi et al., 2018).

1.2 Problem Statement

More than 70 percent of the development budget in Nepal has been channeled into the construction sector. However, research has found that the performance level of Nepalese construction firms is very poor in delivering quality (Kusi et al., 2018). Yet, the magnitude of this investment has not translated proportionally into durable, high-quality infrastructure outcomes. This observation was reinforced by Mishra (2020), whose study documented that quality management practices in Nepalese construction remain weak in implementation. The consequences are evident: buildings crack prematurely; roads fail within a few years; and bridges require significant repairs before reaching their design life. This pattern is not unique to Nepal. A systematic review and meta-analysis by Gurmu & Mahmood (2024) demonstrated that construction quality problems persist across developing countries due to technical and managerial shortcomings. However, the scale of Nepal's investment makes this quality problem particularly acute in terms of economic loss and opportunity cost.

The specific domain of pavement construction in Nepal suffers from an absence of structured quality assessment tools. Global studies on asphalt pavement quality have produced sophisticated methods for evaluation. A quality index for pavement construction and rehabilitation in Pakistan was developed (Imran et al., 2025). In India, a building quality index based on the Analytic Hierarchy Process (AHP) has been introduced for construction projects (Jogdand & Deshmukh, 2017). A construction quality index specifically for public reinforced-concrete buildings in Kathmandu Valley has also been developed (Baral, 2025). These contributions show that index-based quality assessment is both feasible and useful; however, no equivalent index exists for asphalt pavement construction in Nepal. Without a structured tool for assessing pavement quality the sector relies on ad hoc inspection and subjective judgment. A road project may pass a visual inspection at opening and still contain hidden defects in its subgrade or base course. Consequently, the cost of repair often exceeds the cost of correct construction.

This study addresses this gap by pursuing three linked objectives. First, it identifies the key construction-practice-related factors and subfactors that affect asphalt pavement construction quality. Second, it assigns weights to those factors through expert survey data and ranks them by significance. Third, it develops a Pavement Construction Quality Index (PCQI) and applies it to case studies after project-specific scoring. The resulting PCQI model enables road agencies and contractors to diagnose specific construction practice deficiencies and benchmark pavement quality across projects.

1.3 Research Questions

The study addresses the following research questions.

RQ1: What are the relative weights and rankings of construction-practice-related factors?
RQ2: How can a Pavement Construction Quality Index (PCQI) be developed?
RQ3: How can the Pavement Construction Quality Index (PCQI) be applied to quantify asphalt pavement construction quality in selected case study projects?

1.4 Research Objectives

The primary objective of this study is to identify influencing factors and develop a quality index for asphalt pavement construction whereas, the secondary objectives are as follows:

- To determine the relative weights and rankings of the construction-practice-related factors.
- To develop a Pavement Construction Quality Index (PCQI) model.
- To evaluate the applicability of the developed index through case study projects.

1.5 Significance of Research

This study has important practical relevance to the road sector in Nepal. Although substantial resources have been invested in road infrastructure, the outcomes have not consistently reflected the level of investment. It was shown that Nepalese construction firms lack the systems to deliver quality (Kusi et al., 2018). It was confirmed that quality management practices remain underdeveloped (Mishra, 2020). This research addresses this gap by determining the key factors affecting pavement construction quality, ranking them, assigning appropriate weights, and developing a formula-based Pavement Construction Quality Index (PCQI). The resulting tool can be applied to real projects to calculate a quality score on a scale of 0 to 100. This score can help road agencies prioritize inspection efforts and support contractors in planning and improving field operations. It has been argued that quality performance improves when construction practices are integrated early (Song et al., 2006). The PCQI provides a structure for that integration.

The study focuses on public flexible asphalt pavement construction on highways, feeder roads, and urban roads. The findings will serve as a guideline, checklist and benchmark for improving pavement construction quality in future projects. Clients and engineers can use the index to determine the quality of completed works and identify areas that need improvement. The index also has implications for contractor selection. The quality level of previous projects can serve as an evaluative criterion during bid assessment. This approach aligns with the growing emphasis on performance-based contracting in infrastructure development. It has long been advocated for systematic quality assurance in pavement construction (Asphalt Institute, 2009). This study brings that advocacy into the specific context of Nepalese road building.

1.6 Scope and Limitations

The proposed model is mainly intended for Hot Mix Asphalt (HMA) flexible pavement works on highways, feeder roads, and urban roads. The research is limited to the construction-practice perspective and covers site activities that directly affect pavement construction quality, including preparation of the subgrade layer, construction of subbase and base layers, surface preparation before paving, prime and tack coat application, paving, compaction, joint execution, and asphalt mixture transportation. Other pavement types, such as DBST, premix carpet, semi-grouted pavement, and rigid pavement, are not considered within the present study.

The study focuses on construction practices and does not consider material quality or material properties such as aggregate gradation, bitumen grade, mix design parameters, or Marshall stability values. Managerial and organizational factors, including project management, contractual arrangements, and workforce capacity, are also not included in the framework. These factors were intentionally excluded to keep the index focused on field construction practices.

Finally, this study assesses pavement quality at the construction stage only. It does not track long-term pavement performance, distress development, or service life following project completion. The relationship between PCQI scores and actual in-service pavement performance has not been established in this study and remains an area for future research.

CHAPTER TWO: LITERATURE REVIEW

This chapter presents a review of previous studies related to pavement construction quality. It includes published research, government guidelines, quality standards, and index development methods. The review helps identify the major factors affecting construction quality and highlights the research gap addressed in this study.

2.1 Introduction

The quality of pavement construction determines how long a road will last and how safely it will carry traffic. A flexible pavement is a layered system. Each layer sits on the one below it. The subgrade supports the subbase. The subbase supports the base course. The base course supports the asphalt surface. The structural adequacy of flexible pavement depends on the interaction between layers, where the performance of every pavement layer is influenced by the support provided by the layer below it (Huang, 2004). One can think of it as a stack of plates. If the bottom plate is cracked the plates above will eventually shift and break regardless of how well they were made. This argument has been extended to show that material properties and construction practices must work in concert to produce a durable pavement (Mallick & El-Korchi, 2018). A road with excellent aggregate gradation but poor compaction will not perform. A road with good compaction but a weak subgrade will not last.

In developing countries, the problem is compounded by resource constraints and institutional weaknesses. It has been documented that the absence of well-developed quality assessment methodologies in developing nations leads to premature pavement deterioration (Lu et al., 2018). Traditional approaches have focused narrowly on material properties and performance measures like roughness or deflection. But there is a growing recognition in the literature that quality management including construction practices and managerial decisions plays an equally critical role. It was first argued that total quality management should be embedded in the construction process (Arditi & Gunaydin, 1997). Their work shifted the conversation from inspecting the final product to managing the process that creates it. This shift matters for pavement construction because a pavement is built in sequential layers. Each layer represents a decision point. Once the asphalt is placed the lower layers are sealed from view. A defect in the subgrade becomes invisible and irreversible. The literature therefore calls for quality systems that monitor each stage rather than checking only the surface.

The development of a Pavement Construction Quality Index requires proper identification of the construction factors that affect pavement quality. In this thesis, emphasis is given to construction-practice-related factors, including subgrade preparation, subbase and base construction, surface preparation, prime and tack coat application, paving, compaction, joint construction, and transportation of asphalt mixtures. Many of these process-related factors were organized in an early and influential synthesis (Roberts et al., 1991). More recent studies (e.g., Imran et al., 2025; Baral, 2025) have built on that foundation to create quantitative index models. The present study follows that line of work but narrows the framework to construction practices so that the quality index reflects field execution directly.

2.2 Specifications of Pavement Construction Works

Specifications are the written rules that govern how a road should be built. They define the materials and workmanship and test procedures and benchmark criteria for each construction element. In Nepal, the Standard Specifications for Road and Bridge Works serves as the main reference document for pavement construction works (Department of Roads, 2021). This document specifies compaction requirements and layer thicknesses and material properties for subgrade and subbase and base course and surface course. However, the effectiveness of a specification document depends on the level of enforcement in practice. For example, a specified requirement of 97 percent compaction density has little practical value unless it is properly achieved in the field and verified through inspection. It has been noted decades ago that pavement performance depends on compliance with design and construction standards in the field (Yoder & Witczak, 1975). That observation remains relevant.

The Nepalese specification framework draws from international practice but is adapted to local conditions. The Standard Specifications for Road and Bridge Works cover everything from earthwork to drainage to bituminous surfacing. For asphalt pavement construction the specifications address material testing procedures and mix design requirements and compaction criteria and surface tolerance limits. The Asphalt Handbook provides widely referenced guidance on asphalt material handling and placement (Asphalt Institute, 2007). The Hot-Mix Asphalt Paving Handbook as a fieldoriented reference for construction practitioners was compiled (Briere, 2000). These global resources inform the Nepalese specification. But challenges persist. Nonconforming materials enter the supply chain. Workmanship varies across sites. Enforcement is inconsistent. A well-structured specification framework is necessary but not sufficient for quality. What is also needed is a measurement tool that can quantify how well a project has adhered to these standards. The PCQI proposed in this study is designed to serve that function.

2.3 Measurement of Quality

Construction quality measurement converts field observations and expert opinions into quantifiable scores. Quality performance refers to the extent to which a construction project satisfies specified requirements and expected performance levels (Song et al., 2006). That definition covers material quality and workmanship and structural safety and durability and compliance with design requirements. Since pavement construction consists of a number of construction stages, to reduce such complexity into a single value, we rely on a quality index. A quality index assigns weights to identified factors and then scores each factor based on field data or expert ratings. The weighted scores are summed to produce an aggregate score. Multi-criteria decision analysis can be applied to construction quality assessment (Umair et al., 2015). Their work showed that structured weighting methods produce more consistent and defensible quality evaluations than unstructured professional judgment alone.

Several construction quality indices have been reported in the literature. For instance, Jogdand and Deshmukh (2017) introduced a Building Construction Quality Index for projects in India based on the Analytic Hierarchy Process (AHP). Their model assigned weights to factors such as structural integrity, material quality, and workmanship. A similar approach was later adapted in Nepal by developing a Building Construction Quality Index tailored for public reinforced-concrete buildings in Kathmandu Valley (Baral, 2025). His methodology used AHP to derive weights and then aggregated field ratings into a numerical quality score. The present study extends that logic from buildings to pavements. A quality index was developed specifically for pavement construction and rehabilitation projects in Pakistan (Imran et al., 2025). They identified main factors and subfactors from a construction-practice perspective. Using expert survey data, they assigned a weight to each factor based on its mean importance rating.

The index was then calculated by multiplying each factor weight by the project performance score and summing across all factors. The result is expressed as a percentage. Quality tiers were defined as low for scores at or below 60 percent and fair for 61 to 70 percent and moderate for 71 to 80 percent and good for 81 to 90 percent and excellent for above 90 percent. The present study follows a similar weighted-scoring methodology but is tailored to the Nepalese context and the specific conditions of HMA pavement construction.

2.3.1 The Shift from Material-Focused Quality Control to Construction-Practice-Based Quality Assessment

Traditional pavement quality control focused heavily on material properties and final test results. That approach remains important, but it does not fully explain why a pavement with acceptable material properties may still fail early in service. Modern pavement quality assessment gives more attention to construction practices because process quality governs whether the designed material properties are actually achieved in the field. A well-designed mix can still produce a weak pavement if the surface is wet before paving, if the tack coat is applied poorly, if the paver does not maintain thickness, or if the rollers miss the proper compaction window. It has been shown that a pavement quality index becomes more useful when it captures the field practices that shape final performance (Imran et al., 2025). The present thesis adopts this construction-practice-based direction. It therefore removes management practice factors from the analytical framework and concentrates on the construction operations that directly influence pavement quality.

2.4 Factors Affecting Quality in Pavement Construction

The quality of an asphalt pavement is shaped by a sequence of construction practices carried out from the foundation stage to final surfacing. For this thesis, the focus is limited to construction-practice-related factors that directly influence pavement quality during field execution. These include preparation of the subgrade layer, construction of the subbase and base layers, surface preparation before paving, prime or tack coat application, paving practices, compaction practices, joint execution, and transportation of asphalt mixtures. Previous studies have shown that pavement performance is highly sensitive to how these construction operations are carried out in practice (Roberts et al., 1991; Wang et al., 2018; Imran et al., 2025).

Construction practices form the core factor group in this study because each stage influences the finished quality of the pavement. In particular, compaction affects density, surface preparation influences bonding, paving controls geometry and layer thickness, and transportation affects temperature and mixture uniformity. These practices therefore provide a direct basis for construction-focused quality assessment.

Table 2.1: Factors Affecting Quality in Pavement Construction

Main Factor	Key Sub-factors
Subgrade Preparation	Achievement of required compaction and density, moisture control during compaction, removal of topsoil and unsuitable materials, grading to required levels and cross slope, treatment of weak or expansive soils
Subbase and Base Course Construction	Specified layer thickness, required compaction and density, proper grading and particle size distribution, uniform mixing, moisture control, surface evenness, design cross slope and grade
Surface Preparation Before Paving	Removal of dust and debris, proper use of cleaning equipment, ensuring the surface is completely dry, use of hand brooms for remaining material
Prime/Tack Coat Application	Use of specification-compliant material, proper surface preparation, uniform distribution, control of binder rate and temperature, adequate curing time, proper nozzle condition
Paving Practices	Maintaining design cross slope, uniform layer thickness, minimizing heat loss before compaction, proper paver settings, spreading to required line and level, screed setting, visual inspection, continuous paving control
Compaction Practices	Achievement of field density, uniform roller speed, intermediate rolling, correct compaction sequence, temperature control during rolling, adequate contact pressure, overlap of roller passes, final rolling

Execution of Joints	Matching thickness and density at joints, absence of irregularities, joint cleanliness, staggering transverse joints, painting vertical faces, cutting joint edges where required
Transportation of Asphalt Mixtures	Avoiding segregation during transportation, maintaining required HMA temperature, continuous and uniform supply, inspection of delivered mix, clean truck bed, use of release agent

(References: Imran et al., 2025; Department of Roads, 2021; Mishra, 2020)

2.5 Likert Scale Method

The Likert scale is widely used in survey-based research to quantify subjective opinions. Respondents select answers from a graded set of options, typically using a five-point response scale ranging from Strongly Disagree to Strongly Agree or from Very Low to Very High levels of importance. The method was originally introduced by Rensis Likert in 1932 and has since become a standard tool in social and applied sciences. It enables respondents to express varying degrees of opinion rather than simple binary choices. Cronbach's alpha is commonly used to assess the internal consistency of such survey instruments (Cronbach, 1951). That measure is now standard practice in construction quality studies. The data from Likert responses can be aggregated and averaged and converted into weights. A Likert-scale survey was used by Imran et al. (2025) to rate construction and managerial factors in their pavement quality study. In this study, a five-point scale ranging from not relevant to extremely important was adopted to evaluate construction-related factors.

CHAPTER THREE: RESEARCH METHODOLOGY

This chapter outlines the research methodology adopted to accomplish the study objectives. It includes the research design, study population, sample size determination, data collection procedures, data analysis methods, and model development. The study started with an extensive review of existing literature on pavement construction quality. This review helped identify key factors, relevant methodologies, and research gaps that guided the present study.

3.1 Research Methodology

The research was carried out through a systematic sequence of steps

- The first step involves a thorough review of existing literature to identify research gaps and formulate the research questions, objectives, and methods.
- The second step involves a comprehensive review of the literature on quality in pavement construction. Factors and sub-factors from the construction-practice perspective are identified and validated through expert opinion.
- The third step involves questionnaire design. Necessary modifications and contextualization are made to fit the Nepalese construction industry. The questionnaire is reviewed with experts to prevent insufficiency and bias.
- The fourth step includes a questionnaire-based data collection. The survey targets construction personnel involved in pavement construction and quality control.
- The fifth step assigns weights to the identified factors and sub-factors using the weighted average method. Based on the assigned weights, the factors and sub-factors are ranked according to significance. Microsoft Excel is used for data analysis and visualization
- The sixth step includes the development of a quality index equation. The equation quantifies the quality achieved as a percentage-based rating for pavement construction projects.
- The seventh step involves validation. The developed quality index is applied to case studies for practical verification.
- The eighth and final step involves drawing conclusions and recommendations based on the results obtained from earlier stages.

This study employed a mixed-method approach, integrating both quantitative and qualitative techniques. Quantitative data were collected through a Likert-scale-based questionnaire survey, where respondents rated the importance of each construction-practice factor and sub-factor on a five-point scale ranging from irrelevant to extremely important. Qualitative insights were obtained through expert consultation conducted during the factor identification stage and through field observation carried out during the case study evaluation. The overall process followed a sequential approach, including factor identification, questionnaire development, data collection, statistical analysis, weightage determination, PCQI model development, and case study application.

3.2 Research Design

The research design is presented as a flow chart only. The flow chart shows the sequence of literature review, identification of construction-practice factors, questionnaire design, expert survey, weighting and ranking, development of the quality index framework, case study scoring, and final calculation of the Pavement Construction Quality Index. This flow-chart-based presentation keeps the research design clear and directly aligned with the study procedure.

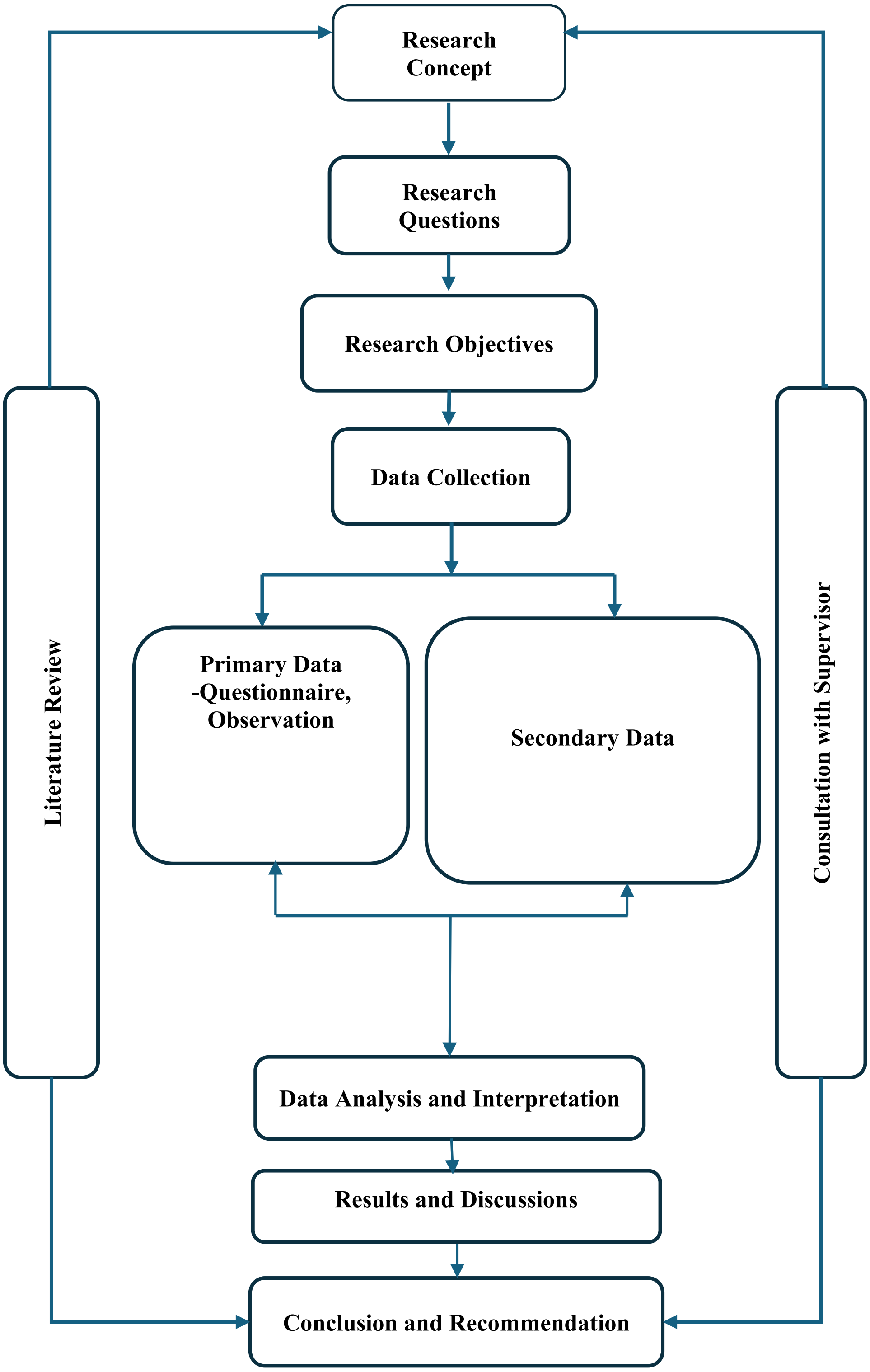


Figure 3.1: Flowchart of Research Design

3.3 Study Area

The study is restricted to highways and feeder roads and urban roads consisting of flexible pavement constructed with hot-mix asphalt.

3.4 Study Population, Sample Selection, and Sample Size

The study population consists of technical personnel including engineers and consultants and project engineers and divisional chiefs and laboratory officers and laboratory technicians from both private and government agencies involved in pavement construction. These individuals work on highways and feeder roads and urban roads under the Department of Roads. A random sampling method was selected for this study to reduce bias. An infinite population was assumed for calculating the sample size.

3.4.1 Sample Size

The sample size was calculated using Cochran's formula (Cochran, 1977)

$n = z^2pq / e^2$

Where n is the required sample size, z is the z-value at the selected confidence level, p is the estimated proportion of the population possessing the attribute, q = 1 - p, and e is the allowable margin of error.

For this study, the confidence level was 90 percent. Therefore $z = 1.645$. The proportion was taken as $p = 0.50$, so $q = 0.50$. The allowable error was taken as $e = 0.10$.

Substituting these values into Cochran's formula gives:

$n = (1.645)^2 \times (0.50) \times (0.50) / (0.10)^2$

$n = 2.706025 \times 0.25 / 0.01$

$n = 0.67650625 / 0.01$

$n = 67.650625$

Therefore, the minimum required sample size was 68 respondents.

3.5 Methods of Data Collection

3.5.1 Primary Data Collection

Primary data were obtained directly from respondents using a survey specifically prepared for this research. Both digital and hard-copy questionnaires, along with site-based interviews, were used for data collection. In the first phase, questionnaire responses were collected to determine the weights of the construction-practice factors and subfactors. In the second phase, case study scores were assigned to the selected pavement projects using the Excel scoring file. The Pavement Construction Quality Index was calculated only after these case study scores were entered into the developed framework.

The data collection process was carried out in **two phases**:

Table 1.1: Phase of Primary Data Collection

Phase	Focus	Activity
Phase 1	Identification and development of PCQI model	Identification of construction-practice factors, questionnaire survey using five-point Likert scale, weightage determination, and PCQI model development
Phase 2	Application of PCQI model in case studies	Field survey, interviews, and PCQI calculation for selected construction sites

3.5.2 Secondary Data Collection

Secondary data collection draws from the existing body of knowledge. This includes published journals and books and government reports and DOR specifications and Nepal Road Standards. Quality factors were first identified from these sources. They were then verified for relevance to the Nepalese construction sector through professional judgment. Standard Specifications for Road and Bridge Works served as a primary secondary source (Department of Roads, 2021).

3.6 Data Analysis

The Pavement Construction Quality Index was developed using the weightage of the relevant quality factors and sub-factors. These weightages were derived from a Likert scale questionnaire survey, where respondents rated the importance of each factor based on their experience and understanding. The collected responses were used to calculate mean scores and normalized weights, which formed the basis of the index. In this way, the method provided a practical and systematic way to identify the most influential factors affecting pavement construction quality.

The survey data were first entered into Microsoft Excel for processing. They were then compiled, analyzed, summarized, tabulated, and presented using different Excel tools. The research matrix presented below provides a clear understanding of the study framework, including the methods of data collection and analysis.

The data analysis is structured according to the three research objectives:

Table 3.2: Data Analysis Method

Research Objective	Data Analysis Method
RO1: Determination of relative weights and rankings of construction-practice factors affecting asphalt pavement construction quality.	Mean score analysis, ranking of factors and sub-factors
RO2: Develop Pavement Construction Quality Index (PCQI) model	Weight calculation, PCQI formula development
RO3: Apply PCQI model in case studies	PCQI computation, quality level interpretation, and comparative analysis

3.6.1 Descriptive Statistics

Descriptive statistics are used to visualize and summarize the obtained data through charts and graphs and tables. In this research demographic data is analysed using descriptive statistics.

3.6.2 Mean Score and Normalized Weight Analysis

Mean score and normalized weight analysis were used to determine the relative importance of the identified construction-practice factors and sub-factors. Respondents rated each factor using a five-point Likert scale, where 1 represented “not relevant” and 5 represented “extremely important.” The mean score was calculated for each factor based on the responses received. The normalized weight was then obtained by dividing the mean score of each factor by the total mean score of all factors within the same group. These normalized weights were used to rank the factors and to develop the Pavement Construction Quality Index (PCQI) model.

The mean score was calculated using the following equation:

$$\text{Mean Score} = \Sigma R / N$$

Where,

ΣR = sum of ratings given by respondents

N = number of respondents

The normalized weight was calculated using the following equation:

$$\text{Normalized Weight} = \text{Mean Score of Factor} / \text{Total Mean Score of All Factors in the Same Group}$$

3.6.3 Formation of Pavement Construction Quality Index

Using the normalized weights, the weights assigned to each main factor and sub-factor were used to develop the quality index formula. The formula yields a quantified level of quality achieved in pavement construction, expressed as a percentage. The index is calculated by multiplying each factor weight by the project performance score for that factor and then summing these products across all factors. The result is a single number that represents the construction quality of a pavement project. A quality index was developed specifically for pavement construction and rehabilitation projects in Pakistan Imran et al. (2025). The researchers identified main factors and subfactors from a construction-practice perspective. Using expert survey data, they assigned a weight to each factor based on its mean importance rating. The index was then calculated by multiplying each factor weight by the project performance score and summing across all factors. The result is expressed as a percentage.

3.7 Reliability Statistics

Reliability analysis ensures the internal consistency of the survey data. Cronbach alpha is the most widely used measure for this purpose. It has been explained that Cronbach alpha evaluates how closely related a set of questionnaire items are as a group (Tavakol & Dennick, 2011). Cronbach (1951) first introduced the coefficient as a generalization of the Kuder-Richardson formula.

Cronbach’s Alpha (α) is calculated using the formula:

$cronbach's$ Alpha (α) = $[k / (k - 1)] * [1 - (\Sigma s_i^2 / s_t^2)]$

where,

k: the number of items;

Σs_i^2 = sum of item variances;

s_t^2 = variance of total score

The value of Cronbach's Alpha ranges between 0 and 1, where a higher value indicates greater internal consistency and reliability. The following thresholds are used to interpret the reliability of the scale:

Table 3.3: Cronbach's Alpha Test Result

VARIABLES	**DESCRIPTION**	**VALUE**	**INTERNAL CONSISTENCY**
K	Number of items	58	
Σs_i^2	Sum of item variances	32.855	
s_t^2	Variance of total score	457.157	
A	Cronbach's alpha	0.944	Excellent

3.8 Research Matrix

Research matrix of the study is presented in table below.

Table 3.4: Research Matrix

Objectives	Data Required	Data Sources	Tools	Expected Outcomes
Determine weightage of factors	Importance ratings (1-5)	Survey responses from engineers	Weighted average method, Cronbach alpha	Weightage and priority of factors
Develop quality index	Weightage and priority of factors/subfactors	Survey responses from engineers	Weights and scores method	Mathematical model for quality measurement
Apply quality index	Project-specific scores for each factor	Field experts involved in the project	Quality Index Formula	Numerical PCQI value

CHAPTER FOUR: RESULTS AND DISCUSSION

This chapter presents the analysis and interpretation of the data collected based on the methodology described in Chapter Three. The collected data were processed using Microsoft Excel and SPSS to perform statistical analysis. The results are presented according to the three research objectives of the study.

- **Section 4.1 presents the respondent profile.**
- **Section 4.2 presents the results for Objective 1:** determination of relative weights and rankings of construction-practice factors affecting asphalt pavement construction quality.
- **Section 4.3 presents the results for Objective 2:** development of the Pavement Construction Quality Index (PCQI) model
- **Section 4.4 presents the results for Objective 3:** application of the PCQI model in case study projects

The results are presented using tables, bar charts, and other relevant graphical representations for clear and effective presentation.

4.1 Respondent Profile

A total of 77 valid responses were collected from professionals involved in pavement construction and quality control. Among them, 41 responses were collected through online forms and 36 responses were collected through physical forms. The respondents included project managers, engineers, sub-engineers, QC/laboratory technicians, consultants, contractors, and other related professionals.

The detailed demographic profile of the respondents, including gender, sector, job title, and work experience, is presented in **Appendix C**.

4.2 Determination of Relative Weights and Ranking of Construction-Practice Factors

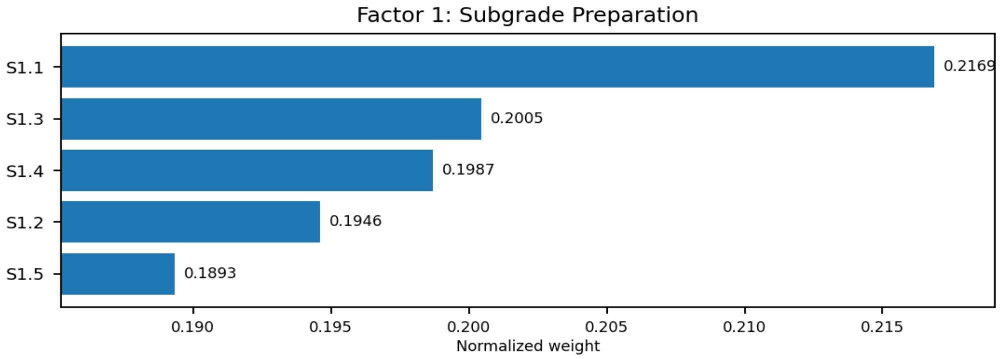
This section presents the ranking of the eight construction-practice factors retained in the revised thesis framework. Each factor is analyzed through its sub-factors using the mean score obtained from the Likert-scale questionnaire, the normalized within-factor weight, the rank. This approach shifts the analysis away from general opinions and converts professional judgment into a structured scoring system. Asphalt pavement construction quality depends on several field activities, including subgrade preparation, surface cleaning, tack coat application, paving, transportation, joint execution, and compaction. It has been shown that these field operations have direct consequences for pavement performance (Roberts et al., 1991; Huang, 2004). The present analysis follows that logic by examining each factor in sequence and explaining what the rankings mean in technical terms.

4.2.1 Subgrade Preparation

Subgrade Preparation was analyzed through five sub-factors. The factor addresses the quality of the underlying support layer before subbase and base construction begin.

Table 4.1: Mean score and ranking of Subgrade Preparation Factors

Sub-code	Sub-factor	Mean	Rank
1.1	Achievement of required compaction/density	4.805	1
1.3	Removal of topsoil, vegetation, unsuitable materials	4.442	2
1.4	Grading to required levels and cross slope	4.403	3
1.2	Uniformity of moisture content during compaction	4.312	4
1.5	Treatment of weak or expansive soils	4.195	5



F1 = 0.2169(S1.1) + 0.2005(S1.3) + 0.1987(S1.4) + 0.1946(S1.2) + 0.1893(S1.5)

Figure 4.1: Subgrade Preparation

Achievement of required compaction or density ranked first under Subgrade Preparation, with a mean score of 4.805 and a weight of 0.2169. It has been explained that the subgrade acts as the support floor of the pavement structure (Huang, 2004). If the subgrade layer is weak, the layers above cannot compensate for it. The respondents therefore treated densification of the subgrade as the first line of quality control. Removal of unsuitable material and proper grading followed closely behind, which shows that respondents viewed preparation of the lower platform as both a strength issue and a shape-control issue.

Treatment of weak or expansive soils ranked last within this factor, but its mean score of 4.195 remains high. This should not be read as lack of importance. The lower rank more likely reflects context. Weak or expansive soil treatment becomes critical where such soils exist, but compaction, cleaning of unsuitable material, and grading are universal tasks across nearly all sites. A similar distinction has been made between general structural requirements and condition-specific treatments (Yoder & Witczak, 1975). The full ranking therefore suggests that respondents saw subgrade quality as a broad construction discipline, with density control as the central element and soil treatment as a conditional but still relevant measure.

4.2.2 Subbase and Base Course Construction

Subbase and Base Course Construction was evaluated through seven sub-factors representing thickness, compaction, gradation, moisture control, smoothness, and geometric conformity.

Table 4.2: Mean score and ranking of Subbase and Base Course Construction Factors

Sub-code	Sub-factor	Mean	Rank
2.2	Achievement of required compaction/density	4.857	1
2.3	Proper grading and particle size distribution	4.610	2
2.1	Achievement of specified layer thickness	4.558	3
2.7	Adherence to design cross-slope and grade	4.429	4
2.5	Control of moisture content during compaction	4.169	5
2.6	Checking surface evenness/smoothness after compaction with a straightedge	4.130	6
2.4	Rectification of irregular /non-conforming areas	4.104	7

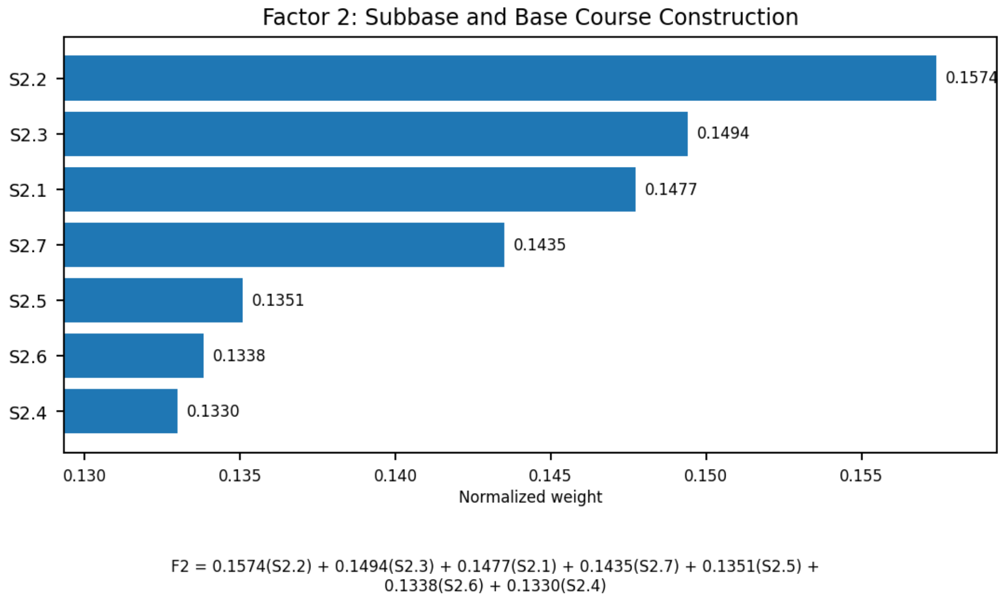


Figure 4.2: Subbase and Base Course Construction

Achievement of required compaction or density again ranked first within Subbase and Base Course Construction, with a mean score of 4.857. This indicates a consistent pattern across the dataset, with respondents repeatedly identifying density as a key physical requirement of pavement quality. Lower pavement layers are required to distribute traffic loads effectively, and this depends on proper control of thickness, gradation, and compaction (Mallick & El-Korchi, 2018). Proper grading and particle size distribution ranked second, while thickness ranked third. These rankings are technically reasonable, as density, gradation, and thickness together determine the structural capacity of the layer. If any one of these is inadequate, the layer may not distribute loads as intended.

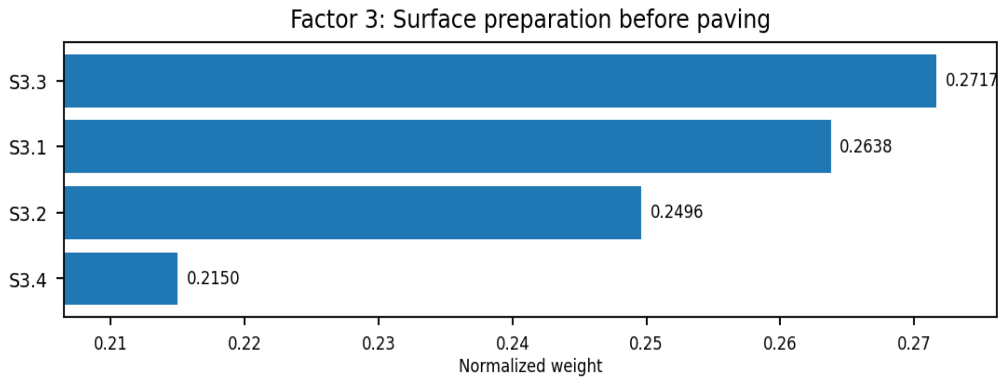
Rectification of irregular/non-conforming areas ranked last within this factor, although its mean score remained above 4.0. This suggests that respondents placed slightly greater emphasis on the finished structural properties of the layer than on the internal process used to achieve those properties. However, the difference was relatively small. The ranking therefore indicates priority rather than exclusion. It shows that practitioners gave greatest importance to the aspects most directly related to the structural performance of the subbase and base course under actual site conditions.

4.2.3 Surface Preparation Before Paving

This factor addresses the readiness of the layer that receives the asphalt mix. It includes cleaning, equipment uses, dryness, and final manual cleaning.

Table 4.3: Mean score and ranking of Surface Preparation Before Paving Factors

Sub-code	Sub-factor	Mean	Rank
3.3	Ensuring the surface is completely dry before paving	4.481	1
3.1	Removal of dust, dirt, and debris from the base before paving	4.351	2
3.2	Proper use of cleaning equipment (e.g., air compressors, mechanical sweepers)	4.117	3
3.4	Use of hand brooms to remove material remaining after air blowing	3.545	4



F3 = 0.2717(S3.3) + 0.2638(S3.1) + 0.2496(S3.2) + 0.2150(S3.4)

Figure 4.3: Surface Preparation Before Paving

Ensuring that the surface is completely dry before paving ranked first, with a mean score of 4.481 and a weight of 0.2717. This result is logical, as moisture at the paving interface can interfere with adhesion and reduce long-term durability. Bonding between pavement layers has been shown to depend heavily on the condition of the receiving surface (Wang et al., 2018). Removal of dust, dirt, and debris ranked second, confirming that respondents considered clean contact surfaces essential for achieving good bond quality.

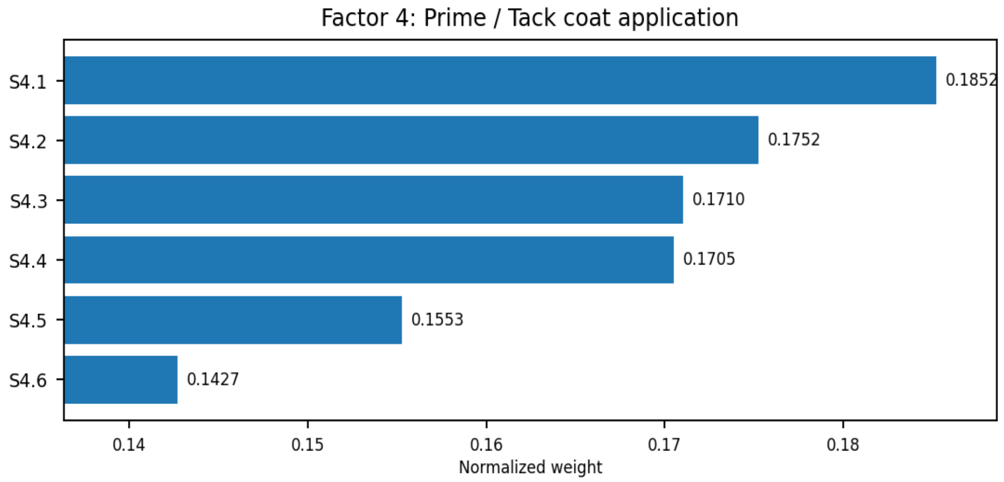
The use of hand brooms after air blowing ranked last within this factor, with a mean score of 3.545. Although it was the lowest-ranked item in the factor, it still remained above the midpoint of the scale. This suggests that respondents viewed final hand cleaning as a supportive measure rather than a primary one compared with surface drying and general cleaning. Nevertheless, even small deficiencies in surface preparation can weaken the bond between bituminous layers (Raposeiras et al., 2013). The ranking therefore reflects a sequence of importance rather than irrelevance. Dryness and overall cleanliness were given primary importance, while hand cleaning remained necessary where loose material persisted after mechanical cleaning.

4.2.4 Prime / Tack Coat Application

This factor covers bond coat material quality and application control before paving.

Table 4.4: Mean score and ranking of Prime / Tack Coat Application Factors

Sub-code	Sub-factor	Mean	Rank
4.1	Using prime/tack coat material that meets specifications	4.584	1
4.2	Ensuring surface cleanliness and proper preparation before prime/tack coat	4.338	2
4.3	Uniform distribution of the asphaltic prime/tack coat	4.234	3
4.4	Accurate control of binder application rate and temperature of the coat	4.221	4
4.5	Providing adequate curing/rest time (e.g., 24 hours) after prime coat	3.844	5
4.6	Ensuring proper nozzle condition for uniform spraying	3.532	6



F4 = 0.1852(S4.1) + 0.1752(S4.2) + 0.1710(S4.3) + 0.1705(S4.4) + 0.1553(S4.5) + 0.1427(S4.6)

Figure 4.4: Prime/Tack Coat Application

Using specification-compliant prime or tack coat material ranked first within this factor. This is reasonable, as poor-quality bond coat material can weaken the interface even when the application process is otherwise satisfactory. Previous studies have shown that tack coat application rate and temperature affect cohesion and friction between asphalt layers (Anh, 2022). Similarly, tack coat performance has been found to depend on both material quality and field application conditions (Wang et al., 2018). The present results reflect this balance. Although material quality ranked first, surface preparation, uniform distribution of the coat, and control of binder rate and temperature followed closely behind. This suggests that respondents viewed bond coat quality as a combined issue of both material properties and construction execution.

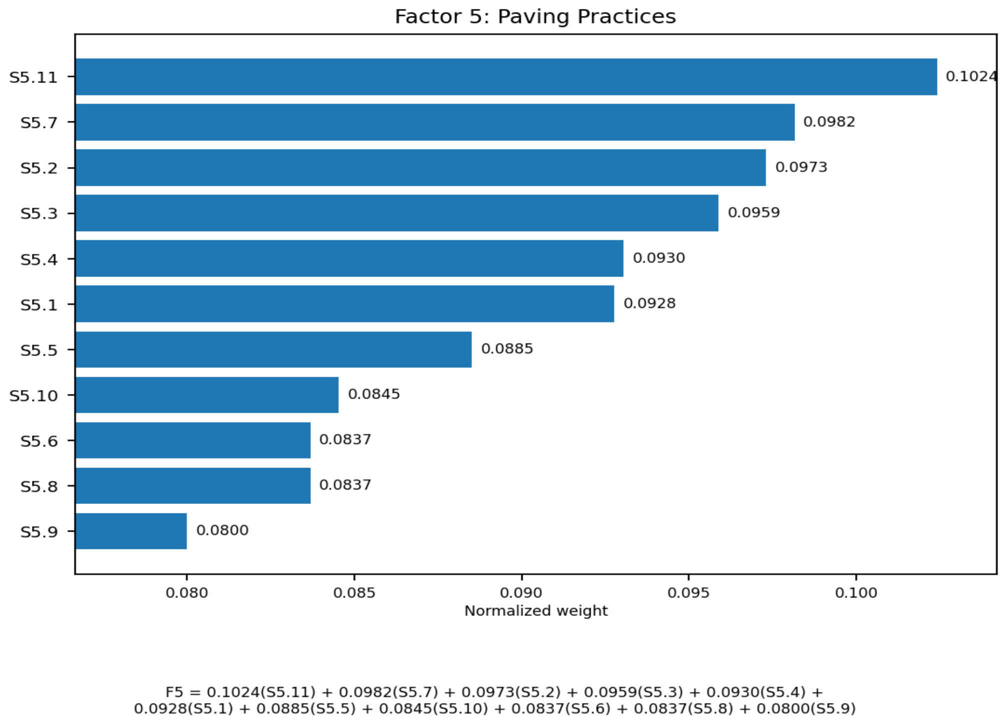
Proper nozzle condition ranked last within this factor; however, its score remained meaningful. This illustrates that lower-ranked items may still be technically important. Although the spray nozzle is a relatively small component, a worn or blocked nozzle can produce streaks, gaps, or localized ponding in the applied coat. Such irregularities may not be immediately visible, but they can adversely affect bond performance. The respondents likely assigned a lower rank to nozzle condition because its influence is reflected through the broader requirement of uniform application rather than as an independent high-level concern. Nevertheless, its effect remains significant, and the ranking supports its inclusion in the framework.

4.2.5 Paving Practices

Paving Practices covers the operational control of asphalt placement, including geometry, thickness, temperature preservation, and paver settings.

Table 4.5: Mean score and ranking of Paving Practices Factors

Sub-code	Sub-factor	Mean	Rank
5.11	Maintaining the design cross slope for proper surface water runoff	4.688	1
5.7	Maintaining uniform layer thickness of asphalt mat	4.494	2
5.2	Placing asphalt promptly to minimize heat loss before compaction	4.455	3
5.3	Setting the paver with proper compaction settings, cross-slope and vibration	4.390	4
5.4	Spreading asphalt mixture to the required line and level with paver	4.260	5
5.1	Using paving methods/settings that achieve the desired design profile	4.247	6
5.5	Setting the screed for initial compaction and correct surface profile	4.052	7
5.10	Keeping the paver hopper adequately filled during continuous paving	3.870	8
5.6	Visually inspecting the asphalt mix on the paver and after placement (before rolling)	3.831	9
5.8	Using automatic screed control (if available) to maintain uniformity	3.831	9
5.9	Laying all lanes on one side of the median simultaneously to avoid cold joints	3.662	11



F5 = 0.1024(S5.11) + 0.0982(S5.7) + 0.0973(S5.2) + 0.0959(S5.3) + 0.0930(S5.4) + 0.0928(S5.1) + 0.0885(S5.5) + 0.0845(S5.10) + 0.0837(S5.6) + 0.0837(S5.8) + 0.0800(S5.9)

Figure 4.5: Paving Practices

Maintaining the design cross slope ranked first within Paving Practices, followed by uniform layer thickness and minimizing heat loss before compaction. This ranking is significant because it shows that respondents did not view paving quality simply as the act of spreading asphalt, but as a process closely linked to drainage, thickness control, and thermal management. A pavement surface without adequate cross slope cannot drain water properly, which may allow water to accumulate and infiltrate vulnerable points. Previous studies have emphasized the importance of thickness and surface geometry in asphalt pavement performance (Roberts et al., 1991; Asphalt Institute, 2009). The present findings extend this understanding by identifying cross slope as the highest-ranked aspect within the paving factor.

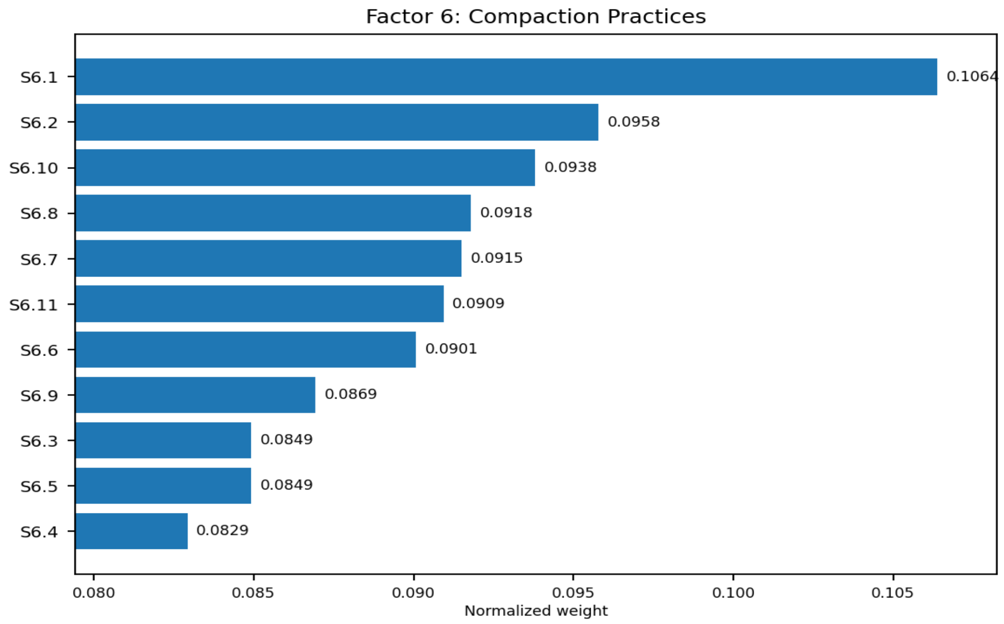
Laying all lanes on one side simultaneously to avoid cold joints ranked last within this factor. This likely reflects its conditional nature, as it may be important in some project arrangements but not always feasible or equally critical across all sites. Even so, the result should not be interpreted as indicating low importance. Rather, it suggests that respondents assigned greater priority to direct paving controls such as thickness, paver setting, geometry, and heat retention. The ranking indicates that practitioners valued these aspects more highly because they influence the asphalt mat continuously across the paved surface, rather than under only specific construction arrangements.

4.2.6 Compaction Practices

Compaction Practices captures rolling pattern, density achievement, temperature timing, overlap, and related field controls.

Table 4.6: Mean score and ranking of Compaction Practices Factors

Sub-code	Sub-factor	Mean	Rank
6.1	Achieving 97–98% of laboratory compaction density in field	4.831	1
6.2	Maintaining uniform/slow speed of tandem rollers and pneumatic tire roller during rolling	4.351	2
6.10	Carrying out secondary/intermediate rolling with pneumatic tire roller	4.260	3
6.8	Following the correct pattern and sequence of compaction	4.169	4
6.7	Adhering to specified initial and breakdown rolling temperatures	4.156	5
6.11	Applying sufficient contact pressure in rollers for proper compaction	4.130	6
6.6	Overlap successive roller passes adequately	4.091	7
6.9	Performing final rolling with steel wheeled roller to remove roller marks before cessation temperature	3.948	8
6.3	Light moistening of roller wheels with water	3.857	9
6.5	Minimizing transverse joints during rolling	3.857	9
6.4	Checking pavement smoothness with a straightedge after compaction	3.766	11



F6 = 0.1064(S6.1) + 0.0958(S6.2) + 0.0938(S6.10) + 0.0918(S6.8) + 0.0915(S6.7) + 0.0909(S6.11) + 0.0901(S6.6) + 0.0869(S6.9) + 0.0849(S6.3) + 0.0849(S6.5) + 0.0829(S6.4)

Figure 4.6: Compaction Practices

Achieving a field density of 97 to 98 percent of laboratory density ranked first within Compaction Practices. This result is among the clearest in the chapter, as density repeatedly emerges as a central practical requirement of pavement quality. Inadequate compaction has been shown to weaken asphalt layers by leaving excessive air voids and increasing susceptibility to moisture damage (Beainy et al., 2014). Compaction quality has also been identified as one of the strongest predictors of pavement performance (Hu et al., 2019). The respondents in this study clearly recognized this relationship. Roller speed, intermediate rolling, rolling sequence, and temperature also ranked highly, indicating that respondents viewed these controls as essential to achieving the required field density.

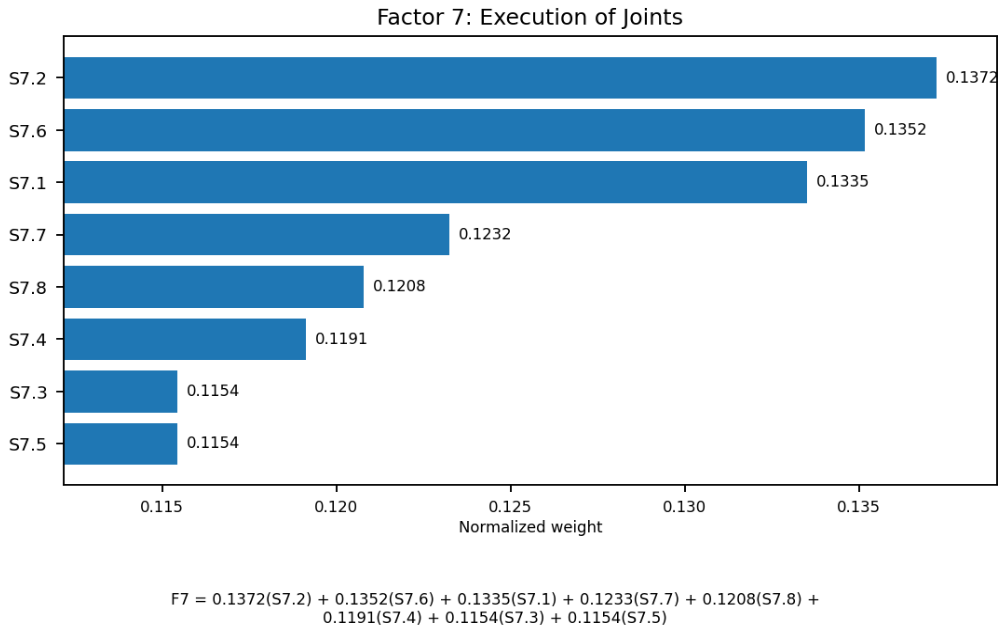
Checking pavement smoothness with a straightedge after compaction ranked last within this factor. This should not be interpreted as suggesting that smoothness is unimportant. Rather, it indicates that respondents considered it a finishing check rather than a primary determinant of compaction effectiveness. In other words, smoothness is assessed after the rolling process, whereas density achievement and rolling pattern directly influence the effectiveness of that process. This distinction is technically reasonable. The straightedge functions as a verification tool, while roller operation at the correct speed and temperature represents the action that shapes compaction quality. The ranking therefore suggests that respondents distinguished between the operational causes of effective compaction and the subsequent checks used to confirm its outcome.

4.2.7 Execution of Joints

Execution of Joints covers the construction of interfaces between paving runs and layers.

Table 4.7: Mean score and ranking of Execution of Joints Factors

Sub-code	**Sub-factor**	**Mean**	**Rank**
7.2	Matching thickness, density and uniformity of both mats at hot joints	4.338	1
7.6	Absence of irregularities at joints	4.273	2
7.1	Ensuring cleanliness (no dirt or foreign matter) at joints before placing mix	4.221	3
7.7	Staggering transverse joints between successive asphalt layers	3.896	4
7.8	Painting vertical joint face with approved bitumen before adjoining mix	3.818	5
7.4	Cutting longitudinal edge to full depth for cold joints	3.766	6
7.3	Cutting joint edges with suitable cutters for a clean finish	3.649	7
7.5	Cutting of previous run to expose full depth at transverse joint	3.649	7



$$F7 = 0.1372(S7.2) + 0.1352(S7.6) + 0.1335(S7.1) + 0.1233(S7.7) + 0.1208(S7.8) + 0.1191(S7.4) + 0.1154(S7.3) + 0.1154(S7.5)$$

Figure 4.7: Execution of Joints

Matching the thickness, density, and uniformity of both mats at hot joints ranked first, followed by the absence of irregularities and joint cleanliness. This ranking indicates that respondents viewed joints primarily as issues of continuity. Although a joint appears as a line of connection, it should not function as a structural seam that weakens the pavement. Where thickness and density are not properly matched across the joint, the interface may become a zone of mechanical weakness. Such locations are more vulnerable to accelerated deterioration under traffic loading and water infiltration. Previous studies have shown that interface preparation and bonding conditions strongly influence the long-term performance of layered pavements (Raposeiras et al., 2013). The present findings are consistent with this understanding.

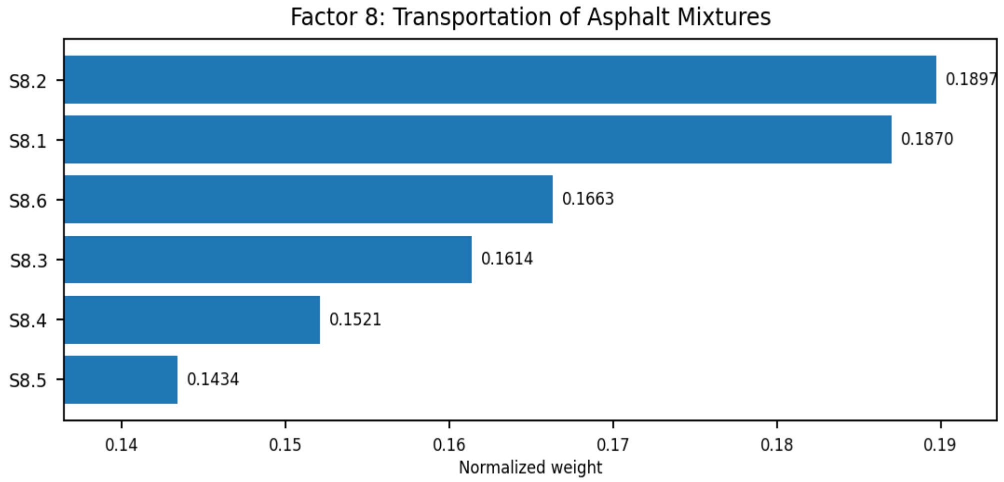
The cutting-related items ranked lowest within this factor. This likely reflects the fact that cutting operations are more procedural and condition-dependent, whereas continuity, uniformity, and cleanliness directly describe the desired performance condition of the joint itself. Nevertheless, cutting remains necessary where cold joints or interfaces from previous runs require proper preparation. The lower rank does not diminish its practical importance; rather, it suggests that respondents viewed it as a supporting measure for achieving the more critical objective of a sound and continuous joint.

4.2.8 Transportation of Asphalt Mixtures

This factor addresses how hot mix asphalt is delivered from plant to paving site without losing quality.

Table 4.8: Mean score and ranking of Transportation of Asphalt Mixtures Factors

Sub-code	Sub-factor	Mean	Rank
8.2	Avoiding segregation or lumping of asphalt mix and proper covering during transportation	4.519	1
8.1	Maintaining required HMA temperature during loading, hauling, laying and compaction	4.455	2
8.6	Maintaining continuous, uniform supply of HMA from plant to paving site	3.961	3
8.3	Conducting visual inspection and necessary tests on delivered asphalt mix	3.844	4
8.4	Ensuring truck/dumper bed is clean before loading	3.623	5
8.5	Coating truck bed with a release agent to prevent mix sticking	3.416	6


Factor 8: Transportation of Asphalt Mixtures

F8 = 0.1897(S8.2) + 0.1870(S8.1) + 0.1663(S8.6) + 0.1614(S8.3) + 0.1521(S8.4) + 0.1434(S8.5)

Figure 4.8: Transportation of Asphalt Mixtures

Avoiding segregation and maintaining proper covering ranked first within Transportation of Asphalt Mixtures, followed closely by temperature maintenance. This is a reasonable result, as part of the quality of the asphalt mixture is determined during transport before it reaches the paver. Previous studies have emphasized that delivery continuity and thermal protection are critical in asphalt paving (Roberts et al., 1991; Asphalt Institute, 2009). A mixture that segregates or loses excessive heat during transport may arrive at the site in a weakened condition. As a result, the paver and rollers must work with material whose quality has already been compromised. The ranking therefore indicates that respondents viewed transportation as an active component of construction quality rather than merely a logistical operation.

Truck-bed release agent ranked lowest within this factor; however, its mean score remained meaningful. This likely reflects a practical hierarchy of importance. Respondents assigned greater weight to temperature maintenance and segregation control because these directly affect the condition of the asphalt mixture, whereas the release agent mainly affects discharge efficiency at a more localized level. Even so, sticking of the mixture to the truck bed can interrupt discharge and lead to uneven material flow. The item therefore remains relevant and its inclusion in the factor structure is justified.

4.2.9 Main Factor Analysis

After the within-factor ranking of sub-factors, the eight main construction-practice factors were ranked using mean score and normalized weight.

Table 4.9: Main factor-wise mean score, weightage, and rank

Code	Main Factor	Mean score	Weightage	Rank
F1	Subgrade Preparation	4.431	0.1331	1
F2	Subbase and Base Course Construction	4.408	0.1324	2
F5	Paving Practices	4.162	0.1250	3
F6	Compaction Practices	4.129	0.1240	4

Code	Main Factor	Mean score	Weightage	Rank
F4	Prime / Tack Coat Application	4.126	0.1239	5
F3	Surface Preparation Before Paving	4.123	0.1238	6
F8	Transportation of Asphalt Mixtures	3.970	0.1192	7
F7	Execution of Joints	3.951	0.1187	8

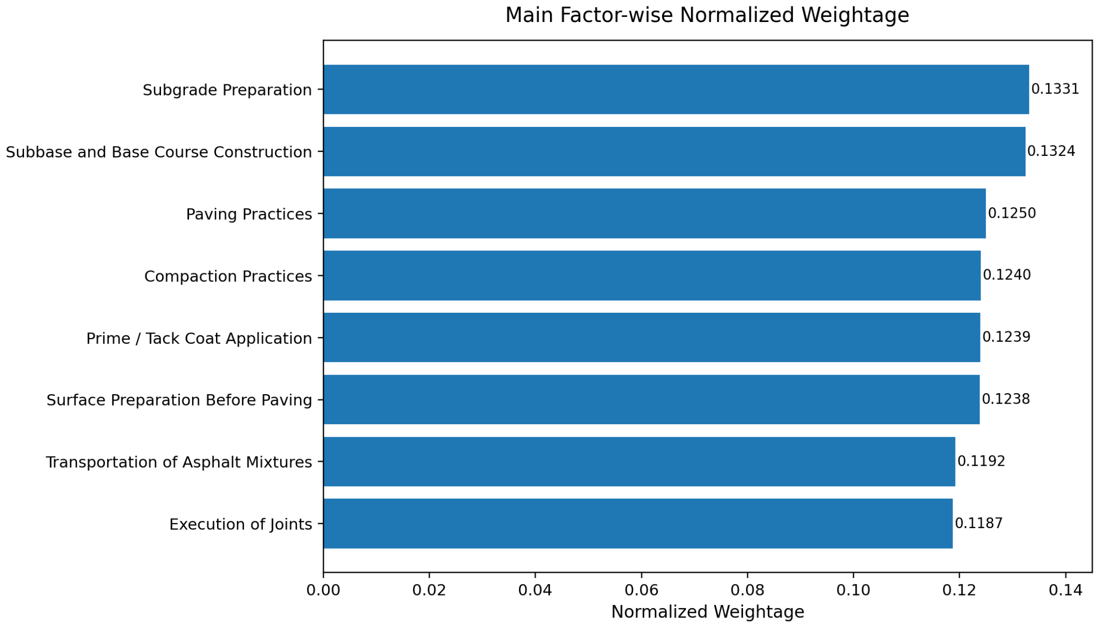


Figure 4.9: Main Factor Weight Distribution

The main factor analysis shows that Subgrade Preparation ranked first with a mean score of 4.431 and weightage of 0.1331. This indicates that respondents considered the quality of the foundation layer as the most important contributor to pavement construction quality. Subbase and Base Course Construction ranked second with a weightage of 0.1324, showing the importance of lower pavement layers in providing structural support.

Paving Practices ranked third, followed by Compaction Practices, Prime/Tack Coat Application, and Surface Preparation Before Paving. These factors are directly related to asphalt placement, bonding, and density achievement. Transportation of Asphalt Mixtures and Execution of Joints ranked seventh and eighth, respectively. Although these factors ranked lower, their mean scores remained high, indicating that all eight factors are important in asphalt pavement construction quality.

4.3 Development of Pavement Construction Quality Index (PCQI) Model

The second objective of this study was to develop a Pavement Construction Quality Index (PCQI) model for assessing asphalt pavement construction quality. The model was developed using the normalized weightages obtained from the questionnaire survey. The PCQI model combines the weight of each main construction-practice factor with the corresponding site performance score. In this way, the model converts construction-practice performance into a single numerical quality score.

The development of the PCQI model was carried out in three stages. First, the sub-factor weights were calculated within each main factor. Second, the score of each main factor was calculated using the weighted summation of its sub-factor scores. Finally, the overall PCQI value was calculated by multiplying each main factor score with its respective main factor weight.

4.3.1 Development of Main Factor Score Equations

Each main factor score was calculated using the normalized weights of its respective sub-factors. The general form of the factor score equation is:

$$\boldsymbol{F_i = \sum w_{ij} S_{ij}}$$

Where,

F_i = score of the i^{th} main factor

w_{ij}= normalized weight of sub-factor j under factor i

S_{ij}= site rating score of sub-factors j under factor i

Based on the normalized sub-factor weights, the individual main factor score equations are presented below.

Subgrade Preparation

$F_1 = 0.2169S_{1.1} + 0.1946S_{1.2} + 0.2005S_{1.3} + 0.1987S_{1.4} + 0.1893S_{1.5}$

Where,

F_1 = Subgrade Preparation score

$S_{1.1}$ = Achievement of required compaction/density

$S_{1.2}$ = Uniformity of moisture content during compaction

$S_{1.3}$ = Removal of topsoil, vegetation, and unsuitable materials

$S_{1.4}$ = Grading to required levels and cross slope

$S_{1.5}$ = Treatment of weak or expansive soils

Subbase and Base Course Construction

$F_2 = 0.1477S_{2.1} + 0.1574S_{2.2} + 0.1494S_{2.3} + 0.1330S_{2.4} + 0.1351S_{2.5} + 0.1338S_{2.6} + 0.1435S_{2.7}$

Where,

F_2 = Subbase and Base Course Construction score

$S_{2.1}$ = Achievement of specified layer thickness

$S_{2.2}$ = Achievement of required compaction/density

$S_{2.3}$ = Proper grading and particle size distribution

$S_{2.4}$ = Rectification of irregular /non-conforming areas

$S_{2.5}$ = Control of moisture content during compaction

$S_{2.6}$ = Checking surface evenness/smoothness after compaction with a straightedge

$S_{2.7}$ = Adherence to design cross-slope and grade

Surface Preparation Before Paving

$F_3 = 0.2638S_{3.1} + 0.2496S_{3.2} + 0.2717S_{3.3} + 0.2150S_{3.4}$

Where,

F_3 = Surface Preparation Before Paving score

$S_{3.1}$ = Removal of dust, dirt, and debris from the base before paving

$S_{3.2}$ = Proper use of cleaning equipment such as air compressors and mechanical sweepers

$S_{3.3}$ = Ensuring the surface is completely dry before paving

$S_{3.4}$ = Use of hand brooms to remove remaining material after air blowing

Prime/Tack Coat Application

$F_4 = 0.1852S_{4.1} + 0.1752S_{4.2} + 0.1710S_{4.3} + 0.1705S_{4.4} + 0.1553S_{4.5} + 0.1427S_{4.6}$

Where,

F4 = Prime/Tack Coat Application score

$S_{4.1}$ = Use of prime/tack coat material that meets specifications

$S_{4.2}$ = Ensuring surface cleanliness and proper preparation before prime/tack coat

$S_{4.3}$ = Uniform distribution of asphaltic prime/tack coat

$S_{4.4}$ = Accurate control of binder application rate and temperature

$S_{4.5}$ = Providing adequate curing/rest time after prime coat

$S_{4.6}$ = Ensuring proper nozzle condition for uniform spraying

Paving Practices

$F5 = 0.093S_{5.1} + 0.097S_{5.2} + 0.096S_{5.3} + 0.093S_{5.4} + 0.089S_{5.5} + 0.084S_{5.6} + 0.098S_{5.7} + 0.084S_{5.8} + 0.080S_{5.9} + 0.085S_{5.10} + 0.102S_{5.11}$

Where,

F_5 = Paving Practices score

$S_{5.1}$ = Use of paving methods/settings that achieve the desired design profile

$S_{5.2}$ = Placing asphalt promptly to minimize heat loss before compaction

$S_{5.3}$ = Setting the paver with proper compaction settings, cross-slope, and vibration

$S_{5.4}$ = Spreading asphalt mixture to the required line and level with paver

$S_{5.5}$ = Setting the screed for initial compaction and correct surface profile

$S_{5.6}$ = Visual inspection of asphalt mixes on the paver and after placement before rolling

$S_{5.7}$ = Maintaining uniform layer thickness of asphalt mat

$S_{5.8}$ = Use of automatic screed control, if available, to maintain uniformity

$S_{5.9}$ = Laying all lanes on one side of the median simultaneously to avoid cold joints

$S_{5.10}$ = Keeping the paver hopper adequately filled during continuous paving

$S_{5.11}$ = Maintaining design cross slope for proper surface water runoff

Compaction Practices

$F_6 = 0.106S_{6.1} + 0.096S_{6.2} + 0.085S_{6.3} + 0.083S_{6.4} + 0.085S_{6.5} + 0.090S_{6.6} + 0.091S_{6.7} + 0.092S_{6.8} + 0.087S_{6.9} + 0.094S_{6.10} + 0.091S_{6.11}$

Where,

F_6 = Compaction Practices score

$S_{6.1}$ = Achieving 97-98% of laboratory compaction density in field

$S_{6.2}$ = Maintaining uniform/slow speed of tandem rollers and pneumatic tire rollers

$S_{6.3}$ = Light moistening of roller wheels with water

$S_{6.4}$ = Checking pavement smoothness with a straightedge after compaction

$S_{6.5}$ = Minimizing transverse joints during rolling

$S_{6.6}$ = Adequate overlap of successive roller passes

$S_{6.7}$ = Adhering to specified initial and breakdown rolling temperatures

$S_{6.8}$ = Following the correct pattern and sequence of compaction

$S_{6.9}$ = Performing final rolling with steel-wheeled roller to remove roller marks

$S_{6.10}$ = Carrying out secondary/intermediate rolling with pneumatic tire roller

$S_{6.11}$ = Applying sufficient contact pressure in rollers for proper compaction

Execution of Joints

$F_7 = 0.1335S_{7.1} + 0.1372S_{7.2} + 0.1154S_{7.3} + 0.1191S_{7.4} + 0.1154S_{7.5} + 0.1352S_{7.6} + 0.1233S_{7.7} + 0.1208S_{7.8}$

Where,

F_7 = Execution of Joints score

$S_{7.1}$ = Ensuring cleanliness at joints before placing mix

$S_{7.2}$ = Matching thickness, density, and uniformity of both mats at hot joints

$S_{7.3}$ = Cutting joint edges with suitable cutters for a clean finish

$S_{7.4}$ = Cutting longitudinal edge to full depth for cold joints

$S_{7.5}$ = Cutting of previous run to expose full depth at transverse joint

$S_{7.6}$ = Absence of irregularities at joints

$S_{7.7}$ = Staggering transverse joints between successive asphalt layers

$S_{7.8}$ = Painting vertical joint face with approved bitumen before adjoining mix

Transportation of Asphalt Mixtures

$F_8=0.1870S_{8.1}+0.1897S_{8.2}+0.1614S_{8.3}+0.1521S_{8.4}+0.1434S_{8.5}+0.1663S_{8.6}$

Where,

F_8 = Transportation of Asphalt Mixtures score

$S_{8.1}$ = Maintaining required HMA temperature during loading, hauling, laying, and compaction

$S_{8.2}$ = Avoiding segregation or lumping of asphalt mix and ensuring proper covering during transportation

$S_{8.3}$ = Conducting visual inspection and necessary tests on delivered asphalt mix

$S_{8.4}$ = Ensuring truck/dumper bed is clean before loading

$S_{8.5}$ = Coating truck bed with release agent to prevent mix sticking

$S_{8.6}$ = Maintaining continuous and uniform supply of HMA from plant to paving site

4.3.2 Development of Overall PCQI Equation

The overall Pavement Construction Quality Index (PCQI) was formulated by multiplying each main factor score by its corresponding normalized main factor weight and then summing the weighted scores of all eight factors. The final PCQI equation is expressed as:

$\mathrm{PCQI} = 0.1331F_1 + 0.1324F_2 + 0.1238F_3 + 0.1239F_4 + 0.1250F_5 + 0.1240F_6 + 0.1187F_7 + 0.1192F_8$

Where:

F_1 = Subgrade Preparation

F_2 = Subbase and Base Course Construction

F_3 = Surface Preparation Before Paving

F_4 = Prime/Tack Coat Application

F_5 = Paving Practices

F_6 = Compaction Practices

F_7 = Execution of Joints

F_8 = Transportation of Asphalt Mixtures

The PCQI value is expressed as a percentage:

$$\mathrm{PCQI}\ (\%) = \mathrm{PCQI} \times 100$$

4.3.3 Interpretation of PCQI Score

The calculated PCQI value was interpreted using percentage-based quality ranges. A similar approach was used by Imran et al. (2025), who classified pavement quality into five levels ranging from low to excellent.

Table 4.10: PCQI Score Range and Interpretation Level

PCQI Score (%)	Interpretation Level
0–60	Low Quality
61–70	Fair Quality
71–80	Moderate Quality
81–90	Good Quality
91–100	Excellent Quality

4.3.4 Sensitivity Analysis of PCQI Model

A sensitivity check was conducted by increasing the weights of the two most dominant factors, Subgrade Preparation and Subbase and Base Course Construction, by 5% each. The PCQI output changed proportionally with the variation in these key factor weights. This indicates that the PCQI model responds logically to changes in major factor weights and supports the internal consistency of the weighting structure.

4.3.5 Discussion of Developed PCQI Model

The developed PCQI model provides a quantitative method for assessing asphalt pavement construction quality from a construction-practice perspective. The model combines expert-based factor weightages with project-specific site rating scores to generate a single quality score in percentage form. This makes the model useful for comparing projects, identifying weak construction activities, and supporting quality improvement during pavement construction.

The weight distribution shows that Subgrade Preparation and Subbase and Base Course Construction received the highest weights. This indicates that the lower pavement layers are considered highly influential in determining overall pavement construction quality. Paving Practices and Compaction Practices also received high weights, showing the importance of proper asphalt placement, thickness control, rolling sequence, density achievement, and temperature control. Although Execution of Joints and Transportation of Asphalt Mixtures ranked lower, their weights remained close to the other factors, indicating that all eight factors contribute meaningfully to pavement construction quality.

The PCQI model is therefore suitable as a structured checklist and decision-support tool for evaluating construction-practice compliance in HMA flexible pavement projects. However, the model should be interpreted within the scope of this study, as it is based on construction-practice factors only and does not include material quality, laboratory test results, long-term pavement performance, or managerial factors.

4.4 Application of PCQI Model in Case Study

This section presents the case study-based evaluation of the Pavement Construction Quality Index (PCQI). The index equation developed in the previous section was applied to the construction projects in Kathmandu Valley to estimate its construction quality level. The data needed for the calculation were collected through field observation and questionnaire survey.

4.4.1 Study Area

As the research focused on urban, feeder, and highway roads, two representative road projects from Kathmandu Valley were selected for the application of the index.

4.4.2 Data Collection

Data for the case studies were collected through site visits, test results obtained during construction, and a questionnaire survey distributed to the engineers involved in the projects. These engineers were also asked to evaluate the construction quality level of the selected projects. The questionnaire used in this assessment is included in Appendix B.

4.4.3 Data Analysis and Results

The collected data were used to calculate the Pavement Construction Quality Index (PCQI) using the equation developed in the previous chapter. First, the value of each main factor was determined from the weighted sum of its corresponding sub-factor scores. Then, the overall PCQI value was calculated using the normalized weights of the eight main factors.

Equations of Main Factors

$$F_1=0.2169S_{1.1}+0.1946S_{1.2}+0.2005S_{1.3}+0.1987S_{1.4}+0.1893S_{1.5}$$

$F_2=0.1477S_{2.1}+0.1574S_{2.2}+0.1494S_{2.3}+0.1330S_{2.4}+0.1351S_{2.5}+0.1338S_{2.6}+0.1435S_{2.7}$

$F_3=0.2638S_{3.1}+0.2496S_{3.2}+0.2717S_{3.3}+0.2150S_{3.4}$

$F_4=0.1852S_{4.1}+0.1752S_{4.2}+0.1710S_{4.3}+0.1705S_{4.4}+0.1553S_{4.5}+0.1427S_{4.6}$

$F_5 = 0.093S_{5.1} + 0.097S_{5.2} + 0.096S_{5.3} + 0.093S_{5.4} + 0.089S_{5.5} + 0.084S_{5.6} + 0.098S_{5.7} + 0.084S_{5.8} + 0.080S_{5.9} + 0.085S_{5.10} + 0.102S_{5.11}$

$F_6 = 0.106S_{6.1} + 0.096S_{6.2} + 0.085S_{6.3} + 0.083S_{6.4} + 0.085S_{6.5} + 0.090S_{6.6} + 0.091S_{6.7} + 0.092S_{6.8} + 0.087S_{6.9} + 0.094S_{6.10} + 0.091S_{6.11}$

$F_7=0.1335S_{7.1}+0.1372S_{7.2}+0.1154S_{7.3}+0.1191S_{7.4}+0.1154S_{7.5}+0.1352S_{7.6}+0.1233S_{7.7}+0.1208S_{7.8}$

$F_8=0.1870S_{8.1}+0.1897S_{8.2}+0.1614S_{8.3}+0.1521S_{8.4}+0.1434S_{8.5}+0.1663S_{8.6}$

The overall Pavement Construction Quality Index was then calculated as:

$$PCQI = 0.1331F_1 + 0.1324F_2 + 0.1238F_3 + 0.1239F_4 + 0.1250F_5 + 0.1240F_6 + 0.1187F_7 + 0.1192F_8$$

Table 4.11: Case Study Data

Code	Sub-factor / Factor	Case Study 1	Case Study 2
F1: Factor 1: Subgrade Preparation			
1.1	Achievement of required compaction/density	1.000	1.000
1.2	Uniformity of moisture content during compaction	0.625	0.750
1.3	Removal of topsoil, vegetation, unsuitable materials	1.000	1.000
1.4	Grading to required levels and cross slope	0.250	0.500
1.5	Treatment of weak or expansive soils	1.000	1.000
F_1	**Score for Factor 1: Subgrade Preparation**	**0.778**	**0.852**
F2: Factor 2: Subbase and Base Course Construction			
2.1	Achievement of specified layer thickness	1.000	1.000
2.2	Achievement of required compaction/density	1.000	1.000
2.3	Proper grading and particle size distribution	1.000	1.000
2.4	Rectification of irregular /non-conforming areas	0.250	0.500
2.5	Control of moisture content during compaction	0.625	0.750
2.6	Checking surface evenness/smoothness after	0.000	0.000

Code	Sub-factor / Factor	Case Study 1	Case Study 2
	compaction with a straightedge		
2.7	Adherence to design cross-slope and grade	0.500	0.500
F_2	**Score for Factor 2: Subbase and Base Course Construction**	**0.644**	**0.694**
F3: Factor 3 Surface preparation before paving			
3.1	Removal of dust, dirt, and debris from the base before paving	0.875	1.000
3.2	Proper use of cleaning equipment (e.g., air compressors, mechanical sweepers)	1.000	1.000
3.3	Ensuring the surface is completely dry before paving	0.750	0.625
3.4	Use of hand brooms to remove material remaining after air blowing	0.750	0.625
F_3	**Score for Factor 3 Surface preparation before paving**	**0.845**	**0.818**
F4: Factor 4 Prime / Tack coat application			
4.1	Using prime/tack coat material that meets specifications	1.000	1.000
4.2	Ensuring surface cleanliness and proper preparation before prime/tack coat	0.750	1.000
4.3	Uniform distribution of the asphaltic prime/tack coat	0.750	0.750
4.4	Accurate control of binder application rate and temperature of the coat	0.750	0.500
4.5	Providing adequate curing/rest time (e.g., 24 hours) after prime coat	1.000	0.875
4.6	Ensuring proper nozzle condition for uniform spraying	0.750	0.500
F_4	**Score for Factor 4 Prime / Tack coat application**	**0.835**	**0.781**
F5: Factor 5 Paving Practices			
5.1	Using paving methods/settings that achieve the desired design profile	0.750	1.000
5.2	Placing asphalt promptly to minimize heat loss before compaction	0.750	0.750

Code	Sub-factor / Factor	Case Study 1	Case Study 2
5.3	Setting the paver with proper compaction settings, cross-slope and vibration	1.000	1.000
5.4	Spreading asphalt mixture to the required line and level with paver	0.750	0.750
5.5	Setting the screed for initial compaction and correct surface profile	1.000	0.750
5.6	Visually inspecting the asphalt mix on the paver and after placement (before rolling)	1.000	0.750
5.7	Maintaining uniform layer thickness of asphalt mat	0.750	0.500
5.8	Using automatic screed control (if available) to maintain uniformity	1.000	1.000
5.9	Laying all lanes on one side of the median simultaneously to avoid cold joints	1.000	0.750
5.10	Keeping the paver hopper adequately filled during continuous paving	1.000	1.000
5.11	Maintaining the design cross slope for proper surface water runoff	0.250	0.500
F_5	**Score for Factor 5 Paving Practices**	**0.828**	**0.789**
F6: Factor 6 Compaction Practices			
6.1	Achieving 97–98% of laboratory compaction density in field	1.000	1.000
6.2	Maintaining uniform/slow speed of tandem rollers and pneumatic tire roller during rolling	1.000	1.000
6.3	Light moistening of roller wheels with water	1.000	1.000
6.4	Checking pavement smoothness with a straightedge after compaction	0.000	0.000
6.5	Minimizing transverse joints during rolling	0.750	0.750
6.6	Overlap successive roller passes adequately	0.750	1.000
6.7	Adhering to specified initial and breakdown rolling temperatures	1.000	1.000
6.8	Following the correct pattern and sequence of compaction	1.000	0.750
6.9	Performing final rolling with steel wheeled roller to remove roller marks before cessation temperature	1.000	1.000

Code	Sub-factor / Factor	Case Study 1	Case Study 2
6.10	Carrying out secondary/intermediate rolling with pneumatic tire roller	1.000	1.000
6.11	Applying sufficient contact pressure in rollers for proper compaction	1.000	0.750
F_6	**Score for Factor 6 Compaction Practices**	**0.873**	**0.850**
F7: Factor 7 Execution of Joints			
7.1	Ensuring cleanliness (no dirt or foreign matter) at joints before placing mix	0.750	1.000
7.2	Matching thickness, density and uniformity of both mats at hot joints	0.500	0.750
7.3	Cutting joint edges with suitable cutters for a clean finish	0.000	0.000
7.4	Cutting longitudinal edge to full depth for cold joints	0.000	0.000
7.5	Cutting of previous run to expose full depth at transverse joint	0.000	0.000
7.6	Absence of irregularities at joints	0.250	0.750
7.7	Staggering transverse joints between successive asphalt layers	0.750	0.750
7.8	Painting vertical joint face with approved bitumen before adjoining mix	0.250	0.250
F_7	**Score for Factor 7 Execution of Joints**	**0.325**	**0.460**
F8: Factor 8 (Transportation of Asphalt Mixture)			
8.1	Maintaining required HMA temperature during loading, hauling, laying and compaction	0.625	0.750
8.2	Avoiding segregation or lumping of asphalt mix and proper covering during transportation	0.625	0.750
8.3	Conducting visual inspection and necessary tests on delivered asphalt mix	0.000	0.250
8.4	Ensuring truck/dumper bed is clean before loading	1.000	1.000
8.5	Coating truck bed with a release agent to prevent mix sticking	1.000	1.000
8.6	Maintaining continuous, uniform supply of HMA from plant to paving site	0.250	0.500

Code	Sub-factor / Factor	Case Study 1	Case Study 2
F_8	**Score for Factor 8 (Transportation of Asphalt Mixture)**	**0.573**	**0.702**

Overall PCQI calculations

Case Study 1

PCQI = 0.1331F1 + 0.1324F2 + 0.1238F3 + 0.1239F4 + 0.1250F5 + 0.1240F6 + 0.1187F7 + 0.1192F8

= 0.1331(0.778) + 0.1324(0.644) + 0.1238(0.845) + 0.1239(0.835) + 0.1250(0.828) + 0.1240(0.873) + 0.1187(0.325) + 0.1192(0.573)

= 0.715 (71.5%)

Thus, the PCQI value for Case Study 01 was found to be 0.715 or 71.5%, which falls under the Moderate Quality category.

Case Study 2

PCQI = 0.1331F1 + 0.1324F2 + 0.1238F3 + 0.1239F4 + 0.1250F5 + 0.1240F6 + 0.1187F7 + 0.1192F8

= 0.1331(0.852) + 0.1324(0.694) + 0.1238(0.818) + 0.1239(0.781) + 0.1250(0.789) + 0.1240(0.850) + 0.1187(0.460) + 0.1192(0.702)

= 0.746 (74.6%)

Thus, the PCQI value for Case Study 02 was found to be 0.746 or 74.6%, which also falls under the Moderate Quality category.

4.4.4 Interpretation of Case Study Quality Index

The case studies showed several weaknesses in construction practice, including improper camber, absence of pavement evenness checking with a straightedge, likely segregation of asphalt mix during transportation, inadequate control of bitumen application rate and required asphalt mix testing, poor joint execution due to lack of skilled workmanship, and improper cutting of joints.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The conclusions are presented in three paragraphs, each corresponding to one of the three research objectives addressed in Sections 5.1.1, 5.1.2, and 5.1.3 respectively.

5.1.1 Conclusion for RO1: Determination of Relative Weights and Rankings of Construction-Practice Factors

The first research objective was to determine the relative weights and rankings of construction-practice-related factors affecting asphalt pavement construction quality. Based on a five-point Likert-scale questionnaire survey administered to 77 construction professionals, eight main factors and their associated sub-factors were identified and ranked using mean score analysis and normalized weight calculation. The survey instrument demonstrated excellent internal consistency, with a Cronbach's Alpha value of 0.944. Subgrade Preparation ranked first (weight = 0.1331), followed by Subbase and Base Course Construction (weight = 0.1324), confirming that foundational layer quality is the most critical determinant of pavement construction quality. The remaining factors, namely Paving Practices, Compaction Practices, Prime/Tack Coat Application, Surface Preparation Before Paving, Transportation of Asphalt Mixtures, and Execution of Joints, also recorded high mean scores, indicating that all eight factors are significant contributors to overall pavement construction quality. The narrow range of normalized weights (0.1187–0.1331) further confirms that pavement construction quality is a multidimensional process in which no single factor can be neglected.

5.1.2 Conclusion for RO2: Development of Pavement Construction Quality Index (PCQI) Model

The second research objective aimed to develop a quantitative model to measure the construction quality of asphalt pavement projects in Nepal. Based on the mean scores obtained from the Likert-scale questionnaire survey responses of 77 construction professionals, normalized weights were derived for each of the eight main construction-practice factors using the weighted average method, where each weight represents the proportional contribution of a factor to the overall pavement construction quality. The weights ranged from 0.1187 (Execution of Joints) to 0.1331 (Subgrade Preparation), with the top three factors — Subgrade Preparation (0.1331), Subbase and Base Course

Construction (0.1324), and Paving Practices (0.1250). The resulting PCQI formula is expressed as a weighted linear combination:

$$PCQI = (0.1331 \times F1) + (0.1324 \times F2) + (0.1238 \times F3) + (0.1239 \times F4) + (0.1250 \times F5) + (0.1240 \times F6) + (0.1187 \times F7) + (0.1192 \times F8)$$

The model classifies pavement construction quality into five levels: Low (0–60%), Fair (61–70%), Moderate (71–80%), Good (81–90%), and Excellent (91–100%).

5.1.3 Conclusion for RO3: Application of PCQI Model in Case Study

The third research objective was to evaluate the applicability of the developed Pavement Construction Quality Index (PCQI) through case study projects. The index was applied to two asphalt pavement construction projects in Kathmandu Valley, where site visits were conducted during construction to observe field operations and collect project-specific performance scores for each factor and sub-factor. The calculated PCQI values for the two projects were 71.55% and 74.56%, placing both within the Moderate quality range (71–80%). The results confirmed that the PCQI model responds appropriately to field-level variations in construction practice and is capable of differentiating quality levels across projects. The application also demonstrated that the index can identify specific construction activities where performance was deficient, thereby providing actionable diagnostic information for project stakeholders. The case study results validate the practical applicability of the PCQI as a structured, field-deployable tool for quantifying asphalt pavement construction quality in the Nepalese context.

5.2 Recommendations from Study

- The developed PCQI should be adopted as a practical field tool by clients, consultants, contractors, and quality-control personnel to assess and monitor asphalt pavement construction quality during project execution.
- Greater attention should be given to the most influential construction factors — particularly Subgrade Preparation, Subbase and Base Course Construction, Paving Practices, Compaction Practices, Joint Execution, and Transportation of Asphalt Mixtures — as weaknesses in these activities can significantly affect the final pavement quality.
- Site engineers and supervisors should ensure strict compliance with specifications related to surface dryness, layer thickness, temperature control,

density achievement, cross slope/camber, tack coat application rate, and joint preparation.

- Construction quality assessment should not rely solely on laboratory test results; it should also include systematic site observation and process-based evaluation, as field execution strongly governs pavement performance.
- The concerned agencies, especially road authorities and project owners, should consider adopting a standardized quality assessment checklist or index system for routine use in pavement construction projects.
- Contractors should improve workmanship, supervision, and training of field staff, particularly for activities such as compaction control, joint cutting and sealing, straightedge checking, and asphalt mix handling during transportation and paving.

5.2.1 Recommendations for Further Studies

- Further studies are recommended to validate the PCQI on more road projects across different geographical locations and road categories in Nepal to improve the robustness and wider applicability of the model.
- The current study is limited to hot mix asphalt pavement construction practices; therefore, future research can extend similar quality-index approaches to other pavement types, including rigid pavements and other surfacing systems.
- Future studies can also incorporate material-related factors, managerial factors, and environmental considerations to develop a more comprehensive and holistic quality assessment model for pavement construction in Nepal.

REFERENCES

AASHTO. (1993). AASHTO guide for design of pavement structures. American Association of State Highway and Transportation Officials.

Al-Hassan, M. S. A. H. (1993). Factors affecting the quality of pavement construction in Saudi Arabia. Doctoral dissertation, King Fahd University of Petroleum and Minerals.

Al-Mohammedawi, A., Mollenhauer, K., Al-Nageim, H., et al. (2022). Current research and challenges in bitumen emulsion manufacturing and use. Materials, 15(6), 2301.

Anh, B. T. Q. (2022). Effect of tack coat application rate and temperature on interlayer cohesion and friction of double-layer asphalt samples. In CIGOS 2021, Emerging Technologies and Applications for Green Infrastructure, pp. 595–606. Springer.

Arditi, D., & Gunaydin, H. M. (1997). Total quality management in the construction process. International Journal of Project Management, 15(4), 235–243.

Asphalt Institute. (2007). The asphalt handbook (7th ed.). Asphalt Institute.

Asphalt Institute. (2009). Construction of quality asphalt pavements (MS-22, 2nd ed.). Asphalt Institute.

Baral, K. (2025). Development and evaluation of a building construction quality index for public RC building construction in Kathmandu Valley, Nepal.

Beainy, F., Chailleux, E., Bodin, D., & de La Roche, C. (2014). Laboratory and field study on compaction quality of asphalt pavements. Construction and Building Materials, 71, 630–638.

Briere, R. (Ed.). (2000). Hot-mix asphalt paving handbook 2000. Transportation Research Board.

Celaya, M., Nazarian, S., & Arambula, E. (2006). Seismic testing to determine quality of hot-mix asphalt. Transportation Research Record, 1970(1), 140–149.

Chang, G. K., Hu, W., Xiao, F., Gransberg, D. D., & Xu, Q. (2019). Utilizing intelligent compaction meter values to evaluate construction quality of asphalt pavement layers. Road Materials and Pavement Design, 20(2), 458–474.

Chen, B., Xu, Q., & Sun, Y. (2021). Compaction quality evaluation of asphalt pavement based on intelligent compaction technology. Journal of Construction Engineering and Management, 147(8), 04021093.

Cochran, W. G. (1977). Sampling techniques (3rd ed.). John Wiley & Sons.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. Psychometrika, 16(3), 297–334.

Department of Roads. (2021). Standard specifications for road and bridge works, 2078 (2nd rev.). Government of Nepal.

Federal Highway Administration. (2014). Intelligent compaction for asphalt pavement materials: Field application manual (FHWA-HIF-14-020). U.S. Department of Transportation.

Federal Highway Administration. (2016). Hot-mix asphalt paving handbook 2000 (reprint). U.S. Department of Transportation.

Gurmu, A. T., & Mahmood, M. N. (2024). Critical factors affecting quality in building construction projects: Systematic review and meta-analysis. Journal of Construction Engineering and Management, 150(3).

Hu, W., Scullion, T., Nazarian, S., & Zheng, J. (2017). Recommendations on intelligent compaction parameters for asphalt resurfacing quality evaluation. Journal of Construction Engineering and Management, 143(11), 04017077.

Hu, W., Scullion, T., Zollinger, D., & Nazarian, S. (2019). Investigating key factors of intelligent compaction for hot-mix asphalt pavements. Construction and Building Materials, 211, 572–583.

Huang, Y. H. (2004). Pavement analysis and design (2nd ed.). Pearson Prentice Hall.

Imran, U., Khurshid, M. B., Khan, U., & Ahmed, S. (2025). Developing a quality index for pavement construction and rehabilitation. Journal of Asian Architecture and Building Engineering.

International Organization for Standardization. (2015). ISO 9000:2015: Quality management systems — Fundamentals and vocabulary.

Jogdand, S. M., & Deshmukh, S. G. (2017). Development of building quality measurement tool: Building Construction Quality Index (BCQI). International Journal of Civil Engineering and Technology, 8(4), 995–1004.

Juran, J. M., & Godfrey, A. B. (Eds.). (1999). Juran’s quality handbook (5th ed.). McGraw-Hill.

Ksaibati, K., Miley, W., & Armaghani, D. J. (2003). Evaluating the impact of QC/QA programs on asphalt pavement performance. Transportation Research Record, 1832(1), 29–37.

Kusi, M., Zhao, X., & Rasdorf, W. (2018). Assessment of construction quality practices in Nepal. Construction Research Congress 2018.

Liu, Y., Su, P., Li, M., You, Z., & Zhao, M. (2020). Review on evolution and evaluation of asphalt pavement structures and materials. Journal of Traffic and Transportation Engineering (English Edition), 7(5), 573–599.

Lu, X., Tighe, S., Jiang, Y., & Morosiuk, G. (2018). Development of pavement performance evaluation indicators: A review. International Journal of Pavement Engineering, 19(6), 495–512.

Ma, Y., Xu, Q., Scullion, T., & Hu, W. (2022). Assessment of intelligent compaction quality evaluation index for asphalt pavement. Journal of Performance of Constructed Facilities, 36(3), 04022017.

Mallick, R. B., & El-Korchi, T. (2018). Pavement engineering: Principles and practice (3rd ed.). CRC Press.

Mendoza-Sanchez, J. F., Castro-Fresno, D., & Lopez, A. (2024). A critical review of pavement design methods based on a sustainability approach. Sustainability, 16(16), 7211.

Mishra, A. K. (2020). Assessment of quality management practices in Nepalese construction projects. Journal of Advanced Research in Civil and Environmental Engineering, 7(3), 1–8.

Raposeiras, A. C., Vega-Zamanillo, Á., Calzada-Pérez, M. Á., & Castro-Fresno, D. (2013). Test methods and influential factors for analysis of bonding between bituminous pavement layers. Construction and Building Materials, 43, 360–369.

Roberts, F. L., Kandhal, P. S., Brown, E. R., Lee, D.-Y., & Kennedy, T. W. (1991). Hot mix asphalt materials, mixture design, and construction (2nd ed.). NAPA.

Shahin, M. Y. (2005). Pavement management for airports, roads, and parking lots (2nd ed.). Springer.

Song, L., Mohamed, Y., & AbouRizk, S. M. (2006). Early contractor involvement in design and its impact on construction quality. Journal of Management in Engineering, 22(4), 183–190.

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach’s alpha. International Journal of Medical Education, 2, 53–55.

Umair, M., Shafiq, N., & Liew, M. S. (2015). Development of quality assessment system for construction projects using multi-criteria decision analysis. Journal of Construction Engineering and Management, 141(3), 04014079.

Umashankar, B., Hariprasad, C. H., & Reddy, M. A. (2016). Compaction quality control of pavement layers using light weight deflectometer. Journal of Materials in Civil Engineering, 28(7), 04016029.

Wang, J., Yuan, J., Kim, Y. R., & Xiao, F. (2018). Review on application of tack coat in pavement engineering. Construction and Building Materials, 152, 210–222.

Xu, Q., Chang, G. K., Gallivan, V. L., & Gransberg, D. D. (2012). Influences of intelligent compaction uniformity on pavement performance. Construction and Building Materials, 30, 746–752.

Yoder, E. J., & Witczak, M. W. (1975). Principles of pavement design (2nd ed.). John Wiley & Sons.

Yoon, S., Prezzi, M., Siddiki, N. Z., & Kim, B. (2018). Suitability of intelligent compaction for asphalt pavement quality control. International Journal of Pavement Engineering, 19(4), 298–310.

APPENDIX A: SURVEY QUESTIONNAIRE

Section 1: Demographic Information

Please tick (✓) the appropriate option or fill in the information:

Name: ____

Gender: ☐ Male ☐ Female ☐ Other

Sector of work: ☐ Government ☐ Private ☐ Both

Primary role in projects:

☐ Project Manager ☐ Engineer ☐ Sub-Engineer ☐ Consultant

☐ Quality Control / Lab Technician ☐ Contractor ☐ Other:

____

Years of experience in road/pavement construction:

☐ Less than 5 years ☐ 6–10 years ☐ 11–20 years ☐ More than 20 years

Section 2: Construction Practice Factors

Below are the main factors related to construction practices, along with their sub-factors. Please rate each factor according to its **importance in affecting the quality of pavement construction** using the following 5-point Likert scale:

Scale	Meaning
1	Irrelevant
2	Not so important
3	Important to some extent
4	Significant
5	Extremely important

FACTOR 1: SUBGRADE PREPARATION

No.	Sub-factor	1	2	3	4	5
1.1	Achievement of required compaction/density	☐	☐	☐	☐	☐
1.2	Uniformity of moisture content during compaction	☐	☐	☐	☐	☐
1.3	Removal of topsoil, vegetation, and unsuitable materials	☐	☐	☐	☐	☐
1.4	Grading to required levels and	☐	☐	☐	☐	☐

	cross-slope					
1.5	Treatment of weak or expansive soils	☐	☐	☐	☐	☐

FACTOR 2: SUBBASE AND BASE COURSE CONSTRUCTION

No.	Sub-factor	1	2	3	4	5
2.1	Achievement of specified layer thickness	☐	☐	☐	☐	☐
2.2	Achievement of required compaction/density	☐	☐	☐	☐	☐
2.3	Proper grading and particle size distribution of material	☐	☐	☐	☐	☐
2.4	Rectification of irregular /non-conforming areas	☐	☐	☐	☐	☐
2.5	Control of moisture content during compaction	☐	☐	☐	☐	☐
2.6	Checking surface evenness/smoothness after compaction with a straightedge	☐	☐	☐	☐	☐
2.7	Adherence to design cross-slope and grade	☐	☐	☐	☐	☐

FACTOR 3: SURFACE PREPARATION BEFORE PAVING

No.	Sub-factor	1	2	3	4	5
3.1	Removal of dust, dirt, and debris from the base before paving	☐	☐	☐	☐	☐
3.2	Proper use of cleaning equipment (e.g. air compressors, mechanical sweepers)	☐	☐	☐	☐	☐
3.3	Ensuring the surface is completely dry before paving	☐	☐	☐	☐	☐
3.4	Use of hand brooms to remove material remaining after air blowing	☐	☐	☐	☐	☐

FACTOR 4: PRIME/TACK COAT APPLICATION

No.	Sub-factor	1	2	3	4	5
4.1	Using prime/tack coat material that meets specifications	☐	☐	☐	☐	☐

4.2	Ensuring surface cleanliness and proper preparation before prime/tack coat	☐	☐	☐	☐	☐
4.3	Uniform distribution of the asphaltic prime/tack coat	☐	☐	☐	☐	☐
4.4	Accurate control of application rate (thickness) of the coat	☐	☐	☐	☐	☐
4.5	Providing adequate curing/rest time (e.g. 24 hours) after prime coat	☐	☐	☐	☐	☐
4.6	Ensuring proper nozzle condition for uniform spraying	☐	☐	☐	☐	☐

FACTOR 5: PAVING PRACTICES

No.	Sub-factor	1	2	3	4	5
5.1	Using paving methods/settings that achieve the desired design profile	☐	☐	☐	☐	☐
5.2	Placing asphalt promptly to minimize heat loss before compaction	☐	☐	☐	☐	☐
5.3	Setting the paver with proper compaction settings, cross-slope and vibration	☐	☐	☐	☐	☐
5.4	Spreading asphalt mixture to the required line and level with paver	☐	☐	☐	☐	☐
5.5	Setting the screed for initial compaction and correct surface profile	☐	☐	☐	☐	☐
5.6	Visually inspecting the Asphalt mix on the paver and after placement (before rolling)	☐	☐	☐	☐	☐
5.7	Maintaining uniform layer thickness of the asphalt mat	☐	☐	☐	☐	☐
5.8	Using automatic screed control (if available) to maintain uniformity	☐	☐	☐	☐	☐
5.9	Laying all lanes on one side of the median simultaneously to avoid	☐	☐	☐	☐	☐

	cold joints					
5.10	Keeping the paver hopper adequately filled during continuous paving	☐	☐	☐	☐	☐
5.11	Maintaining the design cross slope for proper surface water runoff	☐	☐	☐	☐	☐

FACTOR 6: COMPACTION PRACTICES

No.	Sub-factor	1	2	3	4	5
6.1	Achieving 97-98% of laboratory compaction density in field	☐	☐	☐	☐	☐
6.2	Maintaining uniform/slow speed of tandem rollers and Pneumatic Tire Roller during rolling	☐	☐	☐	☐	☐
6.3	Light moistening of roller wheels with water	☐	☐	☐	☐	☐
6.4	Checking pavement smoothness with a straightedge after compaction	☐	☐	☐	☐	☐
6.5	Minimizing transverse joints during rolling	☐	☐	☐	☐	☐
6.6	Overlapping successive roller passes adequately	☐	☐	☐	☐	☐
6.7	Adhering to specified initial and breakdown rolling temperatures	☐	☐	☐	☐	☐
6.8	Following the correct pattern/sequence of compaction	☐	☐	☐	☐	☐
6.9	Performing finish rolling to remove roller marks before cessation temperature	☐	☐	☐	☐	☐
6.10	Carrying out secondary/intermediate rolling with Pneumatic Tire Roller	☐	☐	☐	☐	☐
6.11	Applying sufficient contact pressure in rollers for proper compaction	☐	☐	☐	☐	☐

FACTOR 7: EXECUTION OF JOINTS

No.	Sub-factor	1	2	3	4	5
7.1	Ensuring cleanliness (no dirt or foreign matter) at joints before placing mix	☐	☐	☐	☐	☐
7.2	Matching thickness, density and uniformity of both mats at hot joints	☐	☐	☐	☐	☐
7.3	Cutting joint edges with suitable cutters for a clean finish	☐	☐	☐	☐	☐
7.4	Cutting longitudinal edge to full depth for cold joints	☐	☐	☐	☐	☐
7.5	Cutting of previous run to expose full depth at transverse joint	☐	☐	☐	☐	☐
7.6	Ensuring absence of bumps at joints (smooth riding transition)	☐	☐	☐	☐	☐
7.7	Staggering transverse joints between successive asphalt layers	☐	☐	☐	☐	☐
7.8	Painting vertical joint face with approved bitumen before adjoining mix	☐	☐	☐	☐	☐

FACTOR 8: TRANSPORTATION OF MATERIAL

No.	Sub-factor	1	2	3	4	5
8.1	Maintaining required HMA temperature during loading, hauling, laying and compaction	☐	☐	☐	☐	☐
8.2	Avoiding segregation or lumping of asphalt mix during transport	☐	☐	☐	☐	☐
8.3	Conducting visual inspection and necessary tests on delivered asphalt mix	☐	☐	☐	☐	☐

8.4	Ensuring truck/dumper bed is clean before loading HMA	☐	☐	☐	☐	☐
8.5	Coating truck bed with a release agent to prevent mix sticking	☐	☐	☐	☐	☐
8.6	Maintaining continuous, uniform supply of HMA from plant to paving site	☐	☐	☐	☐	☐

APPENDIX B: SITE OBSERVATION CHECKLIST

Factor 1: Subgrade Preparation

Code	Sub-factor	Scoring criteria	Field score	Remarks
1.1	Achievement of required compaction/density	1.00 = required compaction achieved; 0.75 = slight deviation; 0.50 = partially achieved; 0.25 = poor compaction; 0.00 = not achieved.		
1.2	Uniformity of moisture content during compaction	1.00 = moisture uniformly maintained; 0.75 = minor variation; 0.50 = moderate variation; 0.25 = major variation; 0.00 = no proper control.		
1.3	Removal of topsoil, vegetation, and unsuitable materials	1.00 = fully removed; 0.75 = minor remaining material; 0.50 = partially removed; 0.25 = poorly removed; 0.00 = not removed.		
1.4	Grading to required levels and cross-slope	1.00 = grading and cross-slope fully achieved; 0.75 = minor deviation; 0.50 = moderate deviation; 0.25 = major deviation; 0.00 = not achieved.		
1.5	Treatment of weak or expansive soils	1.00 = proper treatment provided; 0.75 = minor deficiency; 0.50 = partially treated; 0.25 = inadequate treatment; 0.00 = no treatment where required.		

Factor 2: Subbase and Base Course Construction

Code	Sub-factor	Scoring criteria	Field score	Remarks
2.1	Achievement of specified layer thickness	1.00 = thickness fully achieved; 0.75 = slight deviation; 0.50 = moderate deviation; 0.25 = major deviation; 0.00 = unacceptable.		

Code	Sub-factor	Scoring criteria	Field score	Remarks
2.2	Achievement of required compaction/density	1.00 = required density achieved; 0.75 = slight deviation; 0.50 = partially achieved; 0.25 = poor compaction; 0.00 = not achieved.		
2.3	Proper grading and particle size distribution of material	1.00 = fully conforms to specification; 0.75 = minor deviation; 0.50 = moderate deviation; 0.25 = poor conformity; 0.00 = non-conforming.		
2.4	Rectification of irregular /non-conforming areas	1.00 = fully rectified; 0.75 = mostly rectified; 0.50 = partially rectified; 0.25 = poorly rectified; 0.00 = not rectified.		
2.5	Control of moisture content during compaction	1.00 = moisture properly controlled; 0.75 = minor variation; 0.50 = moderate variation; 0.25 = poor control; 0.00 = not controlled.		
2.6	Checking surface evenness/smoothness after compaction with a straightedge	1.00 = properly checked and meets requirement; 0.75 = slight unevenness; 0.50 = moderate unevenness; 0.25 = poor evenness; 0.00 = not checked or unacceptable.		
2.7	Adherence to design cross-slope and grade	1.00 = fully maintained; 0.75 = minor deviation; 0.50 = moderate deviation; 0.25 = poor compliance; 0.00 = not maintained.		

Factor 3: Surface Preparation Before Paving

Code	Sub-factor	Scoring criteria	Field score	Remarks
3.1	Removal of dust, dirt, and debris from the base before paving	1.00 = fully clean; 0.75 = slight remaining dust/debris; 0.50 = partially cleaned; 0.25 = poorly cleaned; 0.00 = not cleaned.		
3.2	Proper use of cleaning equipment (e.g. air compressors, mechanical sweepers)	1.00 = properly used; 0.75 = minor deficiency; 0.50 = partially used; 0.25 = poorly used; 0.00 = not used where required.		
3.3	Ensuring the surface is completely dry before paving	1.00 = completely dry; 0.75 = slight moisture present; 0.50 = partially dry; 0.25 = significantly wet; 0.00 = paving done on wet surface.		
3.4	Use of hand brooms to remove material remaining after air blowing	1.00 = properly done; 0.75 = minor deficiency; 0.50 = partially done; 0.25 = poorly done; 0.00 = not done.		

Factor 4: Prime/Tack Coat Application

Code	Sub-factor	Scoring criteria	Field score	Remarks
4.1	Using prime/tack coat material that meets specifications	1.00 = fully meets specification; 0.75 = minor deviation; 0.50 = partly conforms; 0.25 = doubtful quality; 0.00 = non-conforming material.		
4.2	Ensuring surface cleanliness and proper preparation before prime/tack coat	1.00 = fully prepared and clean; 0.75 = minor deficiency; 0.50 = partially prepared; 0.25 = poorly prepared; 0.00 = not prepared.		
4.3	Uniform distribution of the asphaltic prime/tack coat	1.00 = fully uniform; 0.75 = slight non-uniformity; 0.50 = moderate non-uniformity; 0.25 = poor distribution; 0.00 = not properly distributed.		

Code	Sub-factor	Scoring criteria	Field score	Remarks
4.4	Accurate control of application rate (thickness) of the coat	1.00 = accurately controlled; 0.75 = slight variation; 0.50 = moderate variation; 0.25 = poor control; 0.00 = uncontrolled or unacceptable.		
4.5	Providing adequate curing/rest time (e.g. 24 hours) after prime coat	1.00 = adequate time provided; 0.75 = slight deficiency; 0.50 = partial compliance; 0.25 = inadequate time; 0.00 = not provided.		
4.6	Ensuring proper nozzle condition for uniform spraying	1.00 = proper nozzle condition maintained; 0.75 = minor issue; 0.50 = moderate issue; 0.25 = poor nozzle condition; 0.00 = unsuitable condition.		

Factor 5: Paving Practices

Code	Sub-factor	Scoring criteria	Field score	Remarks
5.1	Using paving methods/settings that achieve the desired design profile	1.00 = design profile achieved; 0.75 = minor deviation; 0.50 = moderate deviation; 0.25 = poor control; 0.00 = not achieved.		
5.2	Placing asphalt promptly to minimize heat loss before compaction	1.00 = prompt placement with proper temperature retention; 0.75 = slight delay; 0.50 = moderate delay; 0.25 = serious delay; 0.00 = severe heat loss.		
5.3	Setting the paver with proper compaction settings, cross-slope and vibration	1.00 = settings properly maintained; 0.75 = minor issue; 0.50 = partial compliance; 0.25 = poor setting; 0.00 = improper setting.		
5.4	Spreading asphalt mixture to the required line and level with paver	1.00 = line and level maintained; 0.75 = slight deviation; 0.50 = moderate deviation; 0.25 = poor control; 0.00 = unacceptable.		

Code	Sub-factor	Scoring criteria	Field score	Remarks
5.5	Setting the screed for initial compaction and correct surface profile	1.00 = properly set; 0.75 = minor issue; 0.50 = partial compliance; 0.25 = poor setting; 0.00 = improperly set.		
5.6	Visually inspecting the asphalt mix on the paver and after placement (before rolling)	1.00 = regularly and properly inspected; 0.75 = minor deficiency; 0.50 = partly done; 0.25 = poorly done; 0.00 = not done.		
5.7	Maintaining uniform layer thickness of the asphalt mat	1.00 = uniform thickness maintained; 0.75 = slight variation; 0.50 = moderate variation; 0.25 = poor uniformity; 0.00 = unacceptable variation.		
5.8	Using automatic screed control (if available) to maintain uniformity	1.00 = properly used; 0.75 = minor deficiency; 0.50 = partial use; 0.25 = poor use; 0.00 = not used where available.		
5.9	Laying all lanes on one side of the median simultaneously to avoid cold joints	1.00 = fully followed where applicable; 0.75 = minor issue; 0.50 = partially followed; 0.25 = poorly followed; 0.00 = not followed.		
5.10	Keeping the paver hopper adequately filled during continuous paving	1.00 = hopper properly maintained; 0.75 = minor interruption; 0.50 = occasional shortage; 0.25 = frequent shortage; 0.00 = poor continuity.		
5.11	Maintaining the design cross slope for proper surface water runoff	1.00 = fully maintained; 0.75 = slight deviation; 0.50 = moderate deviation; 0.25 = poor compliance; 0.00 = not maintained.		

Factor 6: Compaction Practices

Code	Sub-factor	Scoring criteria	Field score	Remarks
6.1	Achieving 97–98% of laboratory compaction density in field	1.00 = target achieved; 0.75 = slightly below target; 0.50 = partially achieved; 0.25 = poor achievement; 0.00 = not achieved.		
6.2	Maintaining uniform/slow speed of tandem rollers and pneumatic tire roller during rolling	1.00 = speed properly controlled; 0.75 = minor variation; 0.50 = moderate inconsistency; 0.25 = poor control; 0.00 = uncontrolled.		
6.3	Light moistening of roller wheels with water	1.00 = properly done; 0.75 = minor deficiency; 0.50 = partially done; 0.25 = poorly done; 0.00 = not done or improperly done.		
6.4	Checking pavement smoothness with a straightedge after compaction	1.00 = properly checked and meets requirement; 0.75 = slight unevenness; 0.50 = moderate unevenness; 0.25 = poor smoothness; 0.00 = not checked or unacceptable.		
6.5	Minimizing transverse joints during rolling	1.00 = properly minimized; 0.75 = minor issue; 0.50 = moderate issue; 0.25 = poorly controlled; 0.00 = not controlled.		
6.6	Overlapping successive roller passes adequately	1.00 = adequate overlap maintained; 0.75 = minor deficiency; 0.50 = moderate deficiency; 0.25 = poor overlap; 0.00 = improper overlap.		
6.7	Adhering to specified initial and breakdown rolling temperatures	1.00 = temperature properly maintained; 0.75 = slight deviation; 0.50 = moderate deviation; 0.25 = poor control; 0.00 = not maintained.		

Code	Sub-factor	Scoring criteria	Field score	Remarks
6.8	Following the correct pattern/sequence of compaction	1.00 = correct sequence followed; 0.75 = minor deviation; 0.50 = moderate deviation; 0.25 = poor sequence; 0.00 = incorrect sequence.		
6.9	Performing finish rolling to remove roller marks before cessation temperature	1.00 = fully done; 0.75 = slight deficiency; 0.50 = partially done; 0.25 = poorly done; 0.00 = not done.		
6.10	Carrying out secondary/intermediate rolling with Pneumatic Tire Roller	1.00 = properly done; 0.75 = minor issue; 0.50 = partial compliance; 0.25 = poorly done; 0.00 = not done where required.		
6.11	Applying sufficient contact pressure in rollers for proper compaction	1.00 = sufficient pressure maintained; 0.75 = slight deficiency; 0.50 = moderate deficiency; 0.25 = poor pressure; 0.00 = insufficient pressure.		

Factor 7: Execution of Joints

Code	Sub-factor	Scoring criteria	Field score	Remarks
7.1	Ensuring cleanliness (no dirt or foreign matter) at joints before placing mix	1.00 = fully clean; 0.75 = minor dirt present; 0.50 = partially clean; 0.25 = poorly cleaned; 0.00 = not cleaned.		
7.2	Matching thickness, density and uniformity of both mats at hot joints	1.00 = proper matching achieved; 0.75 = slight mismatch; 0.50 = moderate mismatch; 0.25 = poor matching; 0.00 = unacceptable.		
7.3	Cutting joint edges with suitable cutters for a clean finish	1.00 = properly cut; 0.75 = minor deficiency; 0.50 = partly proper; 0.25 = poor finish; 0.00 = not properly cut.		

Code	Sub-factor	Scoring criteria	Field score	Remarks
7.4	Cutting longitudinal edge to full depth for cold joints	1.00 = fully achieved; 0.75 = slight deficiency; 0.50 = partial depth; 0.25 = poor cutting; 0.00 = not done.		
7.5	Cutting of previous run to expose full depth at transverse joint	1.00 = fully achieved; 0.75 = slight deficiency; 0.50 = partial depth; 0.25 = poor cutting; 0.00 = not done.		
7.6	Ensuring absence of bumps at joints (smooth riding transition)	1.00 = smooth transition achieved; 0.75 = slight irregularity; 0.50 = moderate irregularity; 0.25 = major bump; 0.00 = unacceptable joint condition.		
7.7	Staggering transverse joints between successive asphalt layers	1.00 = properly staggered; 0.75 = minor issue; 0.50 = partially staggered; 0.25 = poorly staggered; 0.00 = not staggered.		
7.8	Painting vertical joint face with approved bitumen before adjoining mix	1.00 = properly done; 0.75 = minor deficiency; 0.50 = partially done; 0.25 = poorly done; 0.00 = not done.		

Factor 8: Transportation of Asphalt Mixtures

Code	Sub-factor	Scoring criteria	Field score	Remarks
8.1	Maintaining required HMA temperature during loading, hauling, laying and compaction	1.00 = temperature maintained throughout; 0.75 = slight heat loss; 0.50 = moderate heat loss; 0.25 = major heat loss; 0.00 = unacceptable temperature loss.		
8.2	Avoiding segregation or lumping of asphalt mix during transport	1.00 = no segregation or lumping; 0.75 = slight sign of segregation; 0.50 = moderate segregation; 0.25 = severe segregation; 0.00 = unacceptable mix condition.		

Code	Sub-factor	Scoring criteria	Field score	Remarks
8.3	Conducting visual inspection and necessary tests on delivered asphalt mix	1.00 = properly checked; 0.75 = minor deficiency; 0.50 = partly checked; 0.25 = poorly checked; 0.00 = not checked.		
8.4	Ensuring truck/dumper bed is clean before loading HMA	1.00 = fully clean; 0.75 = minor contamination risk; 0.50 = partly clean; 0.25 = poorly cleaned; 0.00 = not clean.		
8.5	Coating truck bed with a release agent to prevent mix sticking	1.00 = properly applied; 0.75 = slight deficiency; 0.50 = partially applied; 0.25 = poorly applied; 0.00 = not applied.		
8.6	Maintaining continuous, uniform supply of HMA from plant to paving site	1.00 = continuous and uniform supply maintained; 0.75 = minor interruption; 0.50 = moderate interruption; 0.25 = frequent interruption; 0.00 = poor supply continuity.		

APPENDIX C: RESPONDENT PROFILE AND DEMOGRAPHIC DATA

Table C.1: Respondents' Data

Category	Count
Online form	41
Physical form	36
Total Response Received	77

Table C.2: Gender Profile

Gender	Frequency	Percentage
Male	56	72.7
Female	21	27.3
Total	77	100.0

Table C.3: Sector Profile

Sector	Frequency	Percentage
Government	43	55.8
Private	33	42.9
Both	1	1.3
Total	77	100.0

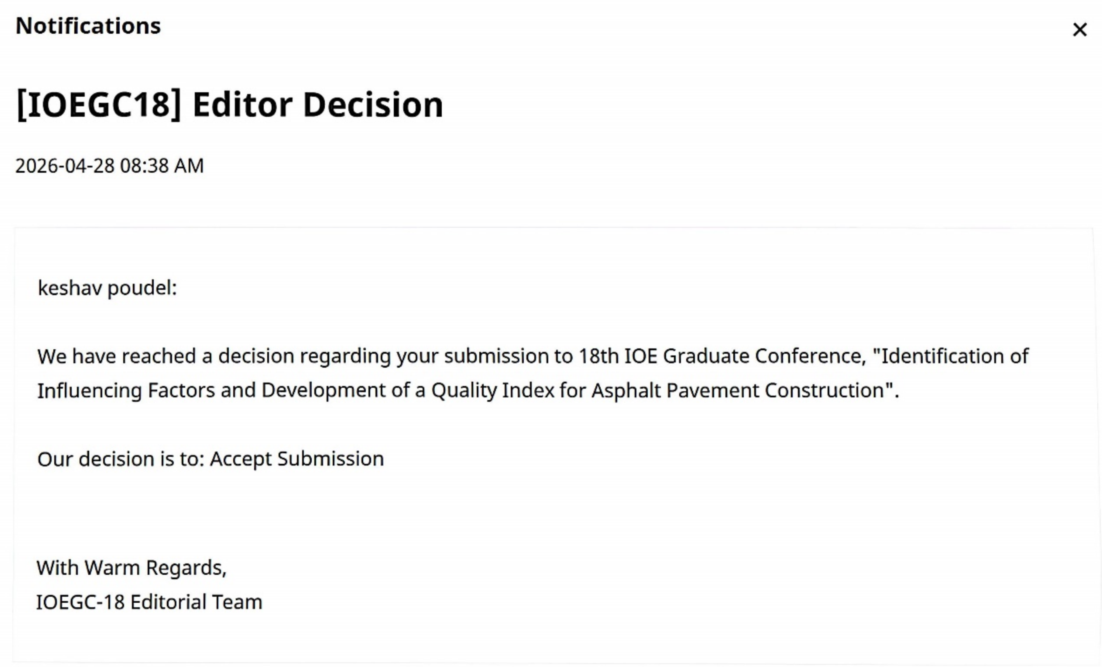
Table C.4: Job Title

Category	Count
Project Manager	4
Engineer	37
Sub Engineer	13
QC/Lab Technician	7
Consultant	5
Contractor	10
Other	1
Total	77

Table C.5: Experience

Category	Count
Less than 5 years	24
6 to 10 years	23
11 to 20 years	26
More than 20 years	4
Total	77

ANNEX I: ACCEPTANCE LETTER FOR 18th IOE GRADUATE CONFERENCE



[IOEGC18] Editor Decision

2026-04-28 08:38 AM

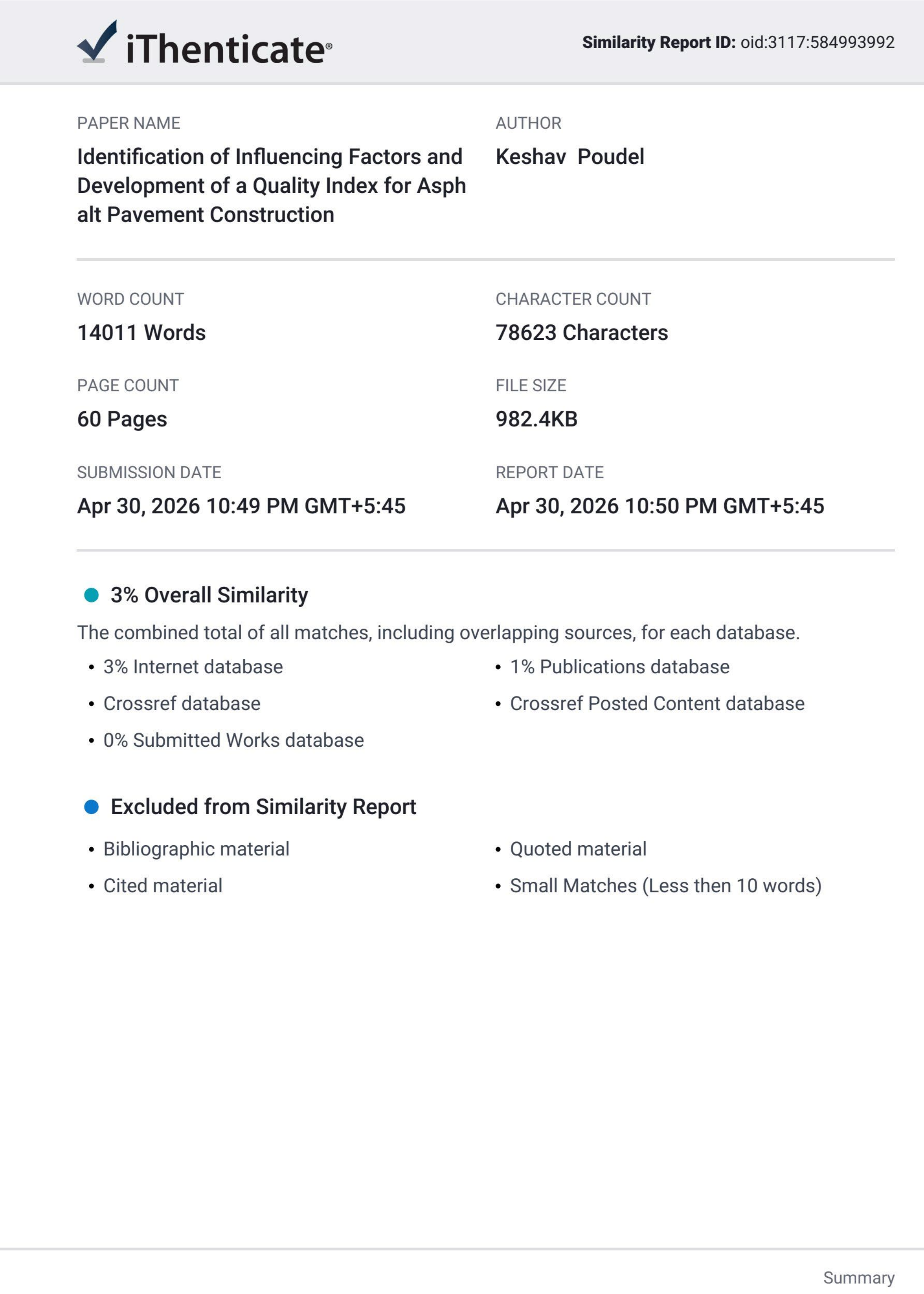
keshav poudel:

We have reached a decision regarding your submission to 18th IOE Graduate Conference, "Identification of Influencing Factors and Development of a Quality Index for Asphalt Pavement Construction".

Our decision is to: Accept Submission

With Warm Regards,
IOEGC-18 Editorial Team

ANNEX II: ORIGINALITY REPORT



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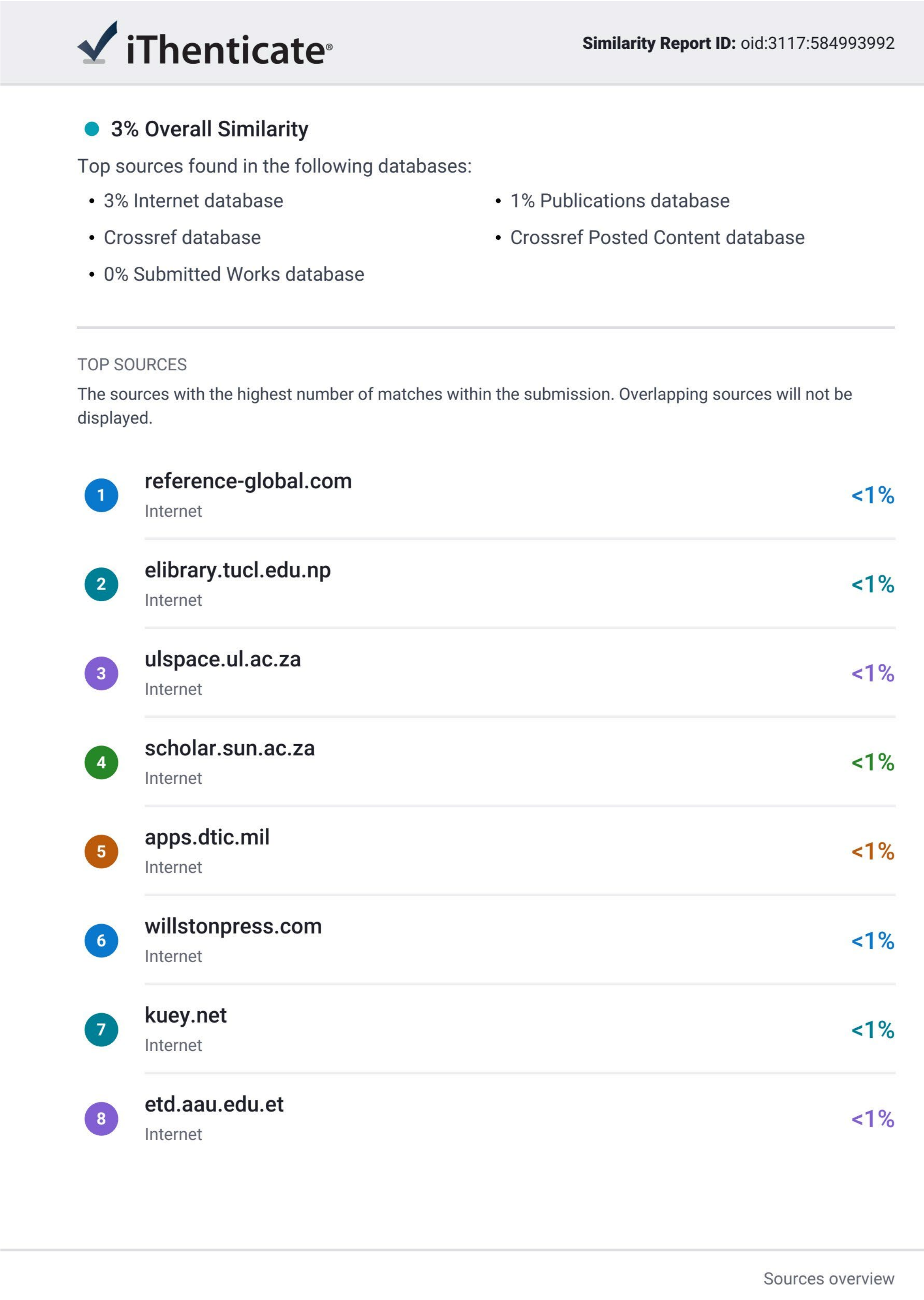

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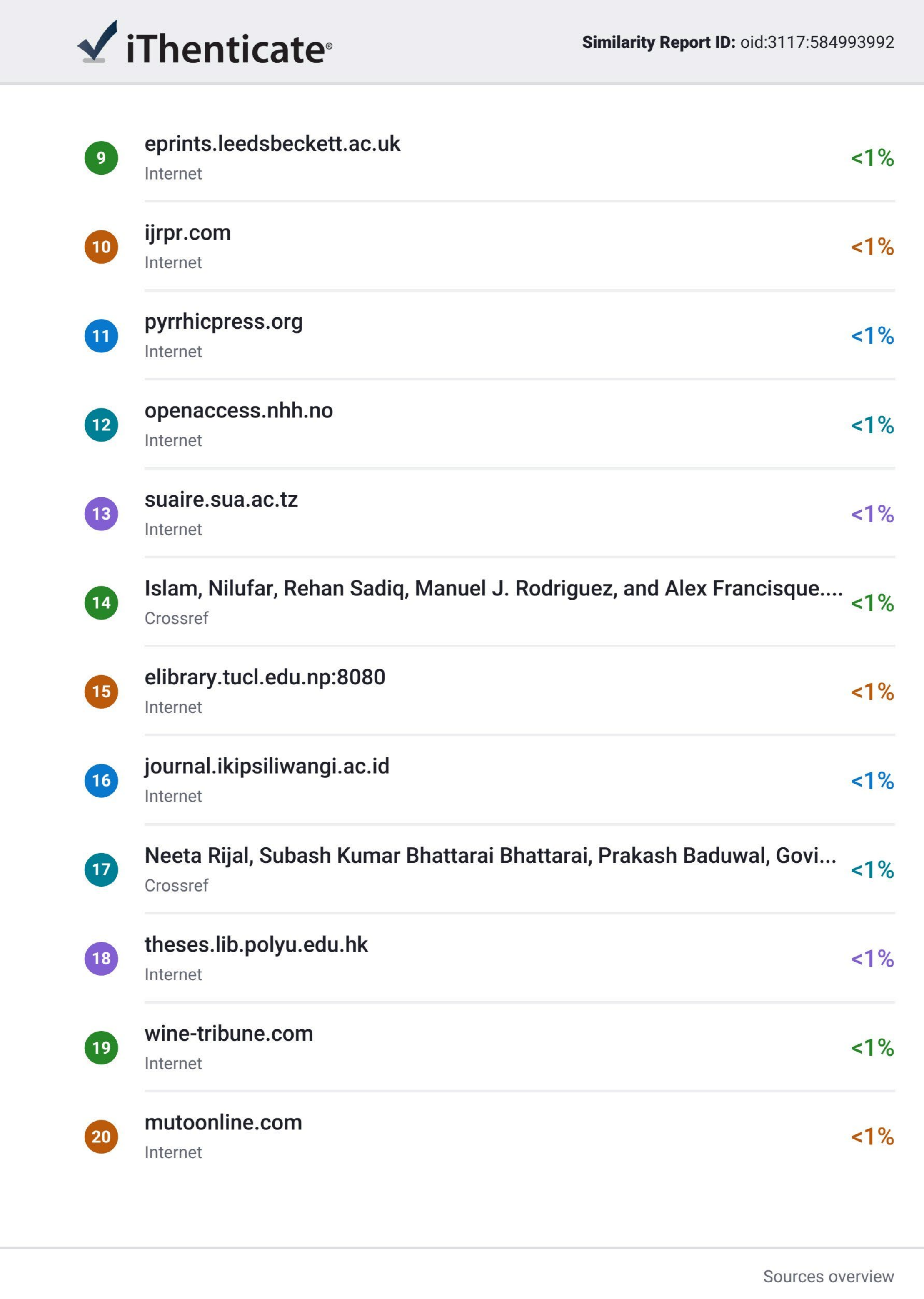

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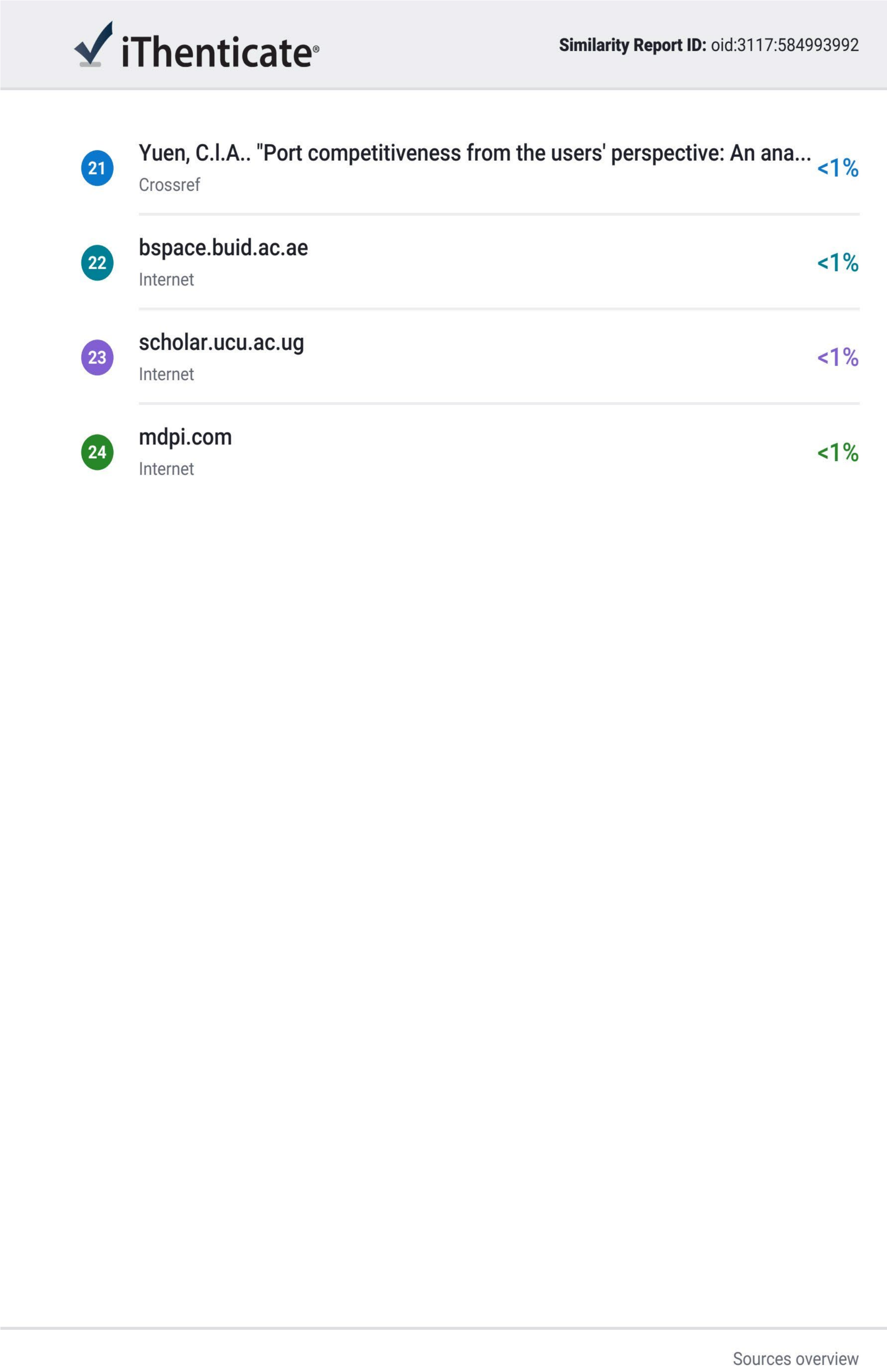

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