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Faculty of Graduate Studies

Evaluation of the Quality Management System of Highway Projects in the Northern West Bank

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This Thesis is Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Roads and Transportation Engineering, Faculty of Graduate Studies, An-Najah National University, Nablus, Palestine.

2021

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Dedication

This thesis is dedicated with special thanks:

To my Mother, Father, Brothers and Sisters for their unlimited support.

To my husband “Ahmad” for his continuous encouragement.

To my daughters Meral and Loure.

To all of my friends.

For their support and encouragement to achieve this work.

Acknowledgment

After thanking Allah, the Merciful, the Graceful who generated me the power and courage to finish this work. I would like to express my special thanks to Dr. Khaled Al-Sahili for the continuous support in accomplishing this thesis; for his motivation and encouragement.

I would like to express my special thanks to Dr. Amjad Issa for his assistance throughout the research.

I would like also to express my gratitude and deep appreciation to MDLF staff for their support and assistance.

الاقرار

أنا الموقعة أدناه مقدمة الرسالة التي تحمل العنوان:

Evaluation of the Quality Management System of Highway Projects in the Northern West Bank

تقييم نظام إدارة الجودة في مشاريع الطرق في شمال الضفة الغربية

أقر بأن ما اشتملت عليه هذه الرسالة إنما هي نتاج جهدي الخاص، باستثناء ما تمت الإشارة إليه حيثما ورد، وإن هذه الرسالة ككل، أو أي جزء منها لم يقدم من قبل لنيل أية درجة عملية أو بحث علمي لدى أي مؤسسة تعليمية أو بحثية أخرى.

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's name: **اسم الطالبة:** أريج نبيل حسن

Signature: **التوقيع:**

Date: **التاريخ:** 4/10/2021

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List of Abbreviations

ASCE	American Society of Civil Engineers
ISO	International Organization for Standardization
FHWA	Federal Highway Administration
LGUs	Local Government Units
MDLF	Municipal Development and Lending Fund
MPWH	Ministry of Public Works and Housing
PCBS	Palestinian Central Bureau of Statistics
PCI	Pavement Condition Index
PNA	Palestinian National Authority
QA	Quality Assurance
QC	Quality Control
QMS	Quality Management System
RII	Relative Important Index
TQM	Total Quality Management
UNRWA	United Nations Relief and Work Agency

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Abstract

In Palestine, there is limited documentation concerning quality management system in construction projects in general, and in highway construction at specific. The lack of specialized studies for this purpose could be attributed to the lack of awareness in quality and their importance in construction in light of economic, social, and political challenges that encounter the Palestinian situation, especially with shrinking budget and the lack of reliable data. Therefore, this study is done to explore the quality management system in highway construction project and to highlight the main factors affecting their quality in the northern West Bank.

Field surveys and a questionnaire were used for data collection. The population under study is made up of highway contractors and consultants who are actively associated with the construction activities and possess sufficient experience in the field of construction. Thirty-seven factors are identified to affect the quality of road projects; subdivided into five groups: managerial, design- and specifications, construction, quality, and environmental factors.

Statistical analyses showed that the critical factors that affect highway construction project's quality are: quality and type of used asphalt, contractor's experience, availability of experienced staff in the owner's and contractor's teams, construction process used for asphalt layers, and design errors.

Pavement roadway condition survey was done visually to twenty-five roads distributed in the northern governments in the West Bank to evaluate roads with an age of less than five years. Common distresses observed in the field were alligator, longitudinal cracks, depression, and patching. These distresses show defects in the construction process of different layers, inaccurate design, and/or weak affective coordination in executing the infrastructure works.

A model has been developed using Pareto approach. The model represents the critical factors of quality in highway projects to be used as a tool to determine important factors of road construction projects to solve or avoid problems and to improve the performance.

The study recommends contracting and consulting firms involved in road construction projects to develop a quality management system to meet the requirements of international quality standards. This also includes a management system for equipment, materials, and labors. The owner should select the most qualified contractors not based on the lowest bidder; rather based on qualified, experienced, and efficient site staff with the team.

Chapter One

Introduction

Chapter One

Introduction

1.1 Background

1.1.1 General

Road transportation plays an essential role in the life of any community today, and it is important in the socio-economic development of the country. Therefore, Palestine rehabilitated and established a network of roads connecting most of the cities and villages in the West Bank and Gaza Strip. In 2015 the national road network length in the West Bank was 3,674.6 km as was reported by the Palestinian Central Bureau of Statistics (PCBS, 2016). It reached 3847.1 km in 2018 (PCBS, 2019), and 3,922 Km in 2019 (PCBS, 2020); meaning that there is a continuous increase over the years. In addition to the importance of expanding roadway network, one should pay attention to its quality to ensure its durability and safety of road users.

Quality is a process that includes everything from planning to the final product. The performance of key players in highway projects is equally important. To produce good quality pavement, specifications are important tools to be concerned with. Specifications describe what is expected from the contractors in terms of materials, workmanship, and other general requirements. Therefore, they should be understandable for both the contractors and the highway agencies.

In addition to this, designers should be competent and be able to produce the optimum road design for the roadway conditions and requirements.

Supervisor engineers should also be competent and be keen to supervise the projects and make sure all are done according to specifications and requirements. The contractors should have the proper experience and equipment to produce the required roads project. The quality control procedure should be well established and testing laboratory should have the knowledge and capacity, as well as the integrity to conduct the quality control procedure. The funding agency and the project's owner should have clear contracts showing the required project and specifications, etc.

Quality may mean different thing for difference people. Some see it as an approved design or construction standards, and others may consider it as less congestion and safer roadways. In short, it is the end result that adds value to everything else.

"Highway quality is all about achieving the shared goal of building, preserving, and maintaining better roadways" (FHWA, 2007). As we face serious challenges in terms of traffic growth, increased roadway congestion, improper traffic management, environmental concerns, limited funding, failing infrastructure, and limited work force, the quality of highways becomes critically important. Therefore, attention to quality in order to get the highest performance possible from the highway projects becomes critically important.

To evaluate road quality projects, road engineer need to check the finished state of a project and its conformance with the design requirements and specifications. Quality –related problems can be projected on the operating life of the highway if their non-conformance occurs. To the contractor, non-conformance can yield penalties, as well as cost and time burdens for rework.

It also results in road user's and owner dissatisfaction, which may show as safety, service, and economy related problem. Quality related problems could be eliminated or prevented in early stages when an effective quality management system is in place.

1.2 Problem Definition

In Palestine, there is little documentation concerning highway quality management system in general. It might be difficult to perform such studies under the exiting economic, social, and political challenges in the country.

As a result of the Israeli occupation, the Israelis paved and built roads to serve their settlement goals and most of these roads are not allowed for Palestinians to use. On the other hand, the roads paved in the Palestinian areas were not built on the basis of economic feasibility and did not take into account the shortest distances between urbanized communities.

The Palestinian National Authority (PNA) has been established in 1994. Since then, the road sector has witnessed a remarkable growth as PNA worked to rehabilitate, develop, and construct road networks that link most Palestinian cities and villages; there are road networks that are partially capable of meeting the needs of the Palestinian community. Most of the road projects implemented depend on financial funding from external assistance because of weak economy; therefore, if we have a highway quality with continuous maintenance, we would guarantee durability.

In order to increase road durability, cost mitigation, and achieve better satisfaction, these questions should be answered:

- Who are entities responsible for implementing road projects in the West Bank?
- How are highway projects managed in the West Bank?
- What changes must be made to improve the quality of highways in the construction phase?
- What are the main factors affecting the quality of the constructed asphalt highways according to contractors and consultants in the northern West Bank? This is the focus area in this study.
- Do contracting and consulting perceive quality factors in highway construction differently?
- How is highway construction project success measured?
- What is the suitable model that can be used for highway construction in the northern West Bank?

These questions and others will be answered in this thesis, in order to improve quality management performance in the highway construction projects in northern West Bank.

1.3 Objectives

The main objectives of this research are:

- To examine the Palestinian highway construction projects and define nature and performance of the quality management.

- To highlight the main factors affecting the quality of the constructed asphalt in highway construction projects in the designated study area in the West Bank.
- To use the results of this study to assist in improving highway construction projects in terms of quality and avoiding problems.
- To highlight the success factors in managing highway projects, especially in the designated study area in the West Bank.

1.4 Study Area

The research will focus on the factors affecting the quality of the constructed asphalt pavement in the West Bank by taking a case study in the northern governorates. These include the governorates of Qalqilia, Tulkarem, Nablus, Tubas, and Jenin. Table (1.1) shows the road network length in the northern West Bank by governorate.

Table (1.1): Road network length (in Kilometers) in the northern West Bank by governorate and road type, 2019

Governorate	**Paved Roads**				**Unpaved Roads**	**Total**
	Main	Regional	Local	Total		
Jenin	56.4	138	221	415.4	63	478.4
Tubas and Northern Valley	13.5	41	53	107.5	24	131.5
Tulkarem	15.8	73	117	205.8	43	248.8
Nablus	111.4	90	202	403.4	36	439.4
Qalqilia	32.2	40	37	109.2	16	125.2
Total	229.3	382	630	1241.3	182	1423.3

Source: Ministry of Public Works and Housing (MPWH), 2019

Note: Road classification used in this table is for external roads, which is adopted by the MPWH; however, the urban road classification (local, collector, and arterial) was used later in this thesis.

1.5 Thesis Structure

This thesis is composed of seven chapters. In addition to the First introduction chapter. Chapter Two reviews the related literature on the quality management system in general and in highway quality construction projects in specific.

Chapter Three describes the methodology of this study, while Chapter Four reviews the procedures followed in collecting the required data. Chapter Five shows the data analysis, and Chapter Six shows the model developed for the quality management. Finally, Chapter Seven presents the summary, conclusions, and recommendations of this study.

Chapter Two

Literature Review

Chapter Two

Literature Review

2.1 Introduction

Road transportation plays an essential role in the life of any community today, and it is important in the socio-economic development of the country.

In roadway construction industry, quality is considering key factor such as time and cost. Road quality assesses the road pavement reaction under traffic loading and environmental condition. Road construction project goes through various phases or life cycle as any construction project; therefore, improvement in highway quality is linked with quality management system in all phases.

The quality in construction process started long time ago; in fact, it is a result of several thousands of years of development and implementation. The Great Pyramid of Giza showed the first signs of quality in a managed form. The tools and measurement used in building the pyramids were professionally done with a high level; therefore, indicating a systematic high quality system. Furthermore, China had a comprehensive set of standards, inspections, and training to provide high quality parts; this was in 700 BC (Juran, 1995).

Several studies in different countries aimed to find out the basic factors that affect quality in construction projects, to develop a comprehensive system to improve quality in projects.

This chapter reviews some of studies that discuss the quality in the construction projects in general and in highway projects at specific. It also defines the quality management system of highway projects.

2.2 Quality Definition

Quality does not always mean the same to everyone. Definitions ranged from authoritative documentation to expressions of experiences and opinions.

The International Organization for Standardization (ISO, 2015) defines quality as " degree to which a set of inherent characteristics of an object fulfils requirements."

(Rumane, 2011) define construction project quality is "The fulfillment of the owner's needs per defined scope of works within a budget and specified schedule to satisfy the owner's/user's requirements."

The American Society of Civil Engineers (ASCE) defined quality in construction projects as "The fulfillment of project responsibilities in the delivery of products and services in a manner that meets or exceeds the stated requirements and expectations of the owner, design professional, and constructor. Responsibilities refer to the tasks that a participant is expected to per-form to accomplish the project activities as specified by contractual agreement and applicable laws and licensing requirements, codes, pre-vailing industry standards, and regulatory guidelines. Requirements are what a team member expects or needs to receive during and after his or her participation in a project" (ASCE, 2007).

2.3 ISO 9001: Quality Management System

2.3.1What is ISO 9001?

ISO 9001 is defined as the international standard that specifies requirements for a quality management system (QMS), which can organization use to develop own guidelines on QMS, regardless of size or industry. The standard does not define the specific quality of product or service. Instead, ISO 9001:2015 helps to achieve consistent results and continually improve into organization processes (ISO9001, 2015).

ISO 9001 is based on the plan-do-check-act (PDCA) cycle methodology and risk- based thinking, which “provides a process to documenting and reviewing the structure, responsibilities, and procedures required to achieve effective quality management in an organization.” The PDCA cycle consists of steps for carrying out change, which should be repeated again for continuous improvement, as shown in Figure (2.1).

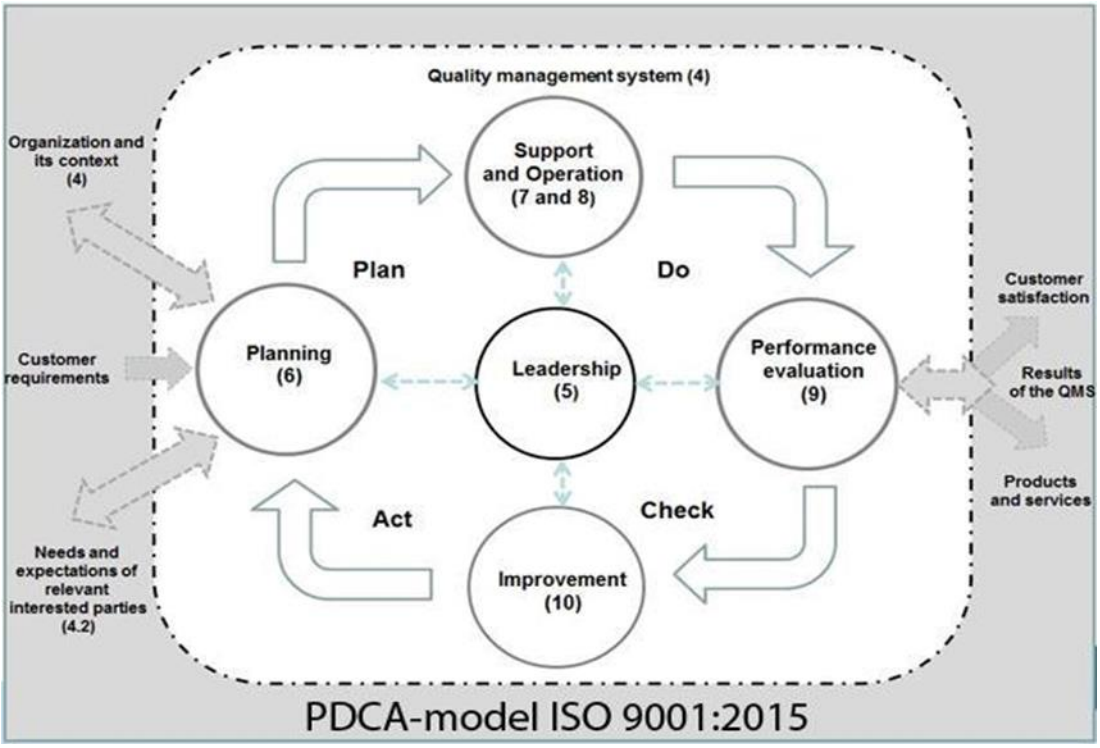


Figure (2.1): Representation of the structure of ISO9000 in the PDCA cycle (ISO9001, 2015)

2.3.2 Quality Management System

A QMS is defined as the part of a management system with regard to quality (ISO9000, 2015). Management system is defined as “a set of interrelated or interacting elements of an organization to establish policies and objectives, and processes to achieve those objectives” (ISO, 2015).

A QMS consists of activities, which define the organization’s objectives and determine and manages the interacting processes and resources required to achieve desired results for relevant interested parties.

The principles included in quality management are focusing on customers, leadership, engaging people, process approach, improvement, decision-making based on evidence, and managing relations (ISO9001, 2015).

The benefits to impletion of a quality management system are meeting customer's requirement and satisfaction, and improving the agency system.

2.4 Importance of Quality Management System in Highway Construction

In order to enhance road users' satisfaction, increased durability, health and safety, and reduce environment damage, the project must meet the expected quality. This expected quality can be ensured through the implementation of quality management system in road construction projects. To apply this, understanding and applying activities of quality planning (identification of quality standards), quality assurance (evaluation of overall project performance), quality control (monitoring of specific project results), and quality improvement (informed by all activities and the requirements of the project) must be done through the life cycle of the road project (aura, 2019).

2.5 Quality Management System in Highway Projects

In highway construction projects, quality management should be involved in all stages of a project. In the design phase, end product's quality is specified to meet the user's needs and the best cost-benefits. Quality management procedures are developed to ensure compliance with the specifications. During construction, non-conformance could be in terms of end products or output products of activities. In such cases, Battikha (2002) stated that "appropriate actions must then be taken to rectify non-conforming situations and, if possible, diagnosis and elimination of the reasons causing nonconformance, in order to avoid similar situations during the remainder of the project and on future projects".

Quality management system is not so widespread in the field of construction as it is in the field of industries. A number of institutions in different countries conducted research and studies and produced quality guides in road construction during the different project phases by develop construction quality assurance and quality control or by using inspection form and testing systems.

To accomplish the road quality, the desired quality, methods, and procedures for the quantification of the quality of road construction should be precisely determined ahead of time. Therefore, highway departments must have a guide for the correct construction practices and procedures to be used in road projects contracts.

2.6 Quality Management System of Highway Projects in Palestine

"A QMS is a dynamic system that evolves over time through periods of improvement. Every organization has quality management activities, whether they have been formally planned or not" (ISO, 2015).

Interviews with the staff of the Municipal Development and lending Fund (MDLF) and Ministry of Public Works and Housing (MPWH) in Palestine revealed that there are no official quality control and quality assurance systems for their highway projects. There are some practices followed by each of them, and sometimes it depends on the nature, location, and size of the project. In year 2018, the MDLF, for example, prepared its own standards and specifications and disseminated them to all municipalities by preparing a manual and through conducting training workshops on the use of the manual. The MDLF has a system of selecting the quality control and testing labs from a set of three licensed labs suggested by the contractors. In recent years, the MDLF has adopted a system of quality assurance by hiring a third-party lab to double check the quality of testing (MDLF, 2018).

The municipalities generally follow the MDLF system of quality control, but not the quality assurance. On the hand, the MPWH prepared draft standards and specifications for road projects in terms of procurement and contracts, geometric design, and construction standards in 2010 through a project funded by the USAID. However, these documents were not finalized; nevertheless, they are used by MPWH in their road projects.

In 2017, MDLF prepared the Operation and Maintenance Manual for buildings and roads, with the aim of providing technical and administrative assistance to workers in Palestinian municipalities in managing operations and maintenance operations; specifically, to prepare operation and maintenance plans for these vital facilities (MDLF, 2017). This guide gives the necessary instructions to do what is needed at the technical, financial, and administrative levels in order to carry out the optimal operation and the necessary maintenance works related to road facilities and public buildings, to ensure the sustainability of these facilities, and to achieve the optimal and effective use of funds allocated by the municipality for these purposes.

2.7 Factor Affecting Quality

Understanding the important factors affecting the quality in road construction is the most important step to develop a system for improving quality and linking it to all stages of the project life cycle. Several studies identified factors affecting the quality of road construction projects. Some of these are presented below.

In Mumbai, India, Minde (2018) focused on identifying and evaluating the various factors affecting quality throughout the lifecycle of a road project. The study considered 54 factors affecting quality of roads throughout their lifecycle and circulated to owners, engineers, contactors, design consultants, and construction managers. The lifecycle of a road project includes quality of concept, design, construction, conformance and of performance (Minde, 2018). The effect of each factor was measured in terms of its importance index and then ranked accordingly. The results of this study demonstrate that owner's policy and effective quality management system are found to be highly significant factors at the conceptual stage. In the design quality, the nature and type of subgrade soil and design errors were found to be extremely important factors. Similarly, the quality of raw materials; i.e., aggregates, etc. and method of construction are of prime importance in quality of construction. Effectiveness of QA/QC program and subgrade failure, rutting, and shoving are significant factors for quality of conformance and performance, respectively.

Abu El-Maaty, et al. (2016) presented thirty-nine factors and their impacts on the quality of highway projects in Egypt. The most important factors from the owners and consultants were:

- Qualified staff available during the project execution within the owner's and contractor's team.
- Efficiency of the owner's inspection team
- Clear roles and responsibilities among the owner, consultant, and the contractor
- Design errors; pavement is not designed according to the regional conditions (e.g., soil type, temperature, and traffic volume)
- Quality and type of used asphalt

Neyestani (2016) evaluated the impact of quality management system implementation on vital factors (time, cost, quality, and customer satisfaction) of construction projects in Metro Manila, Philippines through a questionnaire distributed to managers. The study found that customer's satisfaction and cost and time affected the quality management system, while on scope (quality) had a minimum effect. The factors that have the most significant impact of quality management system on the customer's and client's satisfaction were:

- Increasing business benefits
- Increased customer satisfaction, loyalty, and improved common understanding of goals and values among interested parties
- Improved customer's relationship, communication, and reporting

Molenaar (2015) focused on the identification, understanding, and dissemination of alternative quality management systems applied in the highway industry throughout the United States. These defined the roles and responsibilities of all project key players (agency, contractor, designer, and consultant) and described the fundamental quality assurance organization.

Najmi (2011) studied the project management of construction projects in Palestine through interviewing 36 project managers in the West Bank. The study found that the most important problems were poor planning, poor project management, and poor communications between all parties to reach optimal solutions.

Farooqui and Ahmed (2008) studied the current state of performance of Pakistani construction industry and provided directions for strategic improvement of the construction industry. The top factors that caused quality problems in Pakistan were:

- Material prices escalation
- Inflation
- Procurement
- Selection of material
- Lack of communication
- Poor on site supervision

Jha and Iyer (2006) studied reasons for the underperformance of the quality of Indian construction projects. The conducted survey identified 55 attributes responsible for impacting quality performance of the projects. They investigated the adverse factors on quality of Indian construction projects, which were:

- Bad weather condition
- Communication problem between site staff
- Lack of project management skills
- Low bids due to excessive competition

Studies in the Palestinian area about the quality of highway construction projects are limited. As reported by the United Nations Relief and Works Agency (UNRWA, 2006), many local construction projects in Palestine showed poor performance. This was attributed to: lack of materials; successive amendments of design and drawings; improper coordination among involved parties, poor monitoring and feedback, inappropriate project leadership skills, and conflicts in the region.

Amer (2002) conducted a study in Gaza Strip with the aim of providing building construction projects' stakeholders with information needed to better manage the quality. The most affecting factors were:

- Site characteristics
- Site staff's skills and experience
- Proper documentation
- Proper management system of equipment, materials, quality, and labor
- The owner's taking decision process

- The project’s awarding system and the political environment

AL-Hassan’s (1993) study aimed to identify factors affecting the quality of constructed highway asphalt concrete pavement in Saudi Arabia. Among the fifty-nine studied factors, the top factors were (based on the contractor’s view):

- Design errors
- Interpretation of specifications related to aggregate’s quality and gradation
- Clarity of specifications and appropriate of compaction level
- Amount of flier materials in the mixture
- Quality of material

It should be noted from the literature, that there are several factor affecting quality.

2.8 Quality Modeling

Syaj (2015) conducted a study on the quality of the construction sector in Palestine with the aim of improving the management process, and developing a management model to measure total quality management (TQM) in Palestinian construction companies. A questionnaire was developed to identify the most important factors affecting quality in construction. The most important factors according to managers and engineers were:

- Lowes prices of tender
- Lack of experts in quality management system

- Lack of awareness about the importance of quality
- Clarity of work instruction, awarding tender
- Review drawing and specification before tendering
- Fetch materials in a timely manner

A model representing local quality factors was developed using Pareto approach to develop a management model as a tool to measure TQM in the Palestine's construction company. Figure (2.1) shows the critical success factors used (Syaj, 2015).

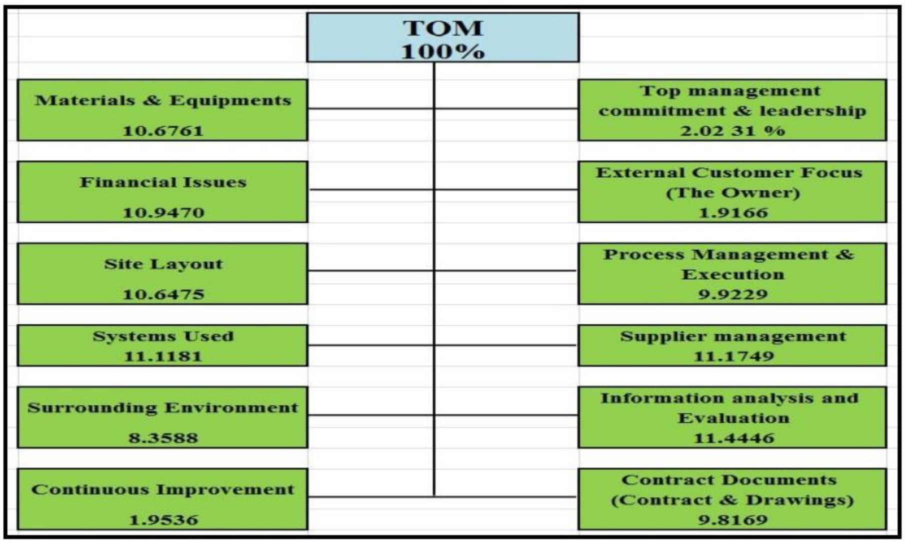


Figure (2.1): Critical success factors of TQM companies (Syaj, 2015).

Battikha (2002) studied the practiced quality management function in highway construction in the USA, which is an interrelated system identifying the main quality activities. The study defined a model for multilevel (contractors, engineers, and managers) quality management involvement, as shown in Figure (2.2).

	Project designer	Force account	Contractor	Special consultant
Production level	Contractor	Contractor	Contractor	Contractor
Management level	Project designer develops and administers QA program and assigns a trained staff of field personnel which provide administrative and surveillance services	Government agencies, corporate and institutional owners establish an internal QA program (e.g. state highway departments) The owner may employ specialized consultants for unusual construction conditions or short duration work	Responsibility for QC and QA is placed on the contractor. The project owner or designer may have limited administrative roles such as assuming final audits. The contractor may assign a superintendent or engineer as a nominal QA representative	The special consultants are responsible for administering the QA program. They are usually design professionals, construction management firms, or sophisticated testing laboratories employed by the owner, and are independent of both the designer and the contractor
Interface level	The designer's field personnel either perform selected QA tasks (e.g. laboratory and field testing), or select and manage specialized consultants to perform these tasks	Trained and indoctrinated personnel from the parent organization with direct owner control during construction perform the tasks at this level	The contractor usually subcontracts all or part of the inspection, testing and engineering functions to outside testing laboratories and consulting engineers	Personnel from the special consultants perform the tasks at this level
Construction domains	Projects using phased construction techniques, projects that are technically complex, and projects that require a lot of design interpretation or coordination during construction (e.g. water and wastewater treatment facilities, industrial plants, power generating stations)	Used for public works construction, and by contractors, and public and private owners where a series of projects having a repetitive type of construction is anticipated (e.g. highways, bridges)	Military, corporate and institutional organizations require this type of approach	Mainly used on projects with complex or highly specialized QA requirements, and where a clear determination of liability is required. Applications of this approach include contracts for soils and foundation inspections, concrete placements and field welding

Figure (2.2): Model applicability in construction practice (BattiKha, 2002)

Amer (2002) used the stepwise multiple regression technic to develop a model that represents the most important factors affecting quality of construction projects in Gaza Strip. Amer's model can summarize as the following:

Quality = (13.67 + 1.35 F1 + 1.21 F3 + 1.28 F4 + 1.02 F5 +1.18 F6 + 1.29 F8+ 0.75 F9 + 1.09 F10 + 0.96 F14 + 1.14 F15 + 0.96 F17 + 1.06 F18) * (100/80.12)

Where: F1, F3, F4, F5, F6, F8, F9, F10, F14, F15, F17, F18 are average weighted scores resulted from collecting the ranking scores of the factors explained as the following:

- F1: Characteristics of site layout
- F3: Characteristics of site staff
- F4: Characteristics design documents

- F5: Material Management System
- F6: Control Systems
- F8: Equipment Management System
- F9: Financial Management System
- F10: Political Environment
- F14: Integrated Management Execution System
- F15: Owner's Quick Response for Taking Decisions
- F17: Type of awarding system
- F18: Labor Management System
- 80.12 = the summation of the formula if each factor has the maximum
- score, which is 5.
- 100 = The expected result of quality score.

2.9 Summary

- Failure in the quality of construction projects in general and in highway projects in particular is a universal problem. In order to satisfy road users, consultants' and owners' ISO and quality management system have become a trend in the construction industry.
- Project management system can be used for ensuring the quality of all components of the process of construction, maintenance, and repair of roads.
- Palestinian road projects suffer from poor performance, and need an integrated and standardized quality management system to improve performance.

Chapter Three

Methodology

Chapter Three

Methodology

3.1 Introduction

This chapter shows an overview of the methodological approach the researcher used for studying the quality management system of highway projects in the northern governorates of the West Bank. The methodology explains how the objectives of this research can be achieved. This study was carried out based on the literature review, documented data on road projects, and a questionnaire survey. Then data collection was analyzed using the statistical methods, and their results were being presented. The methodology in this research has been simplified into Figure (3.1).

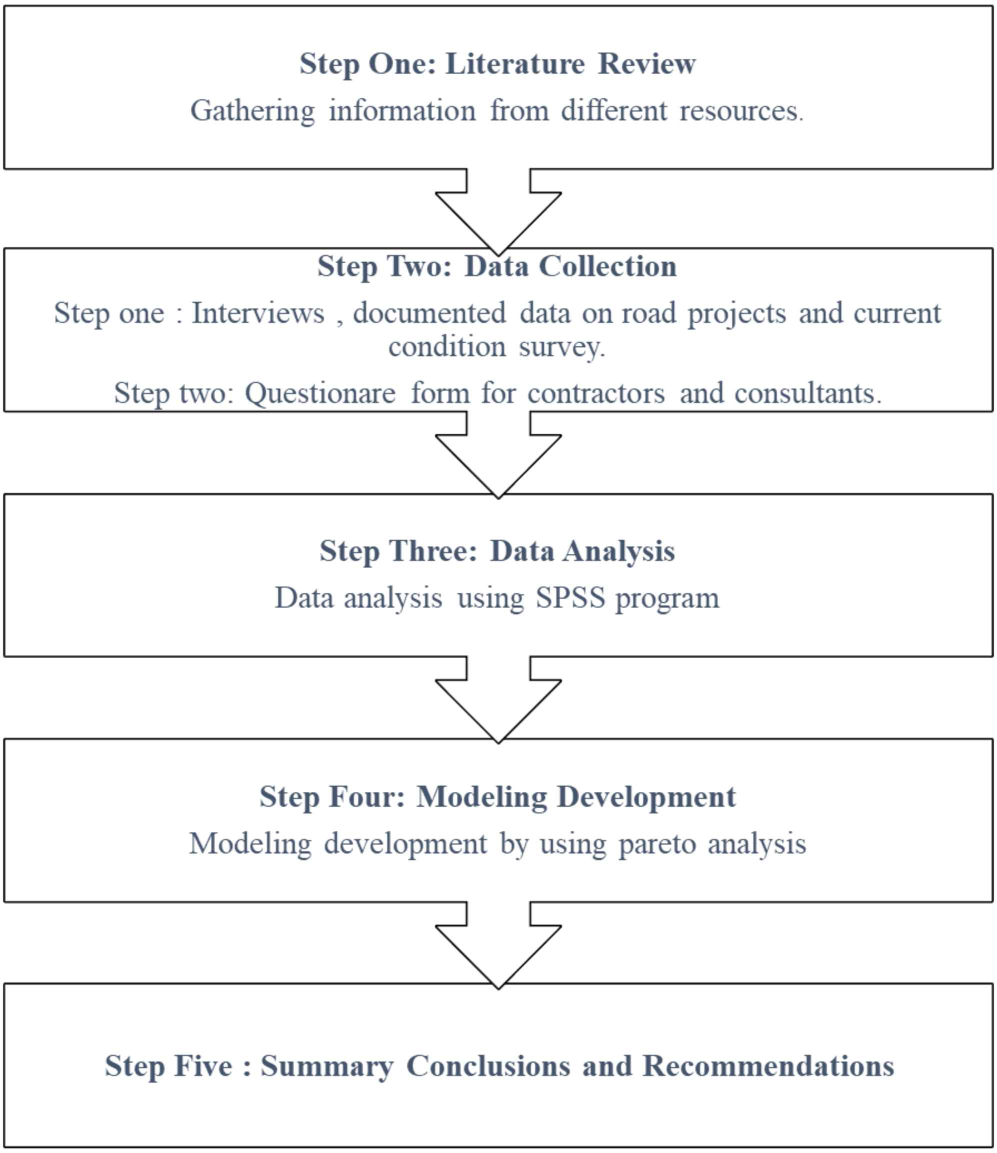


Figure (3.1) Summary of methodology

3.2 Literature review

The first step was a comprehensive literature review, which supported the survey methodology, identified the research problem, and identified goals and objectives. In this phase, the following activities are included:

- Creation of a clear description of the problem.
- Extraction of and gathering information from several sources, such as books, journals, reports and website.

- Identification of factors affecting asphalt highway projects.
- Development of the research methodology.

3.3 Data collection

Data collection is the most critical step of the study since the accuracy and the factuality of the results is related to the success or failure of the research. Data collection was done in two steps:

Step one: Data documented on road projects and road pavement condition survey
Step Two: Questionnaire form

3.3.1 Documented Data on Road Projects and Pavement Condition Survey

Interviews were held with the MDLF staff to clarify the mechanism and policies for implementing road projects administered by MDLF in northern West Bank. A sample of projects was taken such that each project does not exceed five years of age and roadway condition survey of the pavement was done visually, then calculating the pavement condition index (PCI) based on distresses observed according to the distresses identification specification.

Data collected was divided into two sections:

- Section-1: General information about the road such as length, width, road classification.
- Section-2: The current condition of the roads, which was done through visual survey using the PCI method. The pavement is divided into

sections, and each section is divided into sample units. The type and severity of pavement distresses is assessed visually.

3.3.2 Questionnaire Form

First, the critical factors affecting quality based on the literature review were identified. The factors affecting quality were grouped into five categories:

1. Managerial-related factors,
2. Design- and specifications-related factors,
3. Construction-related factors,
4. Quality-related factors, and
5. Environmental-related factors.

In order to measure the impact of these factors on the quality of roads in the northern West Bank, a questionnaire was designed to collect the responses from the contractors and consultants based on their experiences. The questionnaire was divided into two sections:

- Section-1: Records the general information about the respondent.
- Section-2: 37 factors affecting quality as shown in Table (3.1); the respondents were asked to complete the questionnaire form. The factors are subdivided into five groups, and each factor has (5) alternative answers ranging from “highly important” to “not important”.

Table (3.1): Factors affecting the quality of asphalt highway projects

Code	Factor	
1	Group No.1: Managerial Factor	
F1.1	Clear roles and responsibilities (owner, consultant, and contractor)	
F1.2	Contractor's experience	
F1.3	Financial status of the contractor	
F1.4	Contractor's capability in terms of labors and equipment	
F1.5	Contractor's selection based on the lowest bidder	
F1.6	Owners team experience	
F1.7	Efficiency of the owner's inspection team	
F1.8	Amount of work subcontracted	
F1.9	Delay in contactor progress payment	
F1.10	Direct payment to laboratory test by contractor	
F1.11	Weak effective coordination between the departments responsible for infrastructure and road projects	
2	Group No.2: Design and Specification Factor	
F2.1	Pavement is not designed according to the regional conditions (e.g. soil type, temperature, and traffic volume)	
F2.2	Design errors due to inadequate engineer assumptions and inaccurate data (e.g. traffic volume expected growth and soil type)	
F2.3	Clarity and accuracy of specifications in terms of aggregates quality and gradation	
F2.4	Clarity of specifications and appropriate of compaction level	
F2.5	Consistency of specification interpretation of asphalt quality	
F2.6	Limitation on material source selection, equipment type,… etc.	
3	Group No.3: Construction Process Factor	
F3.1	Availability of owner's and contractor's experienced staff for the project	
F3.2	Availability of the specified materials quality	
F3.3	Quality and type of used asphalt	
F3.4	Construction process used for asphalt layers	
F3.5	Quality of used aggregates (e.g., gradation, shape, and type)	
F3.6	Frequent change in the mix design as a result of changing material's sources	
F3.7	Compaction process for:	
	3.7.a	subbase layer
	3.7.b	base course layer

	3.7.c	asphalt layer
F3.8	Acceptance procedure	
F3.9	Public pressure from the community to modify design or increase the speed of works execution	
4	Group No.4: Quality Factor	
F4.1	Existence of quality planning	
F4.2	Existence of quality assurance	
F4.3	Existence of quality control	
F4.4	Existence of proper quality monitoring and evaluation	
F4.5	Lack of quality policy	
5	Group No.5 : Environmental Factor	
F5.1	Existence of environmental management plan to deal with environmental issues	
F5.2	The season during project execution	
F5.3	Time the project execution at night or day	
F5.4	Occurrence of Neutral disasters during or after short period of executing project	

3.4 Data Analysis

The collected raw data was first sorted, edited, coded, and then entered into computer software using SPSS software. Appropriate tables were obtained to understand and analyze.

Data obtained from the questionnaires were analyzed using SPSS as follows:

- For section-1: across-tabulation method was used to obtain a general description of the contractor company.
- For section-2: a qualitative analysis was used to determine the factors affecting the quality. Descriptive statistics such as frequency analysis mean; standard deviation, and variance were presented for each factor. Ranking of the factors affecting quality using Relative Importance Index (RII) was done.

3.5 Conclusions and Recommendations

After collecting and analyzing data and extracting the results, conclusions and recommendations were given.

Chapter Four

Data Collection

Chapter Four

Data collection

4.1 Introduction

The main objectives of this research is to answer the question of "what changes must be made to improve the quality of highway in the construction phase?" And this question will be achieved by two steps:

Step one: Roadway condition survey - Physical condition of the road to determine the real physical condition and to identify factors affecting the quality of the constructed asphalt highways in the designated study area in the West Bank to prevent early distress.

Step two: Identifying factors affecting the quality of the constructed asphalt highways in the designated study area in the West Bank. To achieve the objective, a survey was done using questionnaire form that includes several factors. Each factor listed in the questionnaire was intended to measure the degree of affect it has on the quality of constructed asphalt highways.

4.2 Interview

An interview was made with the technical supervisor of the Municipal Development and Lending Fund (MDLF) to find out how road projects are run .

4.2.1 MDLF History

The MDLF is a quasi-governmental institution that was created in 2005 by the Palestinian government to be the main and preferred channel to support the development and reform process for local government units (LGUs) and entities, and in 2015 the Fund Law was approved by the President of the State of Palestine.

The main objective of the MDLF is to encourage the flow of financial resources from the PNA and various donors to the Palestinian Ministry of Local Government to support LGUs and other local public entities to improve the delivery of local infrastructure and municipal services, pro-mote economic development, and improve municipal efficiency and accountability.

4.2.2 Highway Construction Through MDLF

The municipalities submit a grant application form for the road project to be implemented and financed by the MDLF. The project's documentation contains information such as general information of municipalities and general information about road project as length, width, estimated project cost. It also contains the design details of the road, which is done in three stages. The design is provided by the municipality, which is executed by a specialized engineering office or municipality itself; design review and check by the consultancy office representing the MDLF, which might include the required verification.

The MDLF double checks all the paper works and designs.

The MDLF has specifications and guidelines that are distributed to municipalities and consultants. Technical specifications are reviewed annually and modified; modification is done as needed based on their suitability.

Usually the lowest price bid is accepted, but after the contractor submits the guarantees, a certificate of experience, and all documents that prove the competency to implement the project.

During the construction process, the main supervisor is the municipality, and the work is followed up by the consultant engineer. All laboratory tests and receipts are not carried out without the presence of a representative or consultant engineer who makes the monthly and final reports for the MDLF. At the end, the project is received in the presence of all parties from the municipality engineer, consultant, and MDLF engineer.

Maintenance of the project in the first year is done by contractor, then the municipality will follow up the maintenance work. Typically, the project’s design life is 15 years.

4.3 Roadway Condition Survey

Roadway condition survey of the pavement was done visually; PCI is calculated based on distress observed according to the distresses identification specification. The existence of distress without making suitable maintenance causes damage and failure to the pavement structure thus affecting road users' safety and reducing road durability. The roadway condition survey plays an important role in pavement management, which permits early identification of repair and rehabilitation needed to be done on the roads.

The problems faced through the road condition survey were:

- The absence of a database about of road executed project and unavailability of road condition assessments.
- Traffic hazard while the survey or walking to perform the condition survey.

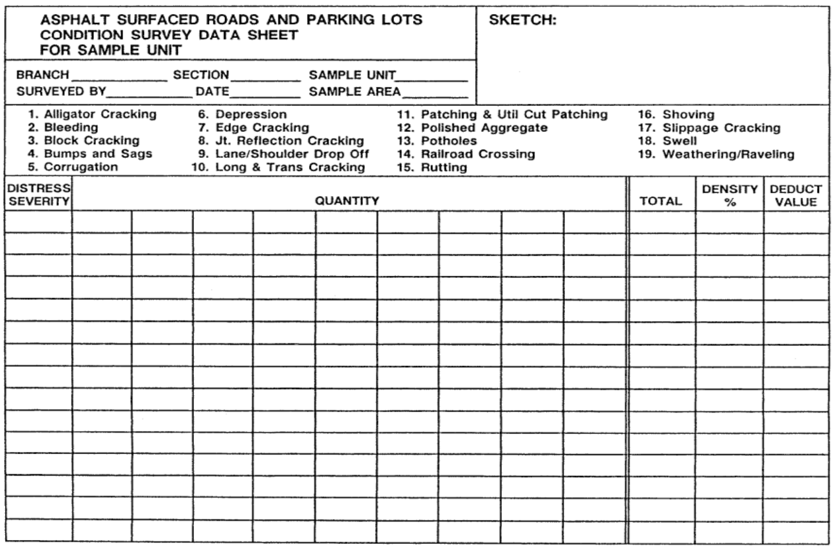
4.3.1 Pavement Condition Index (PCI)

Pavement Condition Index (PCI) is a numerical indicator that rates the surface condition of the pavement road ranging from 0 to 100, as shown in the Figure (4.1). The PCI provides a measure of the present condition based on the distresses observed on the surface of the pavement. Through the PCI method, accurate data is obtained and road condition is estimated based on real filed conditions (ASTM, 2007).

Figure (4.1): Pavement condition index (PCI) rating scale and suggested colors (Source ASTM, 2007)

4.3.2 Calculation of PCI for asphalt pavement

The first step, pavement is divided into sections. Each section is divided into sample units. The type and severity of pavement distresses is assessed by visual inspection. The data sheet is shown in the Figure (4.2).



ASPHALT SURFACED ROADS AND PARKING LOTS
CONDITION SURVEY DATA SHEET
FOR SAMPLE UNIT

SKETCH:

BRANCH________ SECTION________ SAMPLE UNIT________
SURVEYED BY________ DATE________ SAMPLE AREA________

1. Alligator Cracking
2. Bleeding
3. Block Cracking
4. Bumps and Sags
5. Corrugation
6. Depression
7. Edge Cracking
8. Jt. Reflection Cracking
9. Lane/Shoulder Drop Off
10. Long & Trans Cracking
11. Patching & Util Cut Patching
12. Polished Aggregate
13. Potholes
14. Railroad Crossing
15. Rutting
16. Shoving
17. Slippage Cracking
18. Swell
19. Weathering/Raveling

DISTRESS SEVERITY	QUANTITY									TOTAL	DENSITY %	DEDUCT VALUE

Figure (4.2): Flexible pavement condition survey data sheet for sample unit

Next is calculating the PCI value for each sample unit of the road section. The following procedure shows how to determine the value of PCI.

1. Sum the total quantity of each distress type at same severity level to calculate total severity. The units for the quantities are square meters, meters, or number of occurrences; depending on the distress type.
2. Find percentage of damage (density). Density is measured as the percentage of damage level in the sample area of the unit under review. The density is obtained for each distress type and severity level by dividing the total quantity obtained in steps 1 by the unit sample area and multiplying by 100.
3. Determine the deduct value (DV). After the density values are obtained, for each distress type at each severity level a DV obtained by using curves in ASTM appendix.
4. Determine the maximum corrected deducted value (CDV); through the following:
   A. Determine total deduct value by adding individual deduct values.
   B. Determine the value of q, which is the number of deduct values greater than or equal five.
   C. Look for CDV value from total deduct value and q to find appropriate correction curve.
   D. Determine the PCI value using the following formula:

$$PCI = 100 - CDV \qquad (4.1)$$

5. Determine PCI for roads by calculating the weighted PCI of the surveyed sample units (PCI_r) using the following formula (4.2):

$$PCIr = \frac{\sum_{i=1}^{n}(PCIri * Ari)}{\sum_{i=1}^{n} Ari} \qquad (4.2)$$

Where:

PCI_r = Area weighted PCI surveyed sample units

PCI_{ri} = PCI of sample unit i

A_{ri} = Area of sample unit i

n = number of sample units surveyed

4.3.3 Research Sites

In this research, eight municipalities in the northern West Bank and 25 roads were visited and conducted make pavement condition survey for. All roads were with ages less than five years from last maintenance/rehabilitation work.

The selected roads are distributed in the northern governorates of the West Bank, and were selected based on cooperation by the municipalities. These municipalities are:

- Nablus
- Jenin
- Tulkarem
- Tubas
- Hawarah

- Jumain
- Kufr Thalth
- Auzoun

4.4 Questionnaire

The population under study is the highway contractors and consultants who are actively associated with the construction activities and possess sufficient experience in the field of construction in the northern governorates in the West Bank. For this, the questionnaire was translated into Arabic language, shown in the Appendix A. Due to the Corona pandemic, the questioners were distributed in several governorates through emails and followed up by calling.

The questionnaire form consists of two parts. The first part includes general information questions about the respondent's experience and his/her position in the contracting company and other general questions about the company, including:

- Grade/Classification of contracting company in the field of roads
- Number of years of experience
- Number of employees
- Average road project size (in terms of money)
- Average road project duration

The second part concerns the factors affecting quality in highway construction projects, which were grouped into five main categories, and were further sub-categorized into 37 sub-factors as shown in the Appendix. Each factor has 5 alternative answers rating from ‘major effect’ to ‘no affect’.

A total of fifty-five (55) contracting companies were contacted; only forty-five (45) responded, which represents 81.8% of the total population. The questionnaire was then statistically analyzed to determine the degree of effect that the factors have on the quality.

For the available consultants in the northern governorates in the West Bank, these were distributed in two governorates (Nablus and Jenin).

There are only four (4) consulting offices in the northern West Bank and all responded to the questionnaire. All respondents were project managers in these offices.

The questionnaire is given in Appendix.

4.4.1 Response Evaluation System

The Likert scale (1–5) was used such that each answer was given a value from ‘5’ to ‘1’ as below; the respondent should select only one of these answers.

- Value 5 indicates ‘major effect’
- Value 4 indicates ‘effect’
- Value 3 indicates ‘some effect’
- Value 2 indicates ‘neutral’
- Value 1 indicates ‘no effect’

Chapter Five

Data Analysis

Chapter Five

Data Analysis

5.1 Introduction

Data obtained from the questionnaires were analyzed by using the computer program SPSS as follows:

For part one: a cross-tabulation method was used to obtain a general description of the contractor company.

For part two: a qualitative analysis was used to determine the factors affecting the quality. Descriptive statistics such as frequency analysis; mean, standard deviation, and variance were presented for each factor where the effect of each factor was measured by the relative importance index (RII).

5.2 Analysis of Roads' Physical Conditions

The visual PCI method for evaluating pavement conditions was done through field inspection and measurement to assess the type and severity of each distress, as shown in Table (5.1). Roadway condition survey of the pavement was done based on distresses observed in pavement, which permits evaluating and rating the pavement as the first step to improve quality management system; determining the main factors affecting the emergence of distresses in the early stage.

Table (5.1): Pavement condition survey for the targeted roads

Road No.	Year	Road Length (m)	Classification of Roads	Number of Sample Units	Average PCI Value	Rate
R01	2015	200	Local	1	68%	Fair
R02	2018	1655	Collector	5	78%	Satisfactory
R03	2016	147	Local	3	84%	Satisfactory
R04	2016	250	Local	1	94%	Good
R05	2018	1000	Local	3	92%	Good
R06	2018	1362	Local	6	95%	Good
R07	2016	1015	Local	4	95%	Good
R08	2016	926	Collector	5	89%	Good
R09	2017	595	Collector	2	79%	Satisfactory
R10	2015	250	Local	2	92%	Good
R11	2018	300	Local	1	72%	Satisfactory
R12	2016	747	Local	4	79%	Satisfactory
R13	2019	200	Local	1	95%	Good
R14	2017	480	Local	2	83%	Satisfactory
R15	2017	500	Local	4	91%	Good
R16	2019	400	Local	2	93%	Good
R17	2019	383	Local	3	85%	Satisfactory
R18	2016	955	Local	4	92%	Good
R19	2018	700	Local	3	85%	Satisfactory
R20	2018	150	Local	1	95%	Good
R21	2017	655	Local	4	85%	Satisfactory
R22	2019	280	Local	1	98%	Good
R23	2019	290	Local	2	96%	Good
R24	2018	445	Local	4	98%	Good
R25	2016	700	Local	3	98%	Good

During the field condition surveys, repetitive number of distresses were observed as shown in the Table (5.2) (all roads’ ages are less than 5 years).

Note: all pictures in Table (5.2) were taken in the field survey.

Table (5.2): Common distresses observed in the field

Distress	Description	Distress Example
Alligator cracks	Alligator or fatigue cracking is a series of interconnecting cracks caused by fatigue failure of the asphalt concrete surface under repeated traffic loading. Alligator cracks is one of the most cracks occurring in the West Bank roads especially when roads not designed according to real traffic loads or poor construction.	
Longitudinal cracks and transvers cracks	Longitudinal cracks are parallel to the pavement's center line or lay down direction. Transverse cracks extend across the pavement at approximately right angles to the pavement's canter line or direction of lay down. Some roads have longitudinal cracks along the whole road. Longitudinal cracks occur due to different in temperature between day and night or poor construction.	

Depression	Depressions are localized pavement surface areas with elevations slightly lower than those of the surrounding pavement. Depressions are created by settlement of the foundation soil or are a result of improper construction.		 
Potholes	Potholes are small bowl-shaped depressions in the pavement surface.		
Patching and utility cut patching	A patch is an area replaced with new material to repair the existing pavement. A patch is a defect no matter how well it is performing. In northern West Bank, the main reason to this distress is weak effective coordination between the departments responsible for infrastructure and road projects.		   

Table (5.1) shows some roads with ratings ranging from satisfactory to fair; no poor roods. According to the municipal engineers, the reasons for the appearance of such distresses, and based on their knowledge of the area, implementation, and design conditions, there were a number of common factors as follows:

- Weak effective coordination between the departments responsible for infrastructure and road projects. This factor was more noticeable in the large municipalities, where utility patching and sewage lines were implemented after the construction of the road. The incorrect treatment of patches led to weakness in the surrounding area, which weakened the pavement and resulted in occurrence of several types of distresses.
- Pavement is not designed according to the regional conditions especially soil type. This occurs because of the high project cost, where soil replacement is needed and there was a lack of necessary funding.
- Design errors due to inadequate engineer’s assumptions and inaccurate data such as traffic volume and expected growth. Unfortunately, not taking into account the size of the traffic and the nature of the surrounding area as residential, industrial, or agricultural area in the design would lead to the rapid appearance of distresses and shorter road’s life span.
- Availability of resident supervising engineer. It is important to have a resident supervising engineer to follow up the implementation of the works during the period of project.

- Lack of experts and reports on QMS. Defining a system focusing on quality at all levels of project is essential to help in drafting critical issues in quality.
- Asphalt quality and construction process of asphalt.
- Lack of effective quality planning.
- Contractor’s experience.

In addition to the factors mentioned by the engineers' point of view, from my opinion there are a number of factors that must be taken into consideration as:

- Lack of awareness about the importance of quality.
- Weak of supervision system.
- Absence of a good data base; data base should be well documented, systematic, and comprised
- Absence of sense of ownership
- Lack of awareness about the importance of roads. Road users should keep roads in good condition without destroying the pavement by construction waste

5.3 Analysis of Questionnaire for Contractors’ Companies

5.3.1 Contractor’s Profile

The person who filled the survey was the contractor himself, project manager, or the contractor’s engineer.

The grade of the contractor is based on the Ministry of Public Works and Housing (MPWH) classification system, which is based on the experience of the contractor and ability to complete the project, availability of permanent management, availability and experience of engineering and technical staff, and equipment owned. Based on this system, “Grade 1” is the largest size contractor who can bid on large road projects, and so on up to “Grade 5”.

According to this grading system, eleven (11) contractors out of the 45 contractors (24.4%) were first grade, sixteen (16) contractors (35.6%) were second grade, eleven (11) contractors (24.4%) were third grade, and seven (7) contractors (15.6%) were fourth grade. The fifth-grade contracting companies have been excluded since they did not implement road projects during the past five years.

The frequency shows that more than half the contractor’s companies have experience in the road projects for more than 15 years (23) companies; (51.1%), and only one (2.2%) has an experience of less than 5 years.

The size of contractor companies was determined based on the number of employees. Results show that most contractor companies have less than ten (10) workers (20 contractors; 44.4%); small size companies. Only three (3) contractor companies (6.7%) have more than 30 workers. Therefore, the majority of companies in north of the West Bank are considered small to medium size.

In terms of average project duration, all contractors have an average duration of less than two years, and most of contractors (23 contractors; 71.1%) are in the range of less than six months.

As for the average road project's budget, most contractors (24 contractors; 53.3%) have an average project budget range of (200-800) thousand US Dollars (USD). Furthermore, four (4) contractors (8.9%) have an average project between 800 thousand to 1 million USD, seven (7) contractors deal with projects more than one million USD, and ten (10) contractors (22.2%) dealt with project budget less than 200 thousand USD. Table (5.3) shows the frequency and percentages for the forty-five (45) surveyed contractors.

Table (5.3): General information about the contractor companies

Question No.	Frequency	Percent
Job position of Person Filling the Questionnaire		
Contractor	19	42.20%
Project manager	24	53.30%
Engineer	2	4.40%
1. Grade		
1	11	24.40%
2	16	35.60%
3	11	24.40%
4	7	15.60%
2. Years' of experience in road projects		
≤ 5 years	1	2.20%
(5-10) years	7	15.60%
(10-15) years	14	31.10%
≥ 15 years	23	51.10%

3. No. of employees		
Less than 10	20	44.40%
From (10-20)	15	33.30%
From (20-30)	7	15.60%
More than 30	3	6.70%
4. Average project duration		
Less than half year	32	71.10%
(1/2-1) year	10	22.20%
(1-2)year	3	6.70%
more than 2 years	0	0
5. Average road project size ($)		
Less than $200*10^3$	10	22.20%
$(200-800)*10^3$	24	53.30%
$(800-1000)*10^3$	4	8.90%
More than 1million	7	15.60%

5.3.2 Descriptive statistics of contractor

Table (5.4) presents the results of descriptive statistics for part two of the questionnaire according to contractors.

Table (5.4): Descriptive statistics quality factors contractor's response

Code	Factor	Frequencies							
		Major effect	**Effect**	**Some effect**	**Neutral**	**No Effect**			
1	Group No.1 : Managerial Factor	5	4	3	2	1	**Mean**	**Std. deviation**	**Variance**
F1.1	Clear roles and responsibilities (owner, consultant, and contractor)	27	6	9	1	2	4.22	1.126	1.268
F1.2	Contractor's experience	31	12		1	1	4.58	0.812	0.659
F1.3	Financial status of the contractor	26	14	4		1	4.42	0.839	0.704
F1.4	Contractor's capability in terms of labors and equipment	20	13	11	1		4.16	0.878	0.771
F1.5	Contractor's selection based on the lowest bidder	17	9	9	1	9	3.53	1.517	2.3
F1.6	Owners team experience	29	11	5			4.53	0.694	0.482
F1.7	Efficiency of the owner's inspection team	22	12	9	2		4.2	0.919	0.845
F1.8	Amount of work subcontracted	4	15	12	6	8	3.02	1.252	1.568
F1.9	Delay in contactor progress payment	33	9	1	2		4.62	0.747	0.559
F1.10	Labors Direct payment to laboratory test by contractor	3	6	10	3	23	2.18	1.37	1.877
F1.11	Weak effective coordination between the departments responsible for infrastructure and road projects	23	15	5		2	4.31	0.848	0.719
2	Group No.2 : Design and Specification Factor								
F2.1	Pavement is not designed according to the regional conditions (e.g. soil type, temperature, and traffic volume)	26	11	5	2	1	4.31	0.996	0.992

F2.2	Design errors due to inadequate engineer assumptions and inaccurate data (e.g. traffic volume expected growth and soil type)	24	14	3	3	1	4.27	1.009	1.018
F2.3	Clarity and accuracy of specifications in terms of aggregates quality and gradation	18	18	7	2		4.16	0.852	0.725
F2.4	Clarity of specifications and appropriate of compaction level	28	12	4	1		4.49	0.757	0.574
F2.5	Consistency of specification interpretation of asphalt quality	30	10	5			4.56	0.693	0.48
F2.6	Limitation on material source selection, equipment type,… etc.	14	13	10	5	3	3.67	1.225	1.5
3	Group No.3 : Construction Process Factor								
F3.1	Availability of owner's and contractor's experienced staff for the project	36	8	1			4.78	0.471	0.222
F3.2	Availability of the specified materials quality	26	9	7		3	4.22	1.146	1.313
F3.3	Quality and type of used asphalt	37	6	2			4.78	0.517	0.268
F3.4	Construction process used for asphalt layers	30	10	3		2	4.47	0.968	0.936
F3.5	Quality of used aggregates (e.g., gradation, shape, and type)	37	6	2			4.78	0.517	0.268
F3.6	Frequent change in the mix design as a result of changing material's sources	19	17	7		2	4.13	0.991	0.982
F3.7	Compaction process for:								
	3.7.a subbase layer	32	13				4.71	0.458	0.21
	3.7.b base course layer	31	14				4.71	0.549	0.301
	3.7.c asphalt layer	34	9	2			4.71	0.549	0.301
F3.8	Acceptance procedure	18	15	9	2	1	4.04	0.999	0.998

F3.9	Public pressure from the community to modify design or increase the speed of works execution	16	14	12		3	3.89	1.112	1.237
4	Group No.4 : Quality Factor								
F4.1	Existence of quality planning	15	21	6	3		4.07	0.863	0.745
F4.2	Existence of quality assurance	21	13	8	2	1	4.13	1.014	1.027
F4.3	Existence of quality control	25	11	6		3	4.22	1.126	1.268
F4.4	Existence of proper quality monitoring and evaluation	21	10	11	2	1	4.07	1.053	1.109
F4.5	Lack of quality police	11	16	14	2	2	3.71	1.036	1.074
5	Group No.5 : Environmental Factor								
F5.1	Existence of environmental management plan to deal with environmental issue	13	14	8	4	6	3.53	1.358	1.845
F5.2	The season of the project execution	23	14	4	2	2	4.2	1.079	1.164
F5.3	Time the project execution at night or day	9	16	11		9	3.36	1.368	1.871
F5.4	Occurrence Neutral disasters during or after short period of execution the project	21	8	8	6	2	3.89	1.265	1.601

5.3.3 Relative Importance Index

The effect of each factor on the quality of highway project is measured by calculating the relative importance index (RII). The calculated RII of the factors according to contractor is shown in Table (5.7).

The respondent’s feedback on the ranking criteria was rated based on a five-point Likert scale (1–5), which provides an ordinal type as rank orders are in the form of major effect, effect, some effect, neutral, or no effect. In order to ensure the reliability of the scale, Cronbach’s alpha coefficient value was measured. Cronbach's alpha is the most common measure of internal consistency (reliability) (Syaj, 2015) of each of the five main group; i.e., managerial factor, design and specification factor, construction factor, quality factor, and environmental factor; their alpha value for all factors is 0.826, as shown in Table (5.7).

Table (5.5): Cronbach's alpha test measuring reliability statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.826	.853	37

It should be noted that when a value is greater than 0.8 it indicates a high level of internal consistency, and is acceptable for appraising the criteria (Syaj, 2015).

The RII is a descriptive statistical technique to determine the important factors affecting the highway quality (Akadiri, 2011). Construction and facilities management researchers commonly use RII technique for the analysis of structured questionnaire; the RII is obtained as follows:

$$RII = \sum_{i=1}^{n} \frac{Wini}{A \times N} \times 100 \qquad (5.1)$$

$$(0 \leq \text{RII} \leq 1)$$

Where:

W_i = weight of each i^{th} total response given by the respondents. In this case, it ranges from 1 to 5

n_i = total number of each i^{th} in the sample

A = the highest weight in the scale, “5”

N = the total number in the sample

Table (5.6) depicts the used scale; the RII value ranges from 0 to 1. It shows that the higher the RII value the more important effect it has. According to (Akadiri, 2011), five important levels are transformed from Relative Index values, as shown in Table (5.6):

Table (5.6) Importance levels (Akadiri, 2011.)

RII Values	Importance Level	
0.8 ≤ RII ≤1	High	H
0.6≤ RII <0.8	High-Medium	H-m
0.4≤ RII <0.6	Medium	M
0.2≤ RII <0.4	Medium-Low	M-L
0≤ RII <0.2	Low	L

Table (5.7) shows the calculated RII of the factors from contractors’ point of view; ordinal scales were used as a ranking data in ascending order.

Table (5.7): The calculated RII of the quality factors from contractors' point of view

Code	Factor	Mean	Relative Index (RII)	Ranking by Group	Overall Ranking	Importance Level
1	**Group No.1 : Managerial Factor**					
F1.1	Clear roles and responsibilities (owner, consultant, and contractor)	4.22	0.8444	6	17	H
F1.2	Contractor's experience	4.58	0.9156	2	8	H
F1.3	Financial status of the contractor	4.42	0.8844	4	13	H
F1.4	Contractor's capability in terms of labors and equipment	4.16	0.8311	8	23	H
F1.5	Contractor's selection based on the lowest bidder	3.53	0.7067	9	33	H-M
F1.6	Owners team experience	4.53	0.9067	3	10	H
F1.7	Efficiency of the owner's inspection team	4.20	0.8400	7	20	H
F1.8	Amount of work subcontracted	3.02	0.6044	10	36	H-M
F1.9	Delay in contactor progress payment	4.62	0.9244	1	7	H
F1.10	Direct payment to laboratory test by contractor	2.18	0.4356	11	37	M
F1.11	Weak effective coordination between the departments responsible for infrastructure and road projects	4.31	0.8622	5	14	H
2	Group No.2 : Design and Specification Factor					
F2.1	Pavement is not designed according to the regional conditions (e.g. soil type, temperature, and traffic volume)	4.31	0.862	3	14	H

F2.2	Design errors due to inadequate engineer assumptions and inaccurate data (e.g. traffic volume expected growth and soil type)	4.27	0.853	4	16	H
F2.3	Clarity and accuracy of specifications in terms of aggregates quality and gradation	4.16	0.831	5	22	H
F2.4	Clarity of specifications and appropriate of compaction level	4.49	0.898	2	11	H
F2.5	Consistency of specification interpretation of asphalt quality	4.56	0.911	1	9	H
F2.6	Limitation on material source selection, equipment type,… etc.	3.67	0.733	6	32	H-M
3	Group No.3 : Construction Process Factor					
F3.1	Availability of owner's and contractor's experienced staff for the project	4.78	0.956	1	1	H
F3.2	Availability of the specified materials quality	4.22	0.844	8	18	H
F3.3	Quality and type of used asphalt	4.78	0.956	1	1	H
F3.4	Construction process used for asphalt layers	4.47	0.893	7	12	H
F3.5	Quality of used aggregates (e.g., gradation, shape, and type)	4.78	0.956	1	1	H
F3.6	Frequent change in the mix design as a result of changing material's sources	4.13	0.827	9	25	H
F3.7.a	Compaction process for subbase layer	4.71	0.942	4	4	H
F3.7.b	Compaction process for base course layer	4.69	0.938	6	6	H
F3.7.c	Compaction process for asphalt layer	4.71	0.942	4	4	H
F3.8	Acceptance procedure	4.04	0.809	10	28	H

F3.9	Public pressure from the community to modify design or increase the speed of works execution	3.89	0.778	11	29	H-M
4	Group No.4 : Quality Factor					
F4.1	Existence of quality planning	4.07	0.813	3	26	H
F4.2	Existence of quality assurance	4.13	0.827	2	24	H
F4.3	Existence of quality control	4.22	0.844	1	19	H
F4.4	Existence of proper quality monitoring and evaluation	4.07	0.813	3	26	H
F4.5	Lack of quality policy	3.71	0.742	5	31	H-M
5	Group No.5 : Environmental Factor					
F5.1	Existence of environmental management plan to deal with environmental issue	3.53	0.707	3	34	H-M
F5.2	The season of the project execution	4.20	0.840	1	20	H
F5.3	Time the project execution at night or day	3.36	0.671	4	35	H-M
F5.4	Occurrence Neutral disasters during or after short period of execution the project	3.89	0.778	2	30	H-M

5.3.4 Results From the Contractor's Point of View

5.3.4.1 Managerial Factors

Table (5.8) shows the managerial related factors ranked according to the RII, with their degree of effect on the highway quality.

Table (5.8): Managerial factors and effect on quality – contractors' point of view

Code	Factor	Relative Index (RII)	Ranking by Group	Overall Ranking	Importance Level
F1.9	Delay in contactor's progress payment	0.924	1	7	H
F1.2	Contractor's experience	0.916	2	8	H
F1.6	Owners' team experience	0.907	3	10	H
F1.3	Financial status of the contractor	0.884	4	13	H
F1.11	Weak effective coordination between the departments responsible for infrastructure and road projects	0.862	5	14	H
F1.1	Clear roles and responsibilities (owner, consultant, and contractor)	0.844	6	17	H
F1.7	Efficiency of the owner's inspection team	0.840	7	20	H
F1.4	Contractor's capability in terms of labors and equipment	0.831	8	23	H
F1.5	Contractor's selection based on the lowest bidder	0.707	9	33	H-M
F1.8	Amount of work subcontracted	0.604	10	36	H-M
F1.10	Direct payment to laboratory test by contractor	0.436	11	37	M

The importance levels show that most managerial factors are considered with high effect level on the highway project. The following points discuss the three main managerial factors.

1. Delay in contactor progress payment

Table (5.8) shows that the quality of highway project is highly affected by the delay in contractor's progress payment. Most of the contractors (73.3%) answered that delay in payment or slow in payment procedure by the owner is considered the major effect.

Most of the contractors in the West Bank depend on borrowed money (from banks, for example) to fund their operation. Therefore, progress payment is very important for keeping the working capital at an adequate level, and for managing the cash flow for the payment of material and for other financial obligations. Delay in payments or slow payment procedure will impose serious problems to the contractor and this will impact negatively on the final quality.

Most of the contractors' companies emphasized that choosing road projects depends on the funder, because some parties have delays in payments.

2. Contractor's experience

Table (5.8) shows that the contractor's experience is the second factor affecting the quality of highway project. Most of the contractors (68.89%) considered this factor to have a major effect.

The experience of the contractor is essential to perform the required work efficiently. Contractors' experience or prequalification shows their capability, capacity, resources, management processes, and performance. It is very important to obtain a qualified and competent contractor to construct the project. To achieve this objective, the contractor's documentation and employees should be verified. It is also important to check the contractor's previous work record of projects with similar size, complexity, and quality of finish. It is also important to find out if the contractor gave assistance and guarantees. Therefore, only bidders who are prequalified are allowed to submit for a bid.

3. Owners' team experience

It is important for the owner to have a team with sufficient experience to make the right decisions and to produce the required specifications and designs for the project.

Table (5.4) shows the frequency of contractors who answered this factor; 29 of the contractors; (64.44%) considered this a major factor.

5.3.4.2 Design and Specification Factors

Table (5.9) shows the design and specifications related factors ranked according to the RII, with their degree of effect on the highway project quality.

Table (5.9): Design and specifications factors and their effect on quality- contractors' point of view

Code	Factor	Relative Index (RII)	Ranking by Group	Overall Ranking	Importance Level
F2.5	Consistency of specifications interpretation of asphalt quality	0.911	1	9	H
F2.4	Clarity of specifications and appropriate of compaction level	0.898	2	11	H
F2.1	Pavement is not designed according to the regional conditions (e.g. soil type, temperature, and traffic volume)	0.862	3	14	H
F2.2	Design errors due to inadequate engineering assumptions and inaccurate data (e.g. traffic volume expected growth and soil type)	0.853	4	16	H
F2.3	Clarity and accuracy of specifications in terms of aggregates' quality and gradation	0.831	5	22	H
F2.6	Limitation on material source selection, equipment type,… etc.	0.733	6	32	H-M

The importance level shows that most design and specifications factors are considered of high level effect on highway projects. The following points discuss the three main design and specifications factors:

1. Consistency of specifications interpretation of asphalt quality

The adequacy of the specifications is an important factor in determining the final quality that is achieved on a highway construction project. Materials' quality must be included in the technical specifications part of the contract documents. Among the most important specified material characteristics is the asphalt quality, which plays an important role in the quality as shown in Table (5.9). This was ranked as the most important factor from the design and specifications factor.

Asphalt is the face of road; therefore, all measures and specifications should be taken to achieve the required quality. Specifications of asphalt consider:

- Asphalt material, which shall be a composite mixture of coarse and fine aggregates, mineral filler, and bituminous binder proportioned and combined in an approved mixing plant to meet the requirements of this specifications.
- Mixture design and job mix formula.
- Specifications for the implementation of asphalt work and equipment use.

2. Clarity of specifications and appropriate of compaction level

Table (5.9) shows that the specifications of compaction level is the second factor affecting the quality of highway project. Most of the contractors (62.22%) considered this factor to have a major effect, as shown in Table (5.4).

The compaction process plays an important role in improving the strength and bearing capacity of materials used in road construction. Soil compaction reduces settlement and volume change to a minimum, thus enhancing the embankment's or subbase's strength. Asphalt will not be resistant to deformation and will not be durable unless it is properly compacted in the construction phase.

Compaction is achieved in the field by using different types of roller equipment, which have weight specifications and then a suitable compaction test procedure is needed to ensure meeting the specifications.

3. Pavement is not designed according to the regional conditions (e.g. soil type, temperature, and traffic volume)

Table (5.4) shows the frequency of contractors who answered this factor; 26 of the contractors; (57.78%) considered this a major factor.

The pavement design (structural design) process involves the selection of materials, thickness of each layers, and the type of soil to provide a satisfactory level of pavement performance during its service life. These all are major components to producing a good quality pavement; therefore, considered with high effect on quality by the contractors.

5.3.4.3 Construction Process Factors

Table (5.10) shows the design and specifications related factors ranked according to the RII, with their degree of effect on the highway project quality.

Table (5.10): Construction process factors and their effect on quality-contractors' point of view

Code	Factor	Relative Index (RII)	Ranking by Group	Overall Ranking	Importance Level
F3.1	Availability of owner's and contractor's experienced staff for the project	0.956	1	1	H
F3.5	Quality of used aggregates (e.g., gradation, shape, and type)	0.956	1	1	H
F3.3	Quality and type of used asphalt	0.956	1	1	H
F3.7.a	Compaction process for subbase layer	0.942	4	4	H
F3.7.c	Compaction process for asphalt layer	0.942	4	4	H
F3.7.b	Compaction process for base course layer	0.938	6	6	H
F3.4	Construction process used for asphalt layers	0.893	7	12	H
F3.2	Availability of the specified materials quality	0.844	8	18	H
F3.6	Frequent change in the mix design as a result of changing material's sources	0.827	9	25	H
F3.8	Acceptance procedure	0.809	10	28	H
F3.9	Public pressure from the community to modify design or increase the speed of works execution	0.778	11	29	H-M

The importance level shows that most construction process factors are considered of high level effect on the highway projects. The construction factors are also considered as the most (overall) important factor affecting the projects quality. The following points discuss the three main construction factors.

1. Availability of owner's and contractor's experienced staff for the project

Table (5.10) shows that the quality of highway project is affected to a great degree by the availability of owner's and contractor's experienced staff for the project. Most of the contractors (80%) answered that availability of experienced staff, their attitude, skill, and experience play a major effect.

2. Quality of used aggregates (e.g., gradation, shape, and type)

Table (5.4), shows that most of the contractors (82.22%) considered this factor to have a major effect. Based on the contractors, this factor is ranked the first among overall factors.

Aggregate base is the main load spreading layer. Typically, it consists of specific sizes of hard pieces of crushed rock or gravel, and a filler of sand or other fine mineral matter; it should not contain clay. The material must be compacted to produce a close and tight surface texture.

3. Quality and type of used asphalt

Asphalt course is as good as the good material used in the mix. Table (5.4) shows the frequency of contractors' opinion regarding this factor; 37 of the contractors (82.22%) considered this a major factor. Based on the contractors.

5.3.4.4 Quality Factors

Table (5.11) shows the quality related factors ranked according to the RII, with their degree of effect on the highway projects quality.

Table (5.11): Quality factors and their effect on quality-contractors' point of view

Code	Factor	Relative Index (RII)	Ranking by Group	Overall Ranking	Importance Level
F4.3	Existence of quality control	0.844	1	19	H
F4.2	Existence of quality assurance	0.827	2	24	H
F4.1	Existence of quality planning	0.813	3	26	H
F4.4	Existence of proper quality monitoring and evaluation	0.813	3	26	H
F4.5	Lack of quality policy	0.742	5	31	H-M

The importance level shows that most quality factors are consider of high level effect on highway projects. The following points discuss the three main quality factors.

1. Existence of quality control

Quality control (QC) is defined as part of quality management focused on fulfilling quality requirements (ISO, 2015); this concept of quality includes sampling and testing to monitor the process. Usually the contractor is responsible for performing QC, under supervision, to make sure that the result meets the specification.

It is the responsibility of the contractor to provide and maintain a quality control system, which provides reasonable assurance that all brought in material and products conform to the specification requirements. “The contractor shall perform or have performed the inspection and tests required to substantiate product conformance to the mix design requirements, and shall also perform or have performed all inspections and tests otherwise required by the road project specifications” (AASHTO R42, 2006).

Table (5.11) shows that QC was ranked as the first factor affect quality of highway project from quality factor group. Table (5.4) shows the frequency of contractors who answered this factor; 25 of the contractors (55.56%) considered the QC on highway project a major factor.

2. Existence of quality assurance

Quality assurance (QA) is defined as “part of quality management focused on providing confidence that quality requirements will be fulfilled.” (ISO 9000, 2015). QA, “is a schedule of tests performed by the owner or owner’s representative to assure that the materials, and workmanship incorporated on a project are in conformity with the agency or owner of the roadway plans and specifications” (AASHTO R42, 2006).

Table (5.11) shows that QA is ranked the second factor affecting quality of highway projects among the quality factor group. Table (5.4) shows the frequency of contractors’ answers of the QA factor; 21 of the contractors (46.67%) considered this factor a major factor.

3. Existence of quality planning

“Quality does not happen by accident; it has to be planned” (Juran, 1995) Quality planning is defined as “part of quality management focused on setting quality objectives and specifying necessary operational processes, and related resources to achieve the quality objectives.” (ISO, 2015). Quality plan is that from funding agency to doing to control the quality on the construction projects.

Table (5.4) shows the frequency of contractors who answered the existence of quality planning (33.33%); this factor was considered a major factor.

5.3.4.5 Environmental Factors

In addition to roads’ significant economic and social benefits, they might have negative impacts on communities and the Neutral environment; therefore, such impacts should be considered.

Table (5.12) shows the environmental related factors ranked according to the RII, with their degree of effect on the highway project’s quality.

Table (5.12): Environmental factors and their effect on quality-contractors’’ point of view

Code	Factor	Relative Index (RII)	Ranking by Group	Overall Ranking	Importance Level
F5.2	The season during which the project is executed	0.840	1	20	H
F5.4	Occurrence of Neutral disasters during or after short period of execution the project	0.778	2	30	H-M

F5.1	Existence of environmental management plan to deal with environmental issue	0.707	3	34	H-M
F5.3	Time the project execution at night or day	0.671	4	35	H-M

The importance level shows that most environmental factors are considered of high-medium level effect. The following points discuss the three main environmental factors.

1. The season during which the project is execution

Table (5.4) shows the frequency of the contractors (51.11%) who answered that the season of project execution is a major factor.

Road construction is most affected by the weather; therefore, execution takes maximum advantage of the dry seasons in order to complete works. The works shall be restricted in the wet seasons and to ensure that work is executed efficiently and effectively. Project execution in dry seasons ensures that work will be completed without effort spent on repeating the work due to rain. Therefore, this will improve the quality of road in addition to reducing the time.

2. **Occurrence of Neutral disasters**

Table (5.4) shows the frequency of the contractors (46.67%) who answered that this factor is considered a major factor on highway projects.

Neutral disasters such as earthquakes and floods have the potential to cause serious damage to highway infrastructure, and this is considered a challenge, which affects the quality and durability of the highway.

3. **Existence of environmental management plan**

Table (5.4) shows the frequency of the contractors (28.89%) who answered that this factor is considered a major factor on highway projects.

An environmental management plan is “a plan, which is prepared and documented at the beginning of a project in order to plan out and understand how your project will impact the environment, and how you will manage these impacts and risks over the course of a project” (Environmental Management Plan, 2018). This should start early in the planning process to enable a proper consideration of alternatives and avoid potential delays and complications.

The environmental management plan often contains construction guidelines that specifically address how the contractors are to incorporate environmental considerations into their work.

5.4 Analysis of Questionnaires for the Consultant Office

5.4.1 About the Consultant

In the northern West Bank there are only four consultant offices, three in Nablus and one in Jenin. Projects managers in these offices filled the questionnaire. Their experiences ranged between eight and thirty years.

5.4.2 Descriptive Statistics by the Consultants

Table (5.13) presents the results descriptive statistics techniques for part two of the questionnaire according to consultant. The table shows the frequencies, mean, standard deviations, and coefficient of variation (C.V) for all factors.

Table (5.13): Descriptive statistics for factors according to consultants

Code	Factor	Frequencies							
		Major effect	**Effect**	**Some effect**	**Neutral**	**No Effect**			
1	Group No.1 : Managerial Factor	**5**	**4**	**3**	**2**	**1**	**Mean**	**Std. deviation**	**Variance**
F1.1	Clear roles and responsibilities (owner, consultant, and contractor)		3			1	3.5	1	1
F1.2	Contractor’s experience	3	1				4.75	0.5	0.25
F1.3	Financial status of the contractor	2	2				4.5	0.577	0.333
F1.4	Contractor’s capability in terms of labors and equipment	1	1	2			3.75	0.957	0.917
F1.5	Contractor’s selection based on the lowest bidder	2	1	1			4.25	0.957	0.917
F1.6	Owners team experience		2	1	1		3.25	0.957	0.917
F1.7	Efficiency of the owner’s inspection team		2	2			3.5	0.577	0.333
F1.8	Amount of work subcontracted		2	2			3.5	0.577	0.333
F1.9	Delay in contactor progress payment		2	2			3.5	0.577	0.333
F1.10	Direct payment to laboratory test by contractor	1		2	1		3.25	1.258	1.583
F1.11	Weak effective coordination between the departments responsible for infrastructure and road projects			4			3	0	0
2	Group No.2 : Design and Specification Factor								
F2.1	Pavement is not designed according to the regional conditions (e.g. soil type, temperature, and traffic volume)	2	2				4.5	0.577	0.333

F2.2	Design errors due to inadequate engineer assumptions and inaccurate data (e.g. traffic volume expected growth and soil type)	2	2				4.5	0.577	0.333
F2.3	Clarity and accuracy of specifications in terms of aggregates quality and gradation	2	1	1			4.25	0.957	0.917
F2.4	Clarity of specifications and appropriate of compaction level	2	1	1			4.25	0.957	0.917
F2.5	Consistency of specification interpretation of asphalt quality	1	2	1			4	0.816	0.667
F2.6	Limitation on material source selection, equipment type,… etc.		3	1			3.75	0.5	0.25
3	Group No.3 : Construction Process Factor								
F3.1	Availability of owner's and contractor's experienced staff for the project	2	2				4.5	0.577	0.333
F3.2	Availability of the specified materials quality	1	3				4.25	0.5	0.25
F3.3	Quality and type of used asphalt	4					5	0	0
F3.4	Construction process used for asphalt layers	3	1				4.75	0.5	0.25
F3.5	Quality of used aggregates (e.g., gradation, shape, and type)	1	3				4.25	0.5	0.25
F3.6	Frequent change in the mix design as a result of changing material's sources			2	2		3.5	0.577	0.333
F3.7	Compaction process for:								
	3.7.a subbase layer			4			4	0	0
	3.7.b base course layer			4			4.5	0.577	0.333
	3.7.c asphalt layer		2	2			4.5	0.577	0.333
F3.8	Acceptance procedure		1	1	2		3.75	0.957	0.917

F3.9	Public pressure from the community to modify design or increase the speed of works execution			1	1	2	2.75	0.957	0.917
4	Group No.4 : Quality Factor								
F4.1	Existence of quality planning		2		2		3	1.155	1.333
F4.2	Existence of quality assurance	1	2		1		3.75	1.258	1.583
F4.3	Existence of quality control	1	3				4.25	0.5	0.25
F4.4	Existence of proper quality monitoring and evaluation	1	3				4.25	0.5	0.25
F4.5	Lack of quality police	1	3				4.25	0.5	0.25
5	**Group No.5 : Environmental Factor**								
F5.1	Existence of environmental management plan to deal with environmental issue		2	1		1	3	1.414	2
F5.2	The season during the project execution	1	1	1		1	3.25	1.708	2.917
F5.3	Time the project execution at night or day		2		2		3	1.155	1.333
F5.4	Occurrence of Neutral disasters during or after short period of execution the project	1	1		2		3.25	1.5	2.25

5.4.3 Relative Importance Index

The effect of each factor on the quality of highway project is measured by calculating the relative importance index (RII). The calculated RII of the factors according to consultant is shown in Table (5.14).

Table (5.14): The calculated RII of the factors from consultants' view

Code	Factor	Mean	Relative Index (RII)	Ranking by group	Overall ranking	Importance Level
1	**Group No.1 : Managerial Factor**					
F1.1	Clear roles and responsibilities (owner, consultant, and contractor)	3.5	0.7000	5	24	H-M
F1.2	Contractor's experience	4.75	0.9500	1	2	H
F1.3	Financial status of the contractor	4.5	0.9000	2	4	H
F1.4	Contractor's capability in terms of labors and equipment	3.75	0.7500	4	20	H-M
F1.5	Contractor's selection based on the lowest bidder	4.25	0.8500	3	10	H
F1.6	Owners team experience	3.25	0.6500	9	29	H-M
F1.7	Efficiency of the owner's inspection team	3.5	0.7000	5	24	H-M
F1.8	Amount of work subcontracted	3.5	0.7000	5	24	H-M
F1.9	Delay in contactor progress payment	3.5	0.7000	5	24	H-M
F1.10	Direct payment to laboratory test by contractor	3.25	0.6500	9	29	H-M
F1.11	Weak effective coordination between the departments responsible for infrastructure and road projects	3	0.6000	11	33	H-M
2	Group No.2 : Design and Specification Factor					
F2.1	Pavement is not designed according to the regional conditions (e.g. soil type, temperature, and traffic volume)	4.5	0.900	1	4	H
F2.2	Design errors due to inadequate engineer assumptions and inaccurate data (e.g. traffic volume expected growth and soil type)	4.5	0.900	1	4	H
F2.3	Clarity and accuracy of specifications in terms of aggregates quality and gradation	4.25	0.850	3	10	H
F2.4	Clarity of specifications and appropriate of compaction level	4.25	0.850	3	10	H

F2.5	Consistency of specification interpretation of asphalt quality	4	0.800	5	18	H
F2.6	Limitation on material source selection, equipment type,… etc.	3.75	0.750	6	20	H-M
3	Group No.3 : Construction Process Factor					
F3.1	Availability of owner's and contractor's experienced staff for the project	4.5	0.900	3	4	H
F3.2	Availability of the specified materials quality	4.25	0.850	6	10	H
F3.3	Quality and type of used asphalt	5	1.000	1	1	H
F3.4	Construction process used for asphalt layers	4.75	0.950	2	2	H
F3.5	Quality of used aggregates (e.g., gradation, shape, and type)	4.25	0.850	6	10	H
F3.6	Frequent change in the mix design as a result of changing material's sources	3.5	0.700	10	24	H-M
F3.7.a	Compaction process for subbase layer	4	0.800	8	18	H
F3.7.b	Compaction process for base course layer	4.5	0.900	3	4	H
F3.7.c	Compaction process for asphalt layer	4.5	0.900	3	4	H
F3.8	Acceptance procedure	3.75	0.750	9	20	H-M
F3.9	Public pressure from the community to modify design or increase the speed of works execution	2.75	0.550	11	37	M
4	Group No.4 : Quality Factor					
F4.1	Existence of quality planning	3	0.600	5	33	H-M
F4.2	Existence of quality assurance	3.75	0.750	4	20	H-M
F4.3	Existence of quality control	4.25	0.850	1	10	H
F4.4	Existence of proper quality monitoring and evaluation	4.25	0.850	1	10	H
F4.5	Lack of quality policy	4.25	0.850	1	10	H
5	Group No.5 : Environmental Factor					

F5.1	Existence of environmental management plan to deal with environmental issue	3	0.600	3	33	H-M
F5.2	The season during the project execution	3.25	0.650	1	29	H-M
F5.3	Time the project execution at night or day	3	0.600	3	33	H-M
F5.4	Occurrence Neutral disasters during or after short period of execution the project	3.25	0.650	1	29	H-M

5.4.4 Results from the Consultants' Point of View

5.4.4.1 Managerial Factors

Table (5.15) shows the managerial related factors ranked according to the RII, with their degree of effect on the highway quality.

Table (5.15): Managerial factors and their effect on quality for consultant

Code	Factor	Relative Index (RII)	Ranking by Group	Overall Ranking	Importance Level
F1.2	Contractor's experience	0.95	1	2	H
F1.3	Financial status of the contractor	0.90	2	4	H
F1.5	Contractor's selection based on the lowest bidder	0.85	3	10	H
F1.4	Contractor's capability in terms of labors and equipment	0.75	4	20	H-M
F1.1	Clear roles and responsibilities (owner, consultant, and contractor)	0.70	5	24	H-M
F1.7	Efficiency of the owner's inspection team	0.70	5	24	H-M
F1.8	Amount of work subcontracted	0.70	5	24	H-M
F1.9	Delay in contactor progress payment	0.70	5	24	H-M
F1.6	Owners team experience	0.65	9	29	H-M
F1.10	Labors direct payment to laboratory test by contractor	0.65	9	29	H-M
F1.11	Weak effective coordination between the departments responsible for infrastructure and road projects	0.60	11	33	H-M

The importance levels show that most managerial factors are considered with high-medium level effect on the highway project. The following points discuss the three main managerial factors:

1. Contractor’s experience

Contractor’s experience or contractor’s prequalification for consultant also considered the most important factor in managerial group as contractors.

2. Financial status of the contractor

A contractor’s financial status plays a necessary part in evaluating bidding. Financial status gives an indication of potential progress of the project and can reduce the risk of not completing the project on time and with quality required. Inadequate contractor financial status poses a risk of poor construction quality.

3. Contractor’s selection based on the lowest bidder

In every multiple bids, there will always be a lowest bidder and highest bidder. Sometimes, agencies select the lowest bidder in order to save cost. Unfortunately, this often has unintended consequences.

Benjamin Franklin said, “The bitterness of poor quality remains long after the sweetness of low price is forgotten” (Benjamin, 2018).

Selecting the lowest price may result in selecting a contractor who is not qualified enough to construct the project to its specified quality. While the bid price may be low, the final cost including the cost of delays, penalties, and unsatisfactory performance will be high. The concept of constructing projects by the lowest bidder may sometimes place the quality of project in a secondary role.

5.4.4.2 Design and Specifications Factors

Table (5.16) shows the design and specifications related factors ranked according to the RII, with their degree of effect on the highway project quality.

Table (5.16): Design and specification factors and their effect on quality-consultant's perspective

Code	Factor	Relative Index (RII)	Ranking by Group	Overall Ranking	Importance Level
F2.1	Pavement is not designed according to the regional conditions (e.g. soil type, temperature, and traffic volume)	0.90	1	4	H
F2.2	Design errors arising from inadequate engineer assumptions and inaccurate data	0.90	1	4	H
F2.3	Clarity and accuracy of specifications in terms of aggregates quality and gradation	0.85	3	10	H
F2.4	Clarity of specifications and appropriate of compaction level	0.85	3	10	H
F2.5	Consistency of specification interpretation of asphalt quality	0.80	5	18	H
F2.6	Limitation on material source selection, equipment type,… etc.	0.75	6	20	H-M

The importance level shows that most design and specification factors are considered of high level effect on highway projects. The following points discuss the three main design and specifications factors.

1. **Pavement is not designed according to the regional conditions (e.g. soil type, temperature, and traffic volume)**

The pavement design (structural design) process involves the selection of materials, thickness of each layers, and the type of soil to provide satisfactory level of pavement performance during its service life. Pavement design factors can be divided into four categories: traffic and loading, environment, materials, and failure criteria.

Fundamental knowledge of the climate, soil type, and traffic loading effects on pavement performance and on pavement life to produce good quality asphalt pavement.

2. **Design errors due to inadequate engineering assumptions and inaccurate data**

Design errors depend on inaccuracy in studying the expected traffic volume and the nature of the foundation soil in terms of the design of the road layers and the necessary laboratory tests. To avoid design errors, the preliminary design should rely on the following information to produce a highway with safe, efficient, and economic roads:

- Latest GIS map

- Studying the area topography by using topography survey plane and connect with site topography
- Geological survey
- Traffic volume
- Studying materials and their properties, work on structural design

3. **Clarity and accuracy of specifications in terms of aggregates' quality and gradation**

Specifications should be clear and concise, and provide quantitative descriptions of the significant characteristics of aggregate construction material. There are two general types of requirements for aggregates: quality and gradation. Aggregates for use in base course construction shall be either crushed stone or crushed gravel. Proper crushing and screening are very important for producing aggregates to meet the specification requirements. The contractor should make sure to supply uniformity of the quality and gradation of the aggregates to be used in the construction project. Approval and use of aggregates is based upon meeting physical test requirements.

5.4.4.3 Construction Process Factors

Table (5.17) shows the construction related factors ranked according to the RII, with their degree of effect on the highway project quality.

Table (5.17): Construction process factors and their effect on quality-consultant's perspective

Code	Factor	Relative Index (RII)	Ranking by Group	Overall Ranking	Importance Level
F3.3	Quality and type of used asphalt	1.00	1	1	H
F3.4	Construction process used for asphalt layers	0.95	2	2	H
F3.1	Availability of owner's and contractor's experienced staff for the project	0.90	3	4	H
F3.7.b	Compaction process for base course layer	0.90	3	4	H
F3.7.c	Compaction process for asphalt layer	0.90	3	4	H
F3.2	Availability of the specified materials quality	0.85	6	10	H
F3.5	Quality of used aggregates (e.g., gradation, shape, and type)	0.85	6	10	H
F3.7.a	Compaction process for subbase layer	0.80	8	18	H
F3.8	Acceptance procedure	0.75	9	20	H-M
F3.6	Frequent change in the mix design as a result of changing material's sources	0.70	10	24	H-M
F3.9	Public pressure from the community to modify design or increase the speed of works execution	0.55	11	37	M

The importance level shows that most construction process factors are considered of high level effect on the highway projects. The construction factors are also considered the most overall important factor affecting the projects quality. The following points discuss the three main construction factors.

1. Quality and type of used asphalt

Precise proportions of asphalt and aggregates are blended together to produce hot mix asphalt (HMA) paving mixtures. The most common HMA design procedure is the Marshall Method. The types of asphalts used and the proportions of each component vary among mixtures. The contractor must develop a mix design that is within the specifications' guidelines thirty days before paving works. The mix design is then submitted to the supervisor with the design of the asphalt mixture and the bitumen content for testing and approval. No mix must be used on the project before the mix design obtain a written approved. Asphalt is as good as the good material used.

2. Construction process used for asphalt layers

The methodology for laying hot mix asphalt should include surface preparation, prime/tack coat application, traffic management, compaction, joint treatment, temperature control, surface shape and thickness, and material and construction process of asphalt.

3. Availability of owner's and contractor's experienced staff for the project

Working staff engineers, workers during the construction phase is considered one of the most important factors to achieve road quality; their attitude, skills, and experience play a major factor to the success of any project.

5.4.4.4 Quality Factors

Table (5.18) shows the quality related factors ranked according to the RII, with their degree of effect on the highway projects quality.

Table (5.18): Quality factors and their effect on quality for consultant

Code	Factor	Relative Index (RII)	Ranking by Group	Overall Ranking	Importance Level
F4.3	Existence of quality control	0.85	1	10	H
F4.4	Existence of proper quality monitoring and evaluation	0.85	1	10	H
F4.5	Lack of quality policy	0.85	1	10	H
F4.2	Existence of quality assurance	0.75	4	20	H-M
F4.1	Existence of quality planning	0.60	5	33	H-M

The importance level shows that most quality factors are consider of high level effect on highway projects. The following points discuss the three main quality factors.

1. Existence of quality control

2. Existence of proper quality monitoring and evaluation

Project planning, monitoring, and evaluation illustrates the main steps of the project cycle. Information obtained through the monitoring and evaluation process can be used as the basis for improve programming, policy, and future planning, which will eventually improve the quality for highway project.

Monitoring is defined as “collection of data prior to and during the project implementation. These data, when analyzed, pinpoint progress or constraints as early as possible, allowing project managers to adjust project activities as needed. It also provides basis for undertaking evaluation”(Khan, 2015). While evaluation is defined as “a structured process of assessing the success of a project in meeting its goal and to reflect on the lessons learned. It is carried out mostly at the end of a project work. Evaluation is not just about demonstrating success; it is also about learning why things went wrong. As such, identifying and learning from mistakes is one of the key aspects of evaluation” (Khan, 2015).

3. Lack of quality policy

ISO (2015) stated that “the quality policy is consistent with the overall policy of the organization and can be aligned with the organization’s vision and mission and provides a framework for the setting of quality objectives”. A quality policy statement, which should be brief and crisp and written in clear, precise language, is important to achieving quality and providing quality assurance for the owner, the consultant, and the contractor (ISO, 2015).

5.4.4.5 Environmental Factors

Table (5.19) shows the environmental related factors ranked according to the RII, with their degree of effect on the highway project’s quality.

Table (5.19): Environmental factors and their effect on quality-consultant’s perspective

Code	Factor	Relative Index (RII)	Ranking by Group	Overall Ranking	Importance Level
F5.2	The season during the project execution	0.65	1	29	H-M
F5.4	Occurrence Neutral disasters during or after	0.65	1	29	H-M

	short period of execution the project				
F5.1	Existence of environmental management plan to deal with environmental issue	0.60	3	33	H-M
F5.3	Time the project execution at night or day	0.60	3	33	H-M

The importance level shows that most environmental factors are considered of high-medium level effect. The following points discuss the main environmental factors.

1. The season during the project execution
2. Occurrence Neutral disasters during or after short period of execution the project
3. Existence of environmental management plan to deal with environmental issue
4. Time the project execution at night or day

Scheduling of work activities over time consider part from road project management. (Ab Wahid, 2014) found the main reasons for night-time highway constructions as follows:

- Saving time, reducing the construction period.
- Reduce traffic congestion, avoid traffic congestion problem arising from daytime works.
- Ease of conducting works especially work construction need to use large machines.

Night-time highway construction work is not the best option for all cases, the issue of inadequate lighting not only affect the quality but also safety of worker and should only be used when necessary.

Table (5.21) shows the overall RII for consultants and contractor.

Table (5.20): The calculated overall RII for both consultants and contractors

Code	Factor	Consultants		Contractors		Overall RII	No.
		Relative Index (RII)	Overall Ranking	Relative Index (RII)	Overall Ranking		
F3.3	Quality and type of used asphalt	1.0000	1	0.9556	3	0.9778	1
F1.2	Contractor's experience	0.9500	2	0.9156	8	0.9328	2
F3.1	Availability of owner's and contractor's experienced staff for the project	0.9000	4	0.9556	1	0.9278	3
F3.4	Construction process used for asphalt layers	0.9500	2	0.8933	12	0.9217	4
F3.7.c	Compaction process for asphalt layer	0.9000	4	0.9422	4	0.9211	5
F3.7.b	Compaction process for base course layer	0.9000	4	0.9378	6	0.9189	6
F3.5	Quality of used aggregates (e.g., gradation, shape, and type)	0.8500	10	0.9556	1	0.9028	7
F1.3	Financial status of the contractor	0.9000	4	0.8844	13	0.8922	8
F2.1	Pavement is not designed according to the regional conditions (e.g. soil type, temperature, and traffic volume)	0.9000	4	0.8622	14	0.8811	9
F2.2	Design errors due to inadequate engineer assumptions and inaccurate data	0.9000	4	0.8533	16	0.8767	10
F2.4	Clarity of specifications and appropriate of compaction level	0.8500	10	0.8978	11	0.8739	11
F3.7.a	Compaction process for subbase layer	0.8000	18	0.9422	4	0.8711	12
F2.5	Consistency of specification interpretation of asphalt quality	0.8000	18	0.9111	9	0.8556	13
F3.2	Availability of the specified materials quality	0.8500	10	0.8444	18	0.8472	14

F4.3	Existence of quality control	0.8500	10	0.8444	19	0.8472	15
F2.3	Clarity and accuracy of specifications in terms of aggregates quality and gradation	0.8500	10	0.8311	22	0.8406	16
F4.4	Existence of proper quality monitoring and evaluation	0.8500	10	0.8133	26	0.8317	17
F1.9	Delay in contactor progress payment	0.7000	24	0.9244	7	0.8122	18
F4.5	Lack of quality policy	0.8500	10	0.7422	31	0.7961	19
F1.4	Contractor’s capability in terms of labors and equipment	0.7500	20	0.8311	23	0.7906	20
F4.2	Existence of quality assurance	0.7500	20	0.8267	24	0.7883	21
F3.8	Acceptance procedure	0.7500	20	0.8089	28	0.7794	22
F1.5	Contractor’s selection based on the lowest bidder	0.8500	10	0.7067	33	0.7783	23
F1.6	Owners team experience	0.6500	29	0.9067	10	0.7783	24
F1.1	Clear roles and responsibilities (owner, consultant, and contractor)	0.7000	24	0.8444	17	0.7722	25
F1.7	Efficiency of the owner’s inspection team	0.7000	24	0.8400	20	0.7700	26
F3.6	Frequent change in the mix design as a result of changing material’s sources	0.7000	24	0.8267	25	0.7633	27
F5.2	The season during the project execution	0.6500	29	0.8400	20	0.7450	28
F2.6	Limitation on material source selection, equipment type,… etc.	0.7500	20	0.7333	32	0.7417	29
F1.11	Weak effective coordination between the departments responsible for infrastructure and road projects	0.6000	33	0.8622	14	0.7311	30
F5.4	Occurrence Neutral disasters during or after short period of execution the project	0.6500	29	0.7778	30	0.7139	31
F4.1	Existence of quality planning	0.6000	30	0.8133	26	0.7067	32

F3.9	Public pressure from the community to modify design or increase the speed of works execution	0.5500	37	0.7778	29	0.6639	33
F5.1	Existence of environmental management plan to deal with environmental issue	0.6000	33	0.7067	34	0.6533	34
F1.8	Amount of work subcontracted	0.7000	24	0.6044	36	0.6522	35
F5.3	Time the project execution at night or day	0.6000	33	0.6711	35	0.6356	36
F1.10	Direct payment to laboratory test by contractor	0.6500	29	0.4356	37	0.5428	37

5.5 T-test

The T-test was conducted to find if there is a significant difference between the ranking of contracting and consulting companies.

To answer the research question: “Do contracting and consulting perceive quality factors affecting highway construction in northern West Bank differently?”

The null hypothesis: There is no difference in perception of quality factors between contracting and consulting.

The research hypothesis: There is a significant difference in perception between contracting and consulting companies regarding factors affecting quality in highway construction.

Table (5.21) shows that there is a high correlation in the ranking of the two samples. Hence, the null hypothesis can be accepted concluding that the contracting and consulting companies do not perceive factors affecting quality on highway differently, especially in design specification, quality and environmental factor (p-value less than 0.05); However, in managerial and construction factors, eight factors have p-value more than 0.05. This may be due to the fact that they work under the same conditions and they are passing almost the same experience through implementing the several stages of the highway construction projects.

Table (5.21): T-Test results comparing the quality factors from the respondent point of view

Group	Code	Consultants		Contractors		F-value	t-value	P-value
		Mean	Std. deviation	Mean	Std. deviation			
Managerial Factors	F1.1	3.25	1.5	4.22	1.126	0.347	1.616	0.113
	F1.2	4.75	0.5	4.58	0.812	0.529	-0.415	0.68
	F1.3	4.5	0.577	4.42	0.839	0.444	-0.181	0.857
	F1.4	3.75	0.957	4.16	0.878	0	0.88	0.383
	F1.5	4.25	0.957	3.53	1.517	1.952	-0.924	0.36
	F1.6	3.25	0.957	4.53	0.694	0.703	3.446	0.01**
	F1.7	3.5	0.577	4.2	0.919	1.423	1.488	0.143
	F1.8	3.5	0.577	3.02	1.252	1.849	-0.75	0.457
	F1.9	3.5	0.577	4.62	0.747	0.047	2.916	0.002**
	F1.10	3.25	1.258	2.18	1.37	1.306	-1.508	0.138
	F1.11	3	0	4.31	0.848	9.177	10.371	0**
Design and Specification Factors	F2.1	4.5	0.577	4.31	0.996	1	-0.371	0.712
	F2.2	4.5	0.577	4.27	1.009	0.796	-0.453	0.653
	F2.3	4.25	0.957	4.16	0.852	0.081	-0.211	0.834
	F2.4	4.25	0.957	4.49	0.757	0.297	0.593	0.556
	F2.5	4	0.816	4.56	0.693	0.235	1.518	0.136
	F2.6	3.75	0.5	3.67	1.225	3.774	-0.13	0.894
Construction Process Factors	F3.1	4.5	0.577	4.78	0.471	0.881	1.112	0.272
	F3.2	4.25	0.5	4.22	1.146	2.191	-0.048	0.962
	F3.3	5	0	4.78	0.517	3.997	-0.851	0.399
	F3.4	4.75	0.5	4.47	0.968	1.047	-0.575	0.568
	F3.5	4.25	0.5	4.78	0.517	0.03	1.959	0.056
	F3.6	3.5	0.577	4.13	0.991	0.486	3.228	0.002**
	F3.7.a	3	0	4.71	0.458	17.685	25.042	0**
	F3.7.b	3	0	4.71	0.549	23.047	24.199	0**
	F3.7.c	3.5	0.577	4.71	0.549	0.149	4.216	0**
	F3.8	2.75	0.957	4.04	0.999	0.002	2.49	0.016**
	F3.9	1.75	0.957	3.89	1.112	0.095	3.716	0.001**
Quality Factors	F4.1	3	1.155	4.07	0.863	1.602	2.31	0.025**
	F4.2	3.75	1.258	4.13	1.014	0.043	0.713	0.48
	F4.3	4.25	0.5	4.22	1.126	1.848	-0.049	0.961
	F4.4	4.25	0.5	4.07	1.053	2.864	-0.342	0.734
	F4.5	4.25	0.5	3.71	1.036	2.287	-1.022	0.312
Environmen	F5.1	3	1.414	3.53	1.358	0.131	0.75	0.457

	F5.2	3.25	1.708	4.2	1.079	1.366	1.612	0.114
	F5.3	3	1.155	3.36	1.368	0.089	0.503	0.617
	F5.4	3.25	1.5	3.89	1.265	0.376	0.955	0.344

**P-value less than 0.05, there is a significant difference between contracting and consulting.

5.6 Summary

The quality of a project goes through several stages such as management, design, construction, quality, and environmental. There are several factors affecting quality throughout the lifecycle of a highway project. The current study considered 37 factors affecting quality of roads throughout their lifecycle. The responses were analyzed.

As shown, there are common factors between the consultants' and contractors'; they work under the same condition. The following are the ten main factors according to contractors' and consultants' view:

- Quality and type of used asphalt
- Contractor's experience
- Availability of owner's and contractor's experienced staff for the project
- Construction process used for asphalt layers
- Compaction process for asphalt layer
- Compaction process for base course layer
- Quality of used aggregates (e.g., gradation, shape, and type)
- Financial status of the contractor
- Pavement is not designed according to the regional conditions (e.g. soil type, temperature, and traffic volume)

- Design errors due to inadequate engineer assumptions and inaccurate data

Pavement roadway condition survey was done visually for twenty-five roads distributed in the northern governments in the West Bank to evaluate roads with an age of less than five years. Roads rating ranged from good to fair with PCI values 98% to 68%. Common distresses observed in the field were alligator, longitudinal cracks, depression, and patching. These distresses show defects in the construction process of different layers, inaccurate design, and/or weak affective coordination in executing the infrastructure works.

Chapter Six

Model Development

Chapter Six

Model development

6.1 Introduction

From the previous chapter, it was found that many factors affect highway quality, which need to be dealt with. In this chapter, a model representing quality factors in northern West Bank is developed. Through this study, a model representing local quality factors is developed and used as a tool to determine critical factors to be adopted in solving or avoiding most important problems and trying to improve performance of road construction projects.

6.2 Pareto Analysis for Factors Affecting Quality in Northern West Bank

Pareto Analysis is a statistical technique in decision-making in quality management used for the selection of a limited number of factors that produce significant overall effect. It uses the Pareto Principle (also known as the 80/20 rule); the idea is that by doing 20% of the work you can generate 80% of the benefit of doing the entire job.

Pareto - Italian economist in 1897 created a mathematical formula to describe unequal distribution of wealth or income that is held by twenty percent of people who own eighty present of wealth. This means 20% of factors achieves 80% of the importance percentage (Amer, 2002).

This approach was developed based on calculating the importance percentage of factors. The developed model represents the critical factors of quality in highway projects in the northern West Bank. To develop the model, the following steps has been followed:

1. Calculation of the importance percentage (I.P) of factors according to their impact on quality of asphalt pavement by summing the means of factors obtained in Chapter 5. The equation below is used to calculate the importance percentage for each factors as shown in Table 6.1.

$$I.P = \frac{x}{\sum_{1}^{no.factors} x} \times 100\% \qquad (6.1)$$

   Where:

   I.P: Importance percentage for factors

   x: Mean for factors obtained (from chapter five)

Table (6.1): Importance percentage of factors

Group	Code	Mean (x)	x/∑x	I.P
Managerial Factors	F1.1	3.735	0.026 =(3.735/145.815)*100%	2.561
	F1.2	4.665	0.032	3.199
	F1.3	4.46	0.031	3.059
	F1.4	3.955	0.027	2.712
	F1.5	3.89	0.027	2.668
	F1.6	3.89	0.027	2.668
	F1.7	3.85	0.026	2.640
	F1.8	3.26	0.022	2.236
	F1.9	4.06	0.028	2.784
	F1.10	2.715	0.019	1.862
	F1.11	3.655	0.025	2.507
Design and Specification Factors	F2.1	4.405	0.030	3.021
	F2.2	4.385	0.030	3.007
	F2.3	4.205	0.029	2.884
	F2.4	4.37	0.030	2.997
	F2.5	4.28	0.029	2.935
	F2.6	3.71	0.025	2.544
Construction Process Factors	F3.1	4.64	0.032	3.182
	F3.2	4.235	0.029	2.904
	F3.3	4.89	0.034	3.354
	F3.4	4.61	0.032	3.162
	F3.5	4.515	0.031	3.096
	F3.6	3.815	0.026	2.616
	F3.7.a	3.855	0.026	2.644
	F3.7.b	3.855	0.026	2.644
	F3.7.c	b4.105	0.028	2.815
	F3.8	3.395	0.023	2.328
	F3.9	2.82	0.019	1.934
Quality Factors	F4.1	3.535	0.024	2.424
	F4.2	3.94	0.027	2.702
	F4.3	4.235	0.029	2.904
	F4.4	4.16	0.029	2.853
	F4.5	3.98	0.027	2.729
Environmental Factors	F5.1	3.265	0.022	2.239
	F5.2	3.725	0.026	2.555
	F5.3	3.18	0.022	2.181
	F5.4	3.57	0.024	2.448
	Sum=	145.815		

2. The factors are then organized in descending order; the cumulative percentage is found to using the Pareto principle. Table 6.2 shows the cumulative percentages of factors in descending order.

Table (6.2): Cumulative percentages of factors in descending order

Order	Code	Factors	I.P	Cumulative Percentage
1	F3.3	Quality and type of used asphalt	3.354	3.354
2	F1.2	Contractor's experience	3.199	6.553
3	F3.1	Availability of owner's and contractor's experienced staff for the project	3.182	9.735
4	F3.4	Construction process used for asphalt layers	3.162	12.896
5	F3.5	Quality of used aggregates (e.g., gradation, shape, and type)	3.096	15.993
6	F1.3	Financial status of the contractor	3.059	19.052
7	F2.1	Pavement is not designed according to the regional conditions (e.g. soil type, temperature, and traffic volume)	3.021	22.072
8	F2.2	Design errors arising from inadequate engineer assumptions and inaccurate data	3.007	25.080
9	F2.4	Clarity of specifications and appropriate of compaction level	2.997	28.077
10	F2.5	Consistency of specification interpretation of asphalt quality	2.935	31.012
11	F3.2	Availability of the specified materials quality	2.904	33.916
12	F4.3	Existence of quality control	2.904	36.821
13	F2.3	Clarity and accuracy of specifications in terms of aggregates quality and gradation	2.884	39.704
14	F4.4	Existence of proper quality monitoring and evaluation	2.853	42.557
15	F3.7.c	Compaction process for asphalt layer	2.815	45.373
16	F1.9	Delay in contactor progress payment	2.784	48.157
17	F4.5	Lack of quality policy	2.729	50.886
18	F1.4	Contractor's capability in terms of labors and equipment	2.712	53.599

19	F4.2	Existence of quality assurance	2.702	56.301
20	F1.5	Contractor's selection based on the lowest bidder	2.668	58.969
21	F1.6	Owners team experience	2.668	61.636
22	F3.7.a	Compaction process for subbase layer	2.644	64.280
23	F3.7.b	Compaction process for base course layer	2.644	66.924
24	F1.7	Efficiency of the owner's inspection team	2.640	69.564
25	F3.6	Frequent change in the mix design as a result of changing material's sources	2.616	72.181
26	F1.1	Clear roles and responsibilities (owner, consultant, and contractor)	2.561	74.742
27	F5.2	The season during the project execution	2.555	77.297
28	F2.6	Limitation on material source selection, equipment type,… etc.	2.544	79.841
29	F1.11	Weak effective coordination between the departments responsible for infrastructure and road projects	2.507	82.347
30	F5.4	Occurrence Neutral disasters during or after short period of execution the project	2.448	84.796
31	F4.1	Existence of quality planning	2.424	87.220
32	F3.8	Acceptance procedure	2.328	89.548
33	F5.1	Existence of environmental management plan to deal with environmental issue	2.239	91.788
34	F1.8	Amount of work subcontracted	2.236	94.023
35	F5.3	Time the project execution at night or day	2.181	96.204
36	F3.9	Public pressure from the community to modify design or increase the speed of works execution	1.934	98.138
37	F1.10	Direct payment to laboratory test by contractor	1.862	100.000

1. 80% of the results were achieved by 28 factors as shown in Figure 6.1; meaning that the 80/20 is not applicable. However, the critical factors

were assumed as factors meeting 70% of the importance of Pareto chart, which include 24 factors that will be shown in the next step.

Note: Pareto chart in Figures 6.1 contains both bars and lines where the factors are represented in descending order by bars, and the cumulative total of the sample is represented by the curved line. An 80% cut off line is also included to indicate where the 80/20 rule applies.

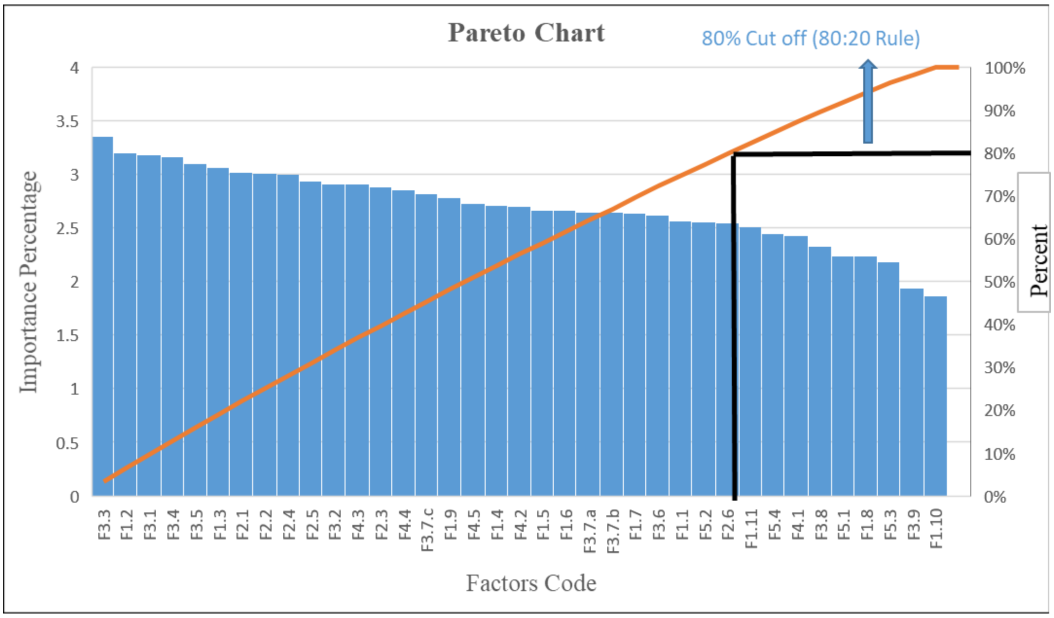


Figure (6.1): Pareto chart for quality factors in highway construction

2. The critical factors affecting the quality in highway construction projects are found; they are arranged as a main group in Table 6.3. The sum of parameter represents about 70%.

Table (6.3): Modify critical factors of quality

Group	No. From Pareto Chart	Code	Factors	I.P	Modify Critical Factor
Group 1:Managerial Factor (28.186)	2	F1.2	Contractor's experience	3.199	4.570
	6	F1.3	Financial status of the contractor	3.059	4.370
	16	F1.9	Delay in contactor progress payment	2.784	3.977
	18	F1.4	Contractor's capability in terms of labors and equipment	2.712	3.874
	20	F1.5	Contractor's selection based on the lowest bidder	2.668	3.811
	21	F1.6	Owners team experience	2.668	3.811
	24	F1.7	Efficiency of the owner's inspection team	2.64	3.771
Group 2:Design and Specifications Factor (21.206)	7	F2.1	Pavement is not designed according to the regional conditions	3.021	4.316
	8	F2.2	Design errors due to inadequate engineer assumptions and inaccurate data	3.007	4.296
	9	F2.4	Consistency of specification interpretation of compaction level	2.997	4.281
	10	F2.5	Consistency of specification interpretation of asphalt quality	2.935	4.193
	13	F2.3	Clarity and accuracy of specifications in terms of aggregates quality and gradation	2.884	4.120

Group 3:Construction Process Factor (34.001)	1	F3.3	Quality and type of used asphalt	3.354	4.791
	3	F3.1	Availability of owner's and contractor's experienced staff for the project	3.182	4.546
	4	F3.4	Construction process used for asphalt layers	3.162	4.517
	5	F3.5	Quality of used aggregates (e.g., gradation, shape, and type)	3.096	4.423
	11	F3.2	Availability of the specified materials quality	2.904	4.149
	15	F3.7.c	Compaction process for asphalt layer	2.815	4.021
	22	F3.7.a	Compaction process for subbase layer	2.644	3.777
	23	F3.7.b	Compaction process for base coarse layer	2.644	3.777
Group 4:Quality Factor (15.983)	12	F4.3	Existence of quality control	2.904	4.149
	14	F4.4	Existence of proper quality monitoring and evaluation	2.853	4.076
	17	F4.5	Lack of quality police	2.729	3.899
	19	F4.2	Existence of quality assurance	2.702	3.860

From the results it is clear that the critical factors affecting the quality of highway construction are: construction process, management, design and specification, and quality factors, in this order.

6.3 Using The Model

The results clearly indicate that there are twenty-four factors, out of thirty-seven factors, that affect lowering road project's quality. Therefore, this helps project owners to take actions towards improving these important factor and hence improving the overall project's quality. The developed model describes the primary factors affecting quality, which may be used by road owners to take actions and working to improve each vital factor according to the nature of the factor with the owner's policy.

In order to discuss the results of the model, a meeting was held with the Municipal Development and Lending Fund (MDLF) engineers. The MDLF stressed on the importance of the study and its results in improving the quality of road projects. In addition to all factors discussed and mentioned in the study, the MDLF has arranged several factors affecting the quality of road projects according to their stages and priority, which are:

- Reasons related to the planning stage
- Reasons related to the design stage

1. Preparing some designs from those who are not qualified in this field.

2. The lack of comprehensiveness of some designs for all the basic elements and the lack of coordination between road specialists and other related disciplines (water, sewage, electricity, etc.)
3. Inaccuracy in studying the expected traffic volume and the nature of the foundation soil in terms of conducting the required technical studies for the design of road layers and the necessary laboratory tests.
4. The reliance on sideways rainwater drainage, especially in low-lying areas.
5. Inadequate bills of quantities and their description of items; quantities and prices.

- Reasons related to the implementation phase
  1. Factors related to supervision
     a. The project supervisor has insufficient experience to supervise road projects and related infrastructure.
     b. The supervising engineer sometimes makes modifications to the project without making a comprehensive study of the reflection of those modifications on the original design without coordination with the original designer.
  2. Factors related to the contractor, often the factors associated with the contractor that cause problems for some roads as a result of the implementation of the project in some cases without being bound by the technical specifications and project plans.
  3. Factors related to laboratories and quality control.

a. Samples sometimes do not represent reality, whether in terms of the number of samples or the method and place of taking them.
b. Conducting laboratory tests by laboratories without getting prior approval; an issue of credibility.
c. Inadequate linkage between the results of the tests and the standards required and specified in the technical specifications of the project.
d. Inconsistencies in test results between two laboratories for the same materials that were examined and in the same region; an issue of credibility.

- Reasons related to the maintenance phase after implementation.
    1. Not allocating sufficient budgets for operation and maintenance in the owner's budget, and paying more attention to the implementation of new projects.
    2. Failure to perform preventive or corrective maintenance in a timely manner.
    3. Lack of prioritization of the streets that need maintenance and the absence of a clear methodology for maintenance procedures.
    4. Lack of equipment and machinery necessary to carry out maintenance.

Chapter Seven

Summary and Conclusions

Chapter Seven

Summary and Conclusions

7.1 Summary

In Palestine, there is little documentation concerning the quality management system in construction projects in general, and in the highway construction at specific. The lack of specialized studies for this purpose may be due to the lack of awareness of quality and its importance in construction, economic, social, and political challenges that encounter the Palestinian situation, especially with the shrinking budget and the lack of reliable data, which makes it difficult to perform such studies.

The pavement condition survey shows that many newly constructed roads exhibited a low quality of performance in the form of various types of distresses. These distresses will result in poor roads and poor safety, and also higher maintenance and rehabilitation costs at the early age. Therefore, it is important to identify those factors that affect quality in highway construction.

In this research thirty-seven factors were defined; divided into five categories: (1) managerial-related factors, (2) design-and specifications-related factors, (3) construction-related factors, (4) quality-related factors, and (5) environmental-related factors. For identifying factors affecting the quality of the constructed asphalt highways in the northern West Bank, a questionnaire was designed to collect the points of views from the contractors and consultant's companies since they are the ones who execute and supervise the construction process of the highway projects. The Relative Importance Index (RII) analysis was used and factors were ranked.

Roadway condition survey of the pavement was done visually for twenty-five roads distributed in the northern governments in the West Bank to evaluate the roads with ages less than five years of the last maintenance/rehabilitation or construction.

A model has been developed using the Pareto approach. The model represents the critical factors of quality in highway projects in the northern West Bank.

7.2 Conclusions

The quality of a project goes through several stages such as planning, management, design, construction, maintenance, quality, and environmental. There are several factors affecting the quality throughout the lifecycle of a highway project; the current study considered 37 factors. The relative important index was carried out to determine important factors affecting the highway quality. It is concluded that the most important factors affecting quality of highway construction project are managerial factors and design and specification factors in this order. Consultants, contractors and owners agreed on the importance of a number of factors; the most important factors are:

- Quality and type of used asphalt, and availability of experienced staff in the owner's and contractor's teams (construction group).
- Contractor's experience, and contractor's financial status during the project exestuation (managerial group).
- Design errors arising from inaccurate data, pavement layer not designed according to the regional condition and clarity of specification (design and specifications group).

Roadway condition survey of the pavement was done visually to twenty-five roads distributed in the northern governments of the West Bank in order to evaluate the roads with age less than five years. Commonly observed distresses in the field were alligator, longitudinal cracks, depression, and patching. These distresses show defects in the construction process for different layers due to inaccurate design and weak affective coordination in executing the infrastructure works.

7.3 Recommendations

1. It is recommended for the contracting and consulting companies to develop their overall management system, which contains materials, equipment, and labors management system. These systems will ensure that most quality elements are achieved.
2. It is recommended for owners seeking high quality projects to select prequalified contractors and not necessarily based on the lowest bidder. Experience showed that when projects were awarded by the open tendering system based on the lowest bid, projects were delayed and suffered from

quality problems. On the other hand, the lower price bidder system could be used after a short list of prequalified quality contractors is prepared. Contractor should be selected on the basis of experience; past performance in highway construction project in Palestine. The process of evaluating contractors' bids might be altered so that very low bids (for example, 30% less than estimated cost, or any other agreed on margin) should be excluded since they might indicate misunderstanding of the work ahead or potential for poor performance.

3. The availability of qualified, experienced, and efficient site staff (both supervision and contractor) plays an important role in affecting the overall quality of a construction project. It is also important to further build their capacity, and improve their skills and qualifications through training courses and to include quality control managers among the staff.
4. To avoid design errors and omissions, proper planning and design should be done in sufficient time site, investigation should be done before procurements and the design must be done by competent engineers not surveyors. This allows for collecting more accurate data regarding design parameters (soil type, temperature, traffic loads, etc.).
5. It is recommended to do design-review checking to ensure that everything is accurate and consistent, and that each is drawn properly and adequately, to reflect the design analysis, use the current standards of presentation, and provide all details needed for construction.
6. Effective quality control and assurance system is highly recommended during the construction process so as to assure the desired end road quality.

This helps project supervisors to periodically inspect the construction material, check the constructed works, and make sure that the project quality is in accordance with its technical specifications.

7. It is also recommended that drawings, specifications, bill of quantities, and design documents for each layer, material properties, and construction specifications should be clear and concise. They should also contain quantitative descriptions. Local standards should also be developed to suite local conditions and criteria.
8. It is recommended for large municipalities to have an effective coordination between the departments responsible for infrastructure and road projects to ensure not negatively affect the road's construction work. They should arrange the works to be done to ensure that the implemented road is not damaged by other works; to maintain their durability.

References

- AASHTO R42. (2006). **Standard Practice for Developing a Quality Assurance Plan for Hot Mix Asphalt (HMA)**. American Association of State Highway and Transportation Officials (AASHTO).
- Ab Wahid, A. A. (2014). **Night-Time Highway Construction or Maintenance/Upgrading Works**, Paper. Department of Quantity Surveying, Faculty Architecture Planning and Surveying, Perak, Malaysia: EDP Sciences.
- Abu El-Maaty, A. A.-H. (2016). **Management of Highway Projects in Egypt Through Identifiying Factors Influencing Quality Performance**. Master thesis, Menoufia University, Egypt.
- Akadiri, O. (2011). **Devlopment of Multi Criteria Approach for the Selection of Sustainable Materials for Building Project**. Doctoral thesis, Woleverhampton University, England.
- Al-Hassan, M. (1993). **Factors Affecting Quality Construction in Saudi Arabia.** Master thesis, King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia.
- Amer, M. (2002). **Modeling the Factors Affecting Quality of Building Construction Projects During the Construction Phaze in Gaza Strip**. Master thesis, Islamic University, Gaza, Palestine.
- ASCE. (2007). **Quality in the Constructed Project: A Guide for Owners, Designers, and Constructors, Second edition**. American Society of Civil Engineers, Reston, Virginia, USA.

- ASTM. (2007). **Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys, ASTM International, D6433-07**. West Conshohocken, PA,USA. www.astm.org.
- aura. (2019). **Importance of Quality Management Systems in Construction Industry**. Retrieved from (Accessd 2021,June 20) http://www.auraqualitymanagement.com/blog/importance-quality-management-systems-construction-industry/.
- BattiKha, M. (2002). **Quality Management Practice in Highway Construction**. Ohio State University, Colombus, Ohio, USA.
- Benjamin, F. (2018). Retrieved from (Accessd 2021,June 20). https://www.goodreads.com/quotes/8373797-the-bitterness-of-poor-quality-remains-long-after-the-sweetness.
- Environmental Management Plan. (2018). Retrieved from (Accessed: 2021, Mar 20). https://sitemate.com/uk/templates/environmental/forms/environmental-management-plan-template/.
- Faroogui, R. a. (2008). **Assessment of Pakistani Construction Industry- Current Performance and Way Forward**. Master Thesis, Florida International University, Miami, Florida, USA.
- FHWA. (2007). **Highway Quality Compendium**. Fedral Highway Administration, Washington, DC, USA.
- ISO. (2015). **Quality Management Systems - Fundemental and Vocabulary ISO9000.**
- ISO9001. (2015). **Quality Management Systems — Requierment. International Standard.**

- Jha, K. I. (2006). **Critical Factors Affecting Quality Performance in Construction Projects**. Total Quality Management and Business Excellence Journal, vol. 17, no. 9, pp. 115-1170.
- Juran, J. (1995). **A History of Managing for Quality: The Evolution, Trends, and Future Directions of Managing for Quality**. Milwaukee, Wisconsin, USA.
- Khan, N. (2015). **Mointring and Evaluation (M&E) Manual on Construction Works**. Monitoring and Evaluation Consultant, SMECI Project, Bangladesh.
- MDLF. (2017). **Operation and Maintenance Manual (O&M)**. Municipal Development & Lending Fund (MDLF), Ramallah, Palestine.
- MDLF. (2018). **Technical Specifications by Municipal Development and Lending Fund**. Ramallah, Palestine.
- Minde, R. (2018). **Analyzing the Factors Influencing Quality Throughout The Lifecycle of a Road Project**. Sardar Patel College of Engineering, Mumbai, India.
- Molenaar, K. G. (2015). **Guide Book on Alternative Quality Management Systems for Highway Construction**. National Cooperative Highway Research Program. Washington, DC, USA.
- Najmi, H. (2011). **Project Management for Construction Projects**. Master thesis, An-Najah National University, Nablus, Palestine.
- Neyestani, B. (2016). **Effictivness of Quality Management System (QMS) on Construction Projects**. Master thesis, Da La Salle University, Manila, Philippines.
- PCBS. (2016). **Transportation and Communication Staitstics**. Palestinian Central Bureau of Statistics, Ramallah, Palestine.

- PCBS. (2019). **Transportion and Communication Staistics**. Palestinian Central Burea of Staistics, Ramallah, Palestine.
- PCBS. (2020). **Transportation and Communication Staistics**. Palestinian Central Bureau of Staistics,Ramallah, Palestine.
- PCU. (2018). **Palestinian Contractors Union**. Construction Sector Palestine, West Bank.
- Rumane, A. (2011). **Quality Tools for Managing Construction Projects**. CRC Press; 1st edition. USA.
- Syaj, M. (2015). **Challenges in the Implementation of Quality Management in the Construction Sector in Palestine**. Master thesis, An-Najah National University, Nablus, Palestine.
- UNRWA. (2006). Project Completion Reports. Gaza, Palestine.

Appendix

Appendix A

Arabic form for contractor

An-Najah National University
Faculty of Graduate Studies

جـامعة النجـاح الوطـنية
كلية الدراسات العليا

السادة/

السلام عليكم ورحمة الله وبركاته، وبعد:

نأمل منكم التكرم بمنحي بضع دقائق من وقتكم للإجابة على كافة اسئلة الاستبانة المرفقة وموافاتنا بالمعلومات الضرورية للعوامل المؤثرة في جودة الطرق ومعرفة تقييمكم لتلك العوامل.

هذه الاستبانة هي لأغراض البحث لرسالتي الماجستير بعنوان " **تقييم نظام إدارة الجودة لمشاريع الطرق في شمال الضفة الغربية"** استكمالا للحصول على درجة الماجستير في تخصص هندسة الطرق والمواصلات من جامعة النجاح الوطنية. الغرض من هذه الاستبانة هو توضيح العوامل التي تؤثر على جودة الطرق في شمال الضفة الغربية وتحديدها، حيث سوف نقوم بتجميع المعلومات من مقاولي الطرق العاملين في شمال الضفة الغربية.

نأمل منكم التفضل بالمشاركة البناءة والتعاون في سرعة الاستجابة والتي تشكل عاملا مهما في إتمام هذا البحث، لذا نرجو تعبئة هذه الاستبانة بالبيانات اللازمة، والإجابات الدقيقة على كل سؤال من الاسئلة المطروحة وحسب رأيكم، لما في ذلك من أثر مهم في الوصول الى النتائج الدقيقة المنشودة التي يمكن الاعتماد عليها. كما أن الإجابة على أسئلة الاستبيان تتكون من جزئيين هما:

الجزء الأول: معلومات حول الشركة

الجزء الثاني: العوامل المؤثرة على جودة الطرق في فترات المشروع المختلفة.

ويسرني أن اتقدم بوافر الشكر وعظيم الامتنان لحسن تعاونكم في تعبة هذه الاستبانة.

وتفضلوا بقبول فائق الشكر والاحترام

الباحثة: م.أريج نبيل ملحم

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0599030431

الجزء الأول: معلومات شخصية

اسم شركة المقاولات (اختياري):	....
عنوان الشركة:	....
منصب المشارك في الاستبيان:	....
عدد سنوات الخبرة:	....

1- تصنيف شركة المقاولات حسب تصنيف وزارة الاشغال والإسكان العامة في مجال الطرق:

أ- الأولى ( )　　ب- الثانية ( )　　جـ- الثالثة ( )　　د - الرابعة ( )　　هـ- الخامسة ( )

2- عدد سنوات الخبرة (شركة المقاولات) في مشاريع الطرق :

أ- أقل من 5 سنوات ( )　　ب- من 5-10 سنوات ( )

جـ- من 10-15 سنة ( )　　د- أكثر من 15 سنة ( )

3- عدد موظفي الشركة:..............................

4- معدل المدة الزمنية (مدة المشروع) لتنفيذ مشاريع الطرق المنفذة من قبل الشركة:

أ- أقل من نصف سنة ( ) ب- من ½ -1 سنة ( )

جـ- من 1-2 سنة ( ) د- أكثر من 2 سنة ( )

5- معدل ميزانية المشاريع المنفذة من قبل الشركة:

أ- 200 الف دولار أو أقل ( ) ب- من (200 - 800) الف دولار( )

جـ- من (800- 1000) الف دولار ( ) د- أكثر من مليون دولار ( )

الجزء الثانى: العوامل المؤثرة على جودة مشاريع الطرق فى فترات المشروع المختلفة

ما أثر العوامل التالية على جودة طبقة الاسفلت للطرق في شمال الضفة الغربية :

الرمز	العوامل	مؤثر جدا	مؤثر	مؤثر بسيط	محايد	غير مؤثر
1	**العوامل الإدارية**					
F1.1	وضوح المسؤوليات والصلاحيات لكل شخص يشارك في المشروع	5	4	3	2	1
F1.2	خبرة المقاول السابقة في تنفيذ المشاريع	5	4	3	2	1
F1.3	الحالة المالية للمقاول خلال فترة تنفيذ المشروع	5	4	3	2	1
F1.4	مقدرة المقاول من ناحية الآلات والأيدي العاملة	5	4	3	2	1
F1.5	اختيار المقاول ذي العطاء الأقل سعرا	5	4	3	2	1
F1.6	خبرة طاقم الإشراف	5	4	3	2	1
F1.7	كفاءة طاقم الإشراف من المالك	5	4	3	2	1

F1.8	كمية الأعمال التي يتم تنفيذها من مقاول فرعي	5	4	3	2	1
F1.9	التأخر في المدفوعات المالية للمقاول	5	4	3	2	1
F1.10	الدفع المباشر لمختبر الفحص من قبل المقاول	5	4	3	2	1
F1.11	ضعف التنسيق الفعال بين الدوائر المسئولة عن مشاريع البنية التحتية ومشاريع الطرق	5	4	3	2	1
2	**عوامل التصميم والمواصفات**					
F2.1	عدم تصميم الطريق حسب الظروف المحلية المختلفة (نوع التربة ، الحرارة ، حجم المرور)	5	4	3	2	1
F2.2	الأخطاء التصميمية الناتجة من المعلومات غير دقيقة والافتراضات الخاطئة	5	4	3	2	1
F2.3	وضوح ودقة المواصفات في تحديد جودة وتدرج الحصمى	5	4	3	2	1
F2.4	وضوح وتناسب المواصفات مع جودة الخلطة الاسفلتية	5	4	3	2	1
F2.5	وضوح وتناسب المواصفات مع مستوى الدمك المطلوب للطبقات المختلفة	5	4	3	2	1
F2.6	المحددات المفروضة على مصدر الموارد والمعدات من خلال المواصفات	5	4	3	2	1
3	**عوامل عملية الانشاء**					
F3.1	وجود أشخاص ذوي خبرة في كل من فريق المقاول والمالك خلال فترة تنفيذ المشروع	5	4	3	2	1
F3.2	توافر المواد ذات الجودة الموصوفة	5	4	3	2	1
F3.3	نوع الاسفلت وجودته	5	4	3	2	1
F3.4	طريقة تنفيذ الأعمال طبقات الاسفلت	5	4	3	2	1
F3.5	جودة الحصمى المستخدمة في التنفيذ	5	4	3	2	1
F3.6	التغيير المستمر في تصميم الخلطة نتيجة التغير في طبيعة المواد ومصدرها	5	4	3	2	1
F3.7	عملية الدمك للوصول للكثافة المطلوبة :					
	أ- لطبقة ال Sub base	5	4	3	2	1

	ب- لطبقة course Base	5	4	3	2	1
	ج- لطبقة الاسفلت	5	4	3	2	1
F3.8	إجراءات قبول الأعمال وطريقة تقييم الاعمال المتبعة	5	4	3	2	1
F3.9	الضغط الشعبي للإسراع في تنفيذ الأعمال أو التي تؤدي إلى تغيير في المخططات الاصلية	5	4	3	2	1
4	**عوامل متعلقة بالجودة**					
F4.1	وجود تخطيط للجودة للوصول للهدف المطلوب	5	4	3	2	1
F4.2	وجود ضمان للجودة خلال المراحل المختلفة للمشروع	5	4	3	2	1
F4.3	وجود مراقبة للجودة	5	4	3	2	1
F4.4	وجود طريقة مناسبة للتقييم وتحقيق الجودة	5	4	3	2	1
F4.5	النقص في سياسات وشروط الجودة الموجودة	5	4	3	2	1
5	**العوامل البيئية**					
F5.1	وجود خطة بيئية للمشروع للتعامل مع الظروف البيئية والاجتماعية المحيطة مثل المياه الجوفية والغبار وغيرها	5	4	3	2	1
F5.2	الفصل من السنة الذي يتم تنفيذ المشروع فيه (الشتاء ، الربيع، الصيف ،الخريف)	5	4	3	2	1
F5.3	وقت تنفيذ الاعمال خلال الليل أو النهار	5	4	3	2	1
F5.4	حدوث كوارث طبيعية خلال تنفيذ الأعمال في المشروع أو بعد فترة زمنية قصيرة	5	4	3	2	1

جامعة النجاح الوطنية
كلية الدراسات العليا

تقييم نظام إدارة الجودة في مشاريع الطرق في شمال الضفة الغربية

إعداد
أريج نبيل أحمد حسين

إشراف
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قدمت هذه الأطروحة استكمالا لمتطلبات الحصول على درجة الماجستير في هندسة الطرق والمواصلات بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس، فلسطين.

2021م

تقييم نظام إدارة الجودة في مشاريع الطرق في شمال الضفة الغربية

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الملخص

في فلسطين، هناك وثائق محدودة تتعلق بنظام إدارة الجودة في مشاريع البناء بشكل عام، وفي مشاريع إنشاء الطرق على وجه التحديد. ويمكن أن يُعزى عدم وجود دراسات متخصصة لهذا الغرض إلى قلة الوعي بالجودة وأهميتها في البناء في ظل التحديات الاقتصادية والاجتماعية والسياسية التي تواجه الوضع الفلسطيني، خاصة مع تقلص الميزانية وعدم وجود بيانات موثوقة. لذلك تم إجراء هذه الدراسة لاستكشاف نظام إدارة الجودة في مشاريع إنشاء الطرق وتسليط الضوء على العوامل الرئيسية التي تؤثر على جودتها في شمال الضفة الغربية.

تم تطوير استبيان بالإضافة الى الكشف الميداني كأداة لجمع البيانات. الفئات المستهدفة من الدراسة مكون من مقاولين واستشاريين يعملون في مشاريع الطرق في شمال الضفة الغربية ولديهم خبرة كافية في مجال تصميم وتنفيذ الطرق بهدف الحصول على آرائهم حول أهم العوامل التي تؤثر على الجودة.

تم تحديد 37 عاملاً تؤثر في جودة مشاريع الطرق؛ تنقسم إلى خمس مجموعات: المتعلقة بالإدارة، التصميم والمواصفات، المتعلقة بالإنشاء، الجودة، والبيئية.

أظهرت التحليلات الإحصائية أن أهم العوامل التي تؤثر على جودة مشروع إنشاء الطرق هي: جودة الأسفلت ونوعه المستخدم في عملية الإنشاء، وخبرة المقاول، وتوافر الموظفين ذوي الخبرة في فرق المالك والمقاول، وعملية الإنشاء المستخدمة لطبقات الإسفلت، بالإضافة إلى الأخطاء التصميمية.

تم إجراء تقييم لحالة سطح الطرق المرصوفة بالمشاهدة لخمسة وعشرين طريق في المحافظات الشمالية في الضفة الغربية للطرق التي يقل عمرها عن خمس سنوات. أظهرت نتائج الكشف الميداني عددا من العيوب في طبقة الاسفلت، وكانت أهم العيوب التي لوحظت هي الشقوق التمساحية والشقوق الطولية والترقيعات. تظهر هذه المشاكل عيوبًا في عملية الإنشاء لطبقات الطريق المختلفة، والتصميم غير الدقيق، بالإضافة إلى ضعف في التنسيق في تنفيذ أعمال البنية التحتية.

تم تطوير نموذج باستخدام نهج باريتو، بحيث يمثل النموذج العوامل الحاسمة للجودة في مشاريع الطرق، والتي يمكن استخدامها كأداة لتحديد العوامل المهمة لمشاريع إنشاء الطرق لحل المشكلات أو تجنبها ولتحسين الأداء.

من أهم التوصيات التي تم التوصل لها أن تقوم شركات المقاولات والمكاتب الاستشارية بتطوير نظام جودة مقدمًا لمشروع إنشاء الطرق لتلبية متطلبات معايير الجودة العالمية، ولتطوير نظام إدارة شامل للمعدات والمواد والعمالة. يجب على المالك اختيار أكثر المقاولين تأهيلا بناءً على توافر طاقم العمل المؤهلين وذوي الخبرة والكفاءة؛ وليس بناء على العطاء الأقل سعرا.