T.C.
ISTANBUL GEDİK UNIVERSITY
INSTITUTE OF GRADUATE STUDIES

IMPROVING OF THE ROAD MAINTENANCE MANAGEMENT SYSTEM IN IRAQ

MASTER THESIS

Mustafa Midhat Hussein HADDAD

Engineering Management Department

Engineering Management Master in English Program

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İSTANBUL GEDİK ÜNİVERSİTESİ
LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ MÜDÜRLÜĞÜ

Yüksek Lisans Tez Onay Belgesi

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DECLARATION

I, Mustafa Haddad, do hereby declare that this thesis titled as “Improving Management of the Road Maintenance Systems” original work done by me for the award of the master's degree in the faculty of Engineering Management. I also declare that this thesis or any part of it has not been submitted and presented for any other degree or research paper in any other university or institution. (14/06/2023)

Mustafa Midhat Hussein HADDAD

To the soul of my parent

PREFACE

In the Name of Allah, the Most Merciful, all praise be to Allah.

First and foremost, I am immensely grateful to Allah, the Ever-Magnificent and the Ever-Thankful, for His guidance and blessings throughout this endeavor. Without His support, this work would not have come to fruition.

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May Allah bless you all abundantly

June 2023 Mustafa Midhat Hussen HADDAD

TABLE OF CONTENTS

Pages

ABBREVIATIONS

RIIs : Relative Importance Indices
O&M : Operational and Maintenance
GPS : Global Position System
PMMS : Pavement Maintenance Management System
IRI : International Roughness Index
HDM-4 : Highway Development and Management
M&R : Maintenance and Rehabilitation
ASTM : American Society for Testing and Materials
SCI : Sidewalks Condition Index
RWIS : Road Weather Information System
AVLS : Automatic Vehicle Location System
RD : Rut Depth
SFC : Sideway Force Coefficient
PCI : Pavement Condition Index
PMS : Pavement Management Systems
PSI : Present Serviceability Index
RMS : Road Management Systems
PPPs : Public-Private Partnerships

LIST OF TABLES

Pages

LIST OF FIGURES

Pages

IMPROVING MANAGEMENT OF THE ROAD MAINTENANCE SYSTEM IN IRAQ

ABSTRACT

The development of an efficient and sustainable road maintenance system is a crucial aspect of infrastructure management in Iraq. This research focuses on understanding the challenges and determining the factors that hinder the effective maintenance of roads in the country. Through the administration of a questionnaire to workers in the field, key problems and determinants are identified, with a particular emphasis on budget and financing as the highest importance factor. The findings underscore the need for adequate funding and resource allocation to address maintenance needs. The research also highlights the significance of other factors, such as traffic volume and road age, in influencing the road maintenance system. Based on these findings, recommendations are provided to improve budgeting and financing mechanisms, mitigate the impact of traffic volume and road age, and enhance the overall effectiveness of the road maintenance system. The outcomes of this research contribute to the understanding of road maintenance challenges in Iraq and provide valuable insights for policymakers and stakeholders to develop evidence-based strategies for the development of the road maintenance system in the country.

Keywords: *Road Maintenance, effective factors, budget and founding*

IRAK'TA YOL BAKIM SİSTEMİNİN YÖNETİMİNİN GELİŞTİRİLMESİ

ÖZET

Verimli ve sürdürülebilir bir yol bakım sisteminin geliştirilmesi, Irak'ta altyapı yönetiminin çok önemli bir yönüdür. Bu araştırma, zorlukları anlamaya ve ülkedeki yolların etkin bakımını engelleyen faktörleri belirlemeye odaklanmaktadır. Sahada çalışanlara bir anket uygulanması yoluyla, en önemli faktör olarak bütçe ve finansmana özel bir vurgu yapılarak temel sorunlar ve belirleyiciler belirlenir. Bulgular, bakım ihtiyaçlarını karşılamak için yeterli finansman ve kaynak tahsisi ihtiyacının altını çiziyor. Araştırma ayrıca yol bakım sistemini etkileyen trafik hacmi ve yol yaşı gibi diğer faktörlerin önemini vurgulamaktadır. Bu bulgulara dayanarak, bütçeleme ve finansman mekanizmalarını iyileştirmek, trafik hacminin ve yol yaşının etkisini azaltmak ve yol bakım sisteminin genel etkinliğini artırmak için öneriler sunulmaktadır. Bu araştırmanın sonuçları, Irak'taki yol bakım zorluklarının anlaşılmasına katkıda bulunur ve ülkedeki yol bakım sisteminin geliştirilmesi için kanıta dayalı stratejiler geliştirmek için politika yapıcılar ve paydaşlara değerli bilgiler sağlar.

AnahtarKelimeler: *Yol Bakımı, etkili faktörler, bütçe ve kuruluş*

INTRODUCTION

Road maintenance is a critical aspect of transportation infrastructure management, as it ensures the safety, efficiency, and durability of road networks. The efficient management of road maintenance is essential for preserving the standard and operability of roads, reducing interruptions to the flow of traffic, and maximizing the distribution of resources. The development of efficient and sustainable road maintenance strategies is crucial due to the increasing demands placed on transportation systems and the limited availability of funding. The aim of this research thesis is to explore and evaluate a variety of variables that impact the management of road maintenance. The study's results will improve knowledge of the fundamental factors that influence the decision-making process in road maintenance, thereby facilitating the creation of management practices that are more efficient and well-informed. The central aim of this study is to identify and evaluate the key determinants that impact the management of road maintenance. The aforementioned factors encompass the financial resources and allocation of the entities accountable for the maintenance of roads, the determinants that influence the magnitude of vehicular traffic, the ramifications of meteorological conditions, the consequences of the age of the road, the importance of construction standards and the quality of the road, and the function of road classification in both construction and operation. Through a review of these factors, the research will offer insights into their individual and cumulative impacts on practices related to the management of road maintenance. The present study aims to investigate the difficulties encountered by road maintenance authorities, the measures adopted to tackle these challenges, and the prospective avenues for enhancing the decision-making mechanism. The research methodology will involve the utilization of a thorough survey questionnaire that has been specifically created to collect data from pertinent stakeholders such as transportation professionals, engineers, and road maintenance authorities. The survey instrument will comprise of 31 questions, with each item targeting distinct facets pertaining to the recognized variables. The data that has been collected will go through analysis through the implementation of suitable statistical methods in order

to detect and determine patterns, correlations, and trends. The study's outcomes will be presented and analysed, yielding significant perspectives on the present condition of road maintenance management and proposing suggestions for improving the efficiency and efficacy of maintenance process.

The primary objective of this study is to enhance the existing knowledge on road maintenance management. The study intends to facilitate evidence-based decision-making and encourage sustainable infrastructure development. Through comprehension of the determinants that impact road maintenance management, policymakers and practitioners can execute focused tactics to guarantee the durability and optimal functionality of road networks, resulting in safer and more effective transportation systems. This thesis aims to provide stakeholders in the road maintenance management industry with a comprehensive understanding of the challenges and opportunities present in the field. The anticipated outcome is an enhancement in decision-making, resource allocation, and maintenance practices.

1.1 Study Topic

The topic of research for the master's thesis refers to the evolution of the road maintenance system within the country of Iraq. The objective of this all-encompassing investigation is to conduct a thorough evaluation and scrutiny of the present road maintenance mechanism in Iraq, with a particular emphasis on detecting scopes for enhancement and suggesting strategic remedies. The study will be supplemented by a comprehensive examination of pertinent scholarly works and citations to substantiate the conclusions and suggestions. The study aims to provide a comprehensive understanding of the primary issues and challenges associated with road maintenance in Iraq by utilizing a diverse array of scholarly sources, such as academic articles, reports, and industry best practices. This approach will establish a strong and reliable basis for the research. The incorporation of references is likely to augment the credibility and dependability of the research, thereby guaranteeing that the suggested approaches and suggestions are well-informed and firmly established in current knowledge and proficiency. The objective of this thesis is to provide a significant asset for policymakers, transportation authorities, and practitioners who are engaged in the development and maintenance of road infrastructure in Iraq. This

will enable them to make decisions based on evidence and enhance the overall quality of the road network in the country

1.2 Purpose of the Thesis

The aim of the research is to investigate and identify the problems and limitations facing the road construction and maintenance system in Iraq. To achieve this, a questionnaire will be developed and administered to a sample of road construction and maintenance workers. The questionnaire will be designed to collect information on various aspects of the system, including current challenges, operational issues, resource allocation, and maintenance practices. By analyzing the responses and data collected, the research aims to identify the most influential factor in the effectiveness of the road maintenance system in Iraq. Understanding this critical determinant will provide valuable insights to policy-makers and stakeholders, enabling them to implement targeted strategies and interventions to enhance the efficiency and functionality of the road maintenance system, ultimately leading to safer and better-maintained roads for the country.

This research is a comprehensive examination of the problems and limitations of road construction and maintenance system in Iraq. Using a questionnaire-based approach, the study seeks to solicit the perspectives and experiences of workers directly involved in the field. The questionnaire will be carefully designed to elicit insights on a range of critical aspects, such as funding constraints, inadequate resources, inadequate training, bureaucratic hurdles, and operational challenges. Through careful analysis of the questionnaire answers, the research aims to identify the single most influential factor in the effectiveness of the road maintenance system in Iraq. By identifying this key determinant, research will contribute to a deeper understanding of the underlying issue and pave the way for evidence-based recommendations and targeted interventions. Ultimately, the results of this study will support efforts to establish an efficient and sustainable road maintenance system in Iraq, leading to improved infrastructure, improved mobility, and increased road safety across the country.

1.3 Structure of the Thesis

In this part of the thesis, we will briefly describe the concept. The first chapter includes A presentation of the thesis and a brief discussion of the importance of the road maintenance system and its influence on resource optimization. It will explain the thesis's objectives and aims, as well as the techniques used to obtain the final results. In the second chapter, the maintenance of roads in general and their types as well as their types, problems that roads endure and the causes of their deterioration. In addition to a review of associated studies published over the past ten years. in the third chapter. The method used to extract the results will be discussed which is a survey of road workers as well as designers and civil engineers. The fourth chapter will use statistical categorization; describe the results of the questionnaire and the data that was retrieved from it. Chapter five. Analyzing the data, and then recommending improvements for the road maintenance system.

1.4 Literature Review

Monirul Islam (2022) The purpose of this study was to examine the variables linked to rising operation and maintenance costs as well as the operational and maintenance challenges faced by roadway components. 23 highway components that are challenging to operate and maintain in the post-construction period were also identified by a literature review as being responsible for rising operation and maintenance expenses. A questionnaire survey was conducted after the study, and 70 respondents in Bangladesh assessed the elements using a Likert scale with a maximum of five points online. The factors and highway components' means and relative importance indices (RIIs) were calculated, and rank analysis was then performed. This study shows how poorly designed roads, a lack of maintenance plans, high maintenance costs caused by poor maintenance quality, poor construction quality, and the possibility of corruption have a substantial impact on operation and maintenance cost budget. The most difficult to operate and maintain among highway components were pavement markings, above-ground bridges (road bridges, pedestrian/motorcycle bridges), electrical devices, traffic calming devices, traffic, and above-ground services. Finally, correlation tests were used to determine the connections between the elements of the highway and the factors impacting operation and maintenance costs. This study has provided light on the key

operational and upkeep budget considerations as well as the degree of maintenance difficulties for highway components. To mitigate the impact on O&M cost budget some recommendations are made based on the insight of the results

First, the quality of new construction must be improved in order to lessen its negative effects on road maintenance. Next, road design documents must to include proper maintenance planning. Rich construction quality is necessary to reduce operating and maintenance costs. For lowering operating and maintenance costs, the risk of corruption should be reduced. Finally, proper training can raise productivity and labor skills. To further investigate maintenance cost minimization, this study has shown the most important variables influencing O&M cost budget. A case study technique is additionally recommended to support the significance of O&M cost concerns on highway projects. [23]

Honggang Wu (2021) the study presented in this paper has some reference value for the future growth of highway construction and maintenance in the province of Zhejiang. in China. The main focus of this paper's analysis of the Hang-Shao-Yong expressway is the following five, which are based on the new construction of seven important areas, particularly big data, 5G technology, and new energy. Wisdom's high-speed cloud platform, GPS vehicle monitoring, control, and operation process monitoring, as well as its auxiliary decision system for road maintenance, intelligent maintenance supplies, and intelligent maintenance integration, are all examples of wisdom technology. The following issues that need to be resolved in order to transition from traditional road maintenance to intelligent road development are examined in this paper: a lack of a unified industry standard; flaws in the hardware support; a lack of sufficient interaction between elements; and a low level of regional integration. The study comes to the following conclusions: the necessity of carrying out the major strategic decision of developing a transportation power; the necessity of adhering to the development trend of smart roads; the necessity of accelerating the regional integration construction of the Yangtze River Delta; and the necessity of maximizing industrial benefits.

Marco (M. M.-A.) (2020) developed a practical method that enables the collection, analysis, processing, and updating of data on pavement problems with the aim of producing inputs for the implementation of long-term programs for road maintenance and rehabilitation, in accordance with pavement management systems. The

Centinela-La Rumorosa Highway in Mexico's state of Baja California is the source of the work that led to the development of the suggested model, which has been active since 2014.and the result showed that it is important to evaluate the surface and structural problems of the existing pavement in order to determine the maintenance and rehabilitation operations that will be most useful to decision-makers and road users.

Antonio Pantuso (2019) this research presented a methodology for analyzing the pavement data collected in preparation for Kazakhstan's network level pavement management program. This methodology, which may also be applicable to the road networks of other developing nations, focuses on the analysis of survey data to determine solutions for each road section's maintenance that are affordable. By drawing information from the survey data, the proposed technique intends to enable a decision-making process for the application of a strategic level business planning analysis. In this study, a technique for Kazakhstan's network-level pavement maintenance program was presented. In Kostanay, this study was put to the test for priority roadways (one region in Kazakhstan) the suggested method results in the implementation of a PMS for Kazakhstan's national network, although it is still a new project that will develop as more pavement inspections are conducted on the network. It now offers a view of the network's existing status, which needs to be adjusted to the local conditions of the nation (building procedures and procurement contracting). Even though that the approach used in this study is based on data from surveys conducted in Kostanay over a single year, the availability of more data may enable the prediction of future pavement conditions. In any event, this approach might be applied to Kazakhstan's other regions.

H. Bello-Salau (2018) this paper suggested a device for monitoring the state of the road surface. The design makes use of an accelerometer sensor that is configured to react to vehicle vibrations in response to the acceleration caused by gravity (g-force). To preserve the signals obtained over the various test surfaces, a database was additionally made and hosted online. The test results demonstrate that the suggested system accurately detected the used road surfaces and correctly recorded the collected traces into the developed database. For monitoring the condition of the road surface, this gadget will be helpful to road maintenance organizations.

Tanuj Chopraa (2017) the study's purpose was to develop a Pavement Maintenance Management System (PMMS) on the Highway Development and Management (HDM-4) model for four road sections of an urban road network in Patiala, Punjab, India. To predict road deterioration in accordance with urban road conditions as measured by the International Roughness Index (IRI) value, the HDM-4 offers a deterministic technique in data input and processing data of existing road condition, traffic volume, and pavement composition. In this work, the HDM-4 model is used to compute the best maintenance and rehabilitation (M&R) plan for each road section and to compare planned and condition-responsive M&R plans. The latest results are useful in gaining decision-makers' support for adequate and prompt funding allocations for maintaining urban roads. And the results showed the optimum M&R strategy for every road section of the Patiala city road network has been successfully identified ,On the basis of optimum M&R strategy all of the road sections' prioritizing for maintenance work has been completed satisfactorily.

Maria Vittoria Corazza (2016) in this study, managing sidewalk pavement maintenance is presented, In order to effectively set up a Sidewalk Management System, which is similar to the more well-known Road Management System, this research created an evaluation index for sidewalk conditions. Surveys, classification, and analysis of sidewalk distresses are all used in the study. The Pavement Condition Index, already established by ASTM for roads and airports, was modified by the authors (PCI). PCI has been altered to take into account the precise types on the sidewalks examined in this article. A case study of a residential area in Rome, Italy, was conducted to validate the methodology. The chosen region is not regularly maintained, which has led to a network of dangerous walkways. Within a broader evaluation of safety, frequent diversion routes were studied and related to the severity of distresses. Since this form of pavement is the only one used in the survey locations, this study focuses on sidewalks with flexible pavements in general throughout Italy; this study was an obvious attempt to use sidewalk assessment techniques from infrastructure maintenance programs for motorized vehicles. To assess sidewalk conditions and the level of dangerous distresses that present difficulties for pedestrians, the Sidewalks Condition Index (SCI) was specifically researched and calculated. The information comes from a study that was conducted among locals in a real urban setting.

The applied method can help road managers to determine maintenance work requirements by using Sidewalks Condition Index (SCI) values acquired from visual surveys.

Andrea Kociánová (2015) this paper described a multi-level solution to manage intelligent winter road maintenance. The method is based on monitoring and analyzing weather conditions as well as the state of selected road sites' road surfaces. Road weather stations, which provide early warnings about dangerous situations on the road, ensure automatic data collection and transmission (such as frost, ice, mist, wet or snow-covered surface). The status and temperature of the pavement surface are predicted using data from these weather stations, weather forecasting models, and data from weather radars and satellites. As a result, information is available to support good maintenance decisions and fast, efficient road repair. The paper took the current situation in the Slovak Republic and the Implementation concept of intelligent winter road maintenance system in Slovak condition and how to develop the central RWIS (Road Weather Information System) the Essential elements of intelligent winter road maintenance include road weather information systems and automatic vehicle positioning systems in winter maintenance trucks. The Slovak Republic currently has a few partially separate subsystems, including the AVLS (Automatic Vehicle Location System) and the standalone and direct RWIS. Weather forecasts, especially for roads, are late or absent. The study recommended developing of a national central RWIS, similar to those in some neighboring countries of the Slovak Republic.

Ivan Pukhlov (2014) the purpose of the research was to compare the approaches used in two closest neighbors, Finland and Russia, with related to road maintenance. The composition of this work included information on road categories, lengths of road networks, traffic volumes, weather conditions, organizations, implementation, requirements for maintaining roads, and equipment for road maintenance. The thesis includes theories regarding the need to maintain the road surface in both the winter and the summer. Text, tables, figures, and charts were used to present the data. It was compiled using information from the Internet and other literature, including books, tutorials, normative papers, manuals, and procedures that have a direct impact on road maintenance. The purpose of this study was to compare and contrast the approaches taken by Finland and Russia in the area of road maintenance, as well as

to compare and contrast the natural characteristics of the two nations, as well as their levels of traffic, their networks of roads, their classifications, and their organizational structures for maintenance services. Materials used in the project represent the climatic characteristics of the two countries generally as well as in their neighboring regions. The paper included information on deicing materials and distribution guidelines. This work has been prepared utilizing reliable sources and pertinent information. In general, the requirements and organizational structure of maintenance services between the two countries have negligible differences that have no bearing on the outcome. Although this, the World Bank reports that the cost of maintenance and repair for Russian regional and federal highways is approximately 8038 euros per 1 km of road, but only about 60% of the roads comply with requirements (according to data for 2010 for the Russian Federation). For all types of roads in Finland in 2008, the cost of road maintenance came to 7274 euros. The availability of weather camera services, which stream online information about the state of the roads for drivers, is another benefit of Finland. In recent years, Russia has actively incorporated the Nordic nations' winter maintenance expertise. This has a favorable impact on the road conditions and road safety.

Kunal Jain1 (2013) the author described the optimum maintenance plan out of a variety of plans.be chosen from a variety of maintenance options. With the aid of the Highway Development and Management tool, it may be done by calculating and comparing the various maintenance and rehabilitation (M&R) alternatives (HDM-4). This technology and technique, which makes it possible to design an efficient pavement repair program, is widely appreciated. This research focused especially on flexible pavement, which includes the multilane highways in India's northern area. The study involved gathering data and selecting the optimal M&R plan for particular road sections utilizing the HDM-4's program analysis component. The information in this paper is expected to be useful in developing the best maintenance management strategy for multilane roadways.

2. ROAD MAINTENANCE SYSTEM

2.1 Road Maintenance Aim

In many countries, roads are among the most important public resources. Through enhanced access to markets, hospitals, and schools, as well as increased comfort, safety, and speed, road upgrades benefit road users immediately and occasionally dramatically. They also result in decreased vehicle operating expenses. Road improvements must be followed by a carefully thought-out program of maintenance if these benefits are to last. Without routine management, roads can quickly deteriorate, impeding the development of the longer-term effects of road improvements, such as greater agricultural production and rise in enrollment in schools. The protection of the asset, not its upgrade, is the aim of maintenance. In contrast to substantial road work, maintenance must be performed frequently. "Activities to maintain pavement, shoulders, slopes, drainage facilities, and all other buildings and property within the margins of the road as near as practicable to their as-constructed or renewed condition “are included in the definition of road maintenance (PIARC World Road Association. 1994). to remove the source of faults and prevent highly repetitive maintenance tasks, it also involves small fixes and enhancements. Even though the requirement for maintenance is well understood, it still isn't being carried out enough. Many nations only invest 20–50 percent of what they ought to on maintaining their road system. There are a lot of factors at play here. The difficulties include separating maintenance from other sorts of road construction, figuring out how much maintenance will cost, where to acquire the money, how to institutionalize planning for it, and hiring contractors to do the work. Road maintenance delays incur significant direct and indirect expenses. Repairing road imperfections quickly typically comes at a low cost. If flaws are not addressed, an entire stretch of road may collapse completely, necessitating complete reconstruction at a cost that is typically three times or higher than maintenance costs. According to the South African National Road Agency Ltd. (SANRAL), after three and five years of neglect, repair costs increase to six times maintenance expenditures and 18 times,

respectively. In order to prevent these rising costs, SANRAL "allocates [its] available funding resources] to optimal maintenance actions (e.g., reseals and overlays), followed by more clear maintenance actions (e.g., rehabilitation), and finally to new construction" (SANRAL South African National Road Agency Ltd. 2004).

A country needs a core road network that transports around 80% of all national traffic, including important urban main roads and rural access roads. Therefore, some of the total money for roads must go toward construction and some toward maintaining the main network. However, many countries have a tendency to prefer new road building, rehabilitation, or reconstruction over upkeep of existing highways. This has resulted in a loss of development effect and a steady rise in the backlog of road repairs. For every kilometer of road rehabilitated in Sub-Saharan Africa, an estimated three kilometers of road deteriorate, giving a net degradation in the entire road network (Kamaruzzaman Syahrul, 2018).

2.1.1 Periodic maintenance

This refers to activity occurring on a road at regular, large periods, these processes are frequently large-scale and require specialized machinery and qualified staff. They are more expensive than ordinary maintenance tasks and call for specific identification, implementation planning, and frequently even design. Preventive, resurfacing overlay and pavement reconstruction are different categories of activities. In general, resealing and overlay projects are started in reaction to measurable degradation in the state of the roads. Repaving is required for paved roads around every eight years, and re-graveling is required for gravel roads roughly every three years [PIARC (World Road Association). 1994]. Depending on the nature and sort of facilities, periodic maintenance is based on thorough inspections carried out at predetermined intervals, such as seasonally or annually. It involves examining and evaluating the state of various properties and structures. Damage and flaws will report for corrections or fixes. Plans for maintenance over a number of years will be (Hussain, S., Fangwei.2018).

2.1.2 Routine maintenance

Ensure the daily usability and safety of existing roads in the short-run and to prevent premature deterioration of the roads, which consists of small-scale works carried out

on a regular basis [PIARC (World Road Association). 1994]. Activities are typically once or more per week or month, though this varies. Roadside verge removal, grass mowing, culvert and ditch cleaning, patching, and pothole repair are typical tasks. Regarding every six months might be necessary for gravel roads. To work efficiently of suitable quality and in a way that is both cost-effective and efficient, routine maintenance tasks require the right combination of manpower and equipment. The aim is to use a labor/equipment mix in a "labor-based" economy that prioritizes labor, but supplements it with light or intermediate equipment where it's necessary for reasons of quality or cost. Using labor as the primary resource in a flexible and efficient manner to assure cost-effectiveness and quality is what is meant by the term "labor-based" .It critical to distinguish between optimal and maximal labor use. The latter can become a "make it work" strategy in which cost-effectiveness and quality considerations are disregarded. Labor-based is different from equipment-based in that the majority of the work is done by labor-replacing equipment, supported by a small labor force (World Bank Rural Transport Thematic Group. 2003).

2.1.3 Urgent or emergency maintenance

Is used for unexpected repairs that must be made right once, including culvert collapses or landslides that obstruct a route**.** [PIARC (World Road Association). 1994].Emergency maintenance essentially entails tasks to repair damaged roads and facilities connected to them after they have been damaged by natural disasters or accidents on the road. Although the frequency cannot be expected, such maintenance requires for quick action. Rehabilitation, the construction of shoulders, and road widening are not included in maintenance. If the parts that need to be replaced make up more than 25% of the total length of the road, the task is rehabilitation rather than maintenance (Hussain, S., Fangwei.2018).

2.2 Road Maintenance Process

2.2.1 Process according to the maintenance types

The road maintenance process changes in terms of the method according to the type of maintenance, whether it is periodic, routine or urgent (Hussain, S., Fangwei.2018). The authority responsible for maintaining and maintaining roads must determine the requirements and set priorities, as shown in the (Table 2.1).

Table 2.1: Typical Maintenance Activities

Type	Activity
Routine Including Preventive	Clearing of pavement
	Mowing and maintenance of plants
	Clearing of ditches and culverts
	Repair of traffic signs and road markings
	Shoulder grading
	Pothole patching and crack sealing
	Repair of sealants and expansion joints of bridges
	Repair of cut and fill slopes
Periodic	Graveling
	Resealing/surface dressing
	Overlay
	Maintenance of traffic signs and road markings
Emergency	Removal of debris or obstacles from natural causes
	Repair of damage caused by traffic accidents

2.2.2 Process according to the road type

I. Maintenance of Bituminous Road

The majority of roadways are adopted on bituminous surfaces. It is made up of flexible pavement. The following upkeep is frequently necessary for bituminous roads.

1-Patching Pot Holes

2-Patching Ruts

3-Patching Corrugations

4-Base Repairs

5-Surface Treatment

6-Re-surfacing

II.Maintenance of Cement Concrete Roads

The monolithic cement concrete slabs that make up cement concrete roadways perform the duties of both the load-bearing base and the wearing surface at the same time. The pavements can be categorized as flexible pavement or rigid pavement based on their structural characteristics (Hussain, S., Fangwei.2018).

1-Repairs of Blown-Ups

2-Repairs of Cracks

3-Repair of Joints

4-Patch Repair

5-Settlement Due to Mud Pumping

6-Surface Defects

2.3 Road Deterioration Causes

Over time, roads degrade mostly because of water and traffic. In addition to harming the actual road infrastructure, water can deteriorate the road's surface, shoulder, and base. This occurs either through erosion, when the road's material is washed away and physical structures are compromised, or by stagnation, where water pressure weakens the road and the foundation of the physical structures. As a result of car tires deforming the road surface and losing surface material, traffic also contributes to the deterioration of the road, exposing the road base and causing ruts, potholes, and corrugations.

2.4 Why Does Asphalt Pavement Deteriorate?

Infrastructure asphalt pavement deterioration is expected. It is normal because as time passes, the components of asphalt start to degrade and are impacted by environmental factors including rain, sunlight, and chemicals that come into touch with the pavement surface. Water can now get into and under pavement because the liquid asphalt binder, which acts as the "glue" of the pavement, starts to lose its resistance to it. Once this occurs, a variety of various types of deterioration can swiftly affect the surface (Naji, H., Zehawi, R., & Hasan, Z. 2018).

2.5 Main Factors Causing the Deterioration

1. Traffic: The major element affecting pavement performance is traffic. The volume, configuration, and frequency of load repeats by heavy vehicles have the most effects on the performance of pavements**.**

2. Moisture (Water): Natural gravel materials, particularly the subgrade, can rapidly lose their ability to support weight when exposed to moisture. Through lateral subgrade penetration, surface cracks and holes, capillary action from the water table below, and lateral subgrade penetration.

3. Subgrade: The subgrade that bears the weight of the wheels is known as the subgrade. The pavement will bend significantly if the subgrade cannot handle the wheel loads, which will possibly lead to pavement failure.

4. Construction Quality: The performance of a pavement is directly impacted by poor compaction, poor moisture conditions during construction, the quality of the materials used, and accurate layer thickness (after compaction).

5. Maintenance: The type, timing, and methods of maintenance have an influence on how well a pavement performs. No matter how carefully the pavement is constructed, the mentioned causes will cause it to degrade over time. When and how to perform maintenance is important (Oke, A.E. 2017).

2.6 Road Pavement Evaluation

2.6.1 Road pavement evaluation methods

Methods for evaluating road pavement are either based on a simple index of a surface characteristic, such as the International Roughness Index (IRI) for roughness, Rut Depth (RD) for rutting, and Sideway Force Coefficient (SFC) for skid resistance; alternatively, If not, try a complicated indicator like the Pavement Condition Index (PCI), which takes the surface condition into account all at once. Road authorities all over the world frequently employ complex indices in the framework of Pavement Management Systems (PMS) to evaluate the condition of the pavement, plan maintenance and rehabilitation activities, and maintain their road network at a level that is safe for users. These intricate indices are now thought to be more trustworthy and appropriate for assessing pavement condition and prioritizing upcoming rehabilitation efforts. The first line of the question is: is this truly true? In other words, can indices like the Present Serviceability Index (PSI) indicate the true state without misinterpretation or secret problems? Can they be used in every situation, and if so, are they accurate enough to guide road authorities to a sound decision and, subsequently, to the proper and efficient maintenance operations without misleading them or incurring unnecessary expenses? In order to identify their benefits and drawbacks and ultimately gauge their level of effectiveness, several of the most popular evaluation techniques are illuminated in the context of the current study. The most popular techniques for evaluating pavement evaluation methods employing

complicated indicators are explored in the following in an effort to decide which is optimal for each situation. Although The Australian technique appears to be the most thorough and reliable one, but as there is no one solution that applies to all situations, the most cost-effective way should be used for evaluations regardless of budget in cases where there are severe budgetary limits (Papageorgiou, G. 2019).

2.6.2 Collected data by smart phones

Road quality is strongly influenced by the condition of the road's surface, according to previous studies. The road surface needs to be carefully monitored and maintained as needed to maintain quality. Road surface condition can be determined using a variety of methods. Because of its low cost, greater population coverage ability, and simplicity, using a smart phone to collect data is an alternate and simple application. Roadroid is an Android software that uses smartphone sensors to provide a low-cost vehicle-based solution for tracking the state of road surfaces. On-site tests have been carried out to gather data using a smartphone's acceleration and GPS capabilities in a particular kind of (passenger car) vehicle. 3259 km of urban and rural road data were obtained for the site experiments, which were used to evaluate this strategy. The results showed that, on average, 84.4% of Turkish roads are in good condition, 7.9% are satisfactory, 3.8 are unsatisfactory, and 3.8% are rougher than they should be. It indicates that about 4% of Turkish roads require urgent maintenance. (Aydın, M. M. 2018).

2.7 Road Structural and Functional Evaluation

1. Functional evaluation: Gives details on surface qualities that directly impact the serviceability, comfort, and safety of users. Serviceability is measured using roughness metrics, while safety is assessed in terms of skid resistance and surface texture (Chamorro, A. 2006).

2. Structural evaluation: evaluates whether the pavement structure is operating efficiently given the traffic volume and environmental factors. These surveys cover mechanical and structural issues as well as pavement distresses (Chamorro, A. 2006).

3. **Road infrastructure data needs:** For the maintenance of roads, various sorts of data are employed. Depending on whatever infrastructure component is being assessed, different technology and data requirements are required. Generally

speaking, items like Road Inventory, Pavements, Structures, and Traffic call for two different kinds of data: Inventory and Condition the parts of the road system are described in the inventory data. These do not significantly alter over time. The state of items that are subject to expected changes over time is described by condition data. The state of items that are subject to expected changes over time is described by condition data. The road manager has access to a variety of technology for measuring the characteristics of the road network. The tricky part is choosing the right tools for the job, taking into account the environment and the intended use of the data. (Bennet, C.R., Chamorro, 2006).

2.8 What Data Should Be Collected

One of the top five reasons road management systems (RMS) are abandoned is probably excessive data collecting (Chamorro, A. 2006).

The systems are thought to be excessively expensive and data-intensive to maintain. Three guiding principles should always be taken into account when choosing which data to collect in order to prevent this situation:

- Collect only the data you need
- Collect data to the lowest level of detail sufficient to make appropriate decisions
- Collect data only when they are needed.

2.8.1 Location referencing data

The most important factor when organizing a survey is location referencing. The usefulness of the data for management choices will be reduced if they are not correctly referenced. In road management there are two common location referencing methods: **Linear:** gives an address that includes the direction and distance from a known location, such as: kilometer point, kilometer post, Reference point, Reference post.

Spatial: gives a set of coordinates that make up an address. Data from the Global Positioning System (GPS) is commonly used for this.

2.9 Factors Effecting Road Maintenance

Usually, the following factors affect the maintenance of pavements

1. Poor design or Inadequate Thickness of Pavement: Pavement failure, unevenness, and heavy spots will occur often if insufficient thickness is provided. As a result, regular maintenance becomes necessary,
2. Increase in the intensity of traffic: Since we are aware that road transportation grows by around 8% annually. As a result, this is the principal factor that affects road maintenance (Hussain, S., Fangwei, 2018).

2.9.1 The impact of traffic overload on road pavement performance

There are many various vehicle kinds that make up traffic on a road's pavement, and these can be taken into account when designing the pavement by utilizing truck factors to convert the damage they cause to the pavement to the damage caused by a normal axle. By taking into account the average loads for each axle, the truck factors used to convert trucks into standard axles or the load equivalent factors used to convert axles into standard axles are defined. Vehicles that carry axle loads above the permissible maximum are included in this process. In terms of the weight of the entire vehicle, there are also a sizable number of overweight cars. The expense of constructing new pavement and repairing existing pavement is increased by these axles and cars. The preliminary research showed that compared to the cost of the same vehicles with legal loads, the presence of overloaded vehicles can cause pavement costs to rise by more than 100 % (Pantuso, A., Loprencipe, 2019).

2.10 Factors That Affect the Management System for Road Maintenance

There are a range of factors that can affect the management of road maintenance, including:

1. Funding: Road maintenance requires adequate funding because it enables organizations to set aside resources for maintenance tasks and purchase the equipment and supplies they need. The scope and efficiency of road maintenance initiatives may be constrained by a lack of funding.
2. Traffic volume: The volume of traffic on a road can influence the requirement for maintenance as well as the types of maintenance operations required.

Roads with high traffic amounts may require more regular maintenance to keep them in good condition.

3. Weather: The weather may have a major impact on the state of roads and what type of maintenance required. Heavy rain or snow, for example, might cause road damage and demand more regular repair.
4. Age of the road: The age of a road can also have an impact on the requirement for maintenance, since older roads are more at risk for deterioration and might require more regular maintenance.
5. Road type: Depending on criteria such as the kind of surface material and the amount of use, various types of roads might have different maintenance requirements.
6. Organization and resources: The organizational framework and resources of the company responsible for the operation of road maintenance can also have an impact on road maintenance management. For example, an organization with a solid organizational framework and access to the right equipment and tools may be able to manage road maintenance duties more successfully. (Hussain, S., Fangwei, 2018).

2.10.1 The factors that affect the funding of management system for road maintence

Funding is an important factor that influences road maintenance management since it states the resources available for maintenance operations and the extent of work that can be completed. Some particular elements that might influence road maintenance spending include:

1. Level of government: Road maintenance funding can come from several levels of government, including federal, state, and municipal governments. The amount of financing available may be determined by various bodies' goals and budgets, as well as the unique demands of the road network.
2. Economic conditions: Economic factors such as the overall level of economic activity and the availability of tax revenues can also have an impact on road maintenance financing. Funding may be constrained during economic

downturns, but during periods of economic boom, more resources may be available for repair and maintenance.

3. Transportation needs: A region's different transportation demands might also influence financing for road repair. A location with a large volume of freight traffic, for example, may require additional money for road maintenance to guarantee that roads are in excellent shape and capable of supporting the transportation industry's demands.
4. Political considerations: Political concerns may also impact road maintenance expenditure. For example, financing decisions may be impacted by elected leaders' agendas or local community preferences.

Overall, Road maintenance funding is decided by a complicated combination of elements that might change based on the region's individual demands and resources. Adequate financing for road maintenance is critical for keeping roads in excellent condition and assuring the transportation system's safety and efficiency. (Naji, H., Zehawi.2018).

2.10.2 The factors that affect the traffic volume of management system for road maintenance

Traffic volume is a key factor that can influence road maintenance management since it impacts the amount of damage occurring on a road and the requirement for maintenance operations. The following are some specific methods in which traffic volume might affect road maintenance:

1. Frequency of maintenance: Higher traffic volumes might require more regular maintenance to guarantee that roads are in excellent condition and capable of supporting the transportation system's demands.
2. Type of maintenance activities: Traffic volume may also impact the sort of maintenance duties required. Roads with high traffic levels, for example, may require additional maintenance treatments, such as resurfacing, to guarantee they are capable of meeting the demands of heavy traffic.
3. Impact on costs: Increased traffic levels may also result in increased maintenance costs since more resources may be required to maintain roads in excellent condition.

4. Impact on timing of maintenance: The scheduling of maintenance activities can also be influenced by the volume of traffic, since it may be important to plan maintenance during periods when traffic numbers are lower in order to avoid a delay.

Overall, when managing road maintenance, traffic volume is an important issue to consider since it can impact the type and frequency of maintenance operations necessary, as well as the resources required to carry out these activities.(Naji, H., Zehawi.2018).

2.10.3 The factors that affect the weather on management system for road maintenance

Weather is a significant factor that can affect road maintenance management since it has a considerable impact on the state of roads and the types of maintenance operations that are necessary. Weather can have a special influence on road maintenance in the following ways:

1. Impact on road conditions: Weather may have a direct influence on road conditions, since excessive temperatures, rainfall, and other weather-related conditions can cause road damage. Freezing conditions, for example, can induce fractures in asphalt and other surface materials, while excessive rain can cause potholes to appear.
2. Impact on maintenance activities: Weather conditions could affect the types of maintenance duties required. Certain maintenance works, like as resurfacing, may, for example, require to be scheduled during dry and warm weather to guarantee that the materials used set adequately.
3. Impact on timing of maintenance: Weather can also have an effect on the scheduling of maintenance activities, since it may be essential to change the maintenance schedule to accommodate for weather conditions. Maintenance work, for example, may need to be delayed during extreme weather occurrences to ensure the safety of maintenance staff members.
4. Impact on costs: Weather can also impact road maintenance costs, since the requirement for emergency repairs or additional maintenance operations as a result of weather-related damage can increase maintenance costs.

Overall, Weather is a crucial factor when managing road maintenance since it can have significant effects on the state of roads and the success of maintenance activities.

2.10.4 The factors that affect the age of the road on management system for road maintenance

The age of a road may be an important issue in road maintenance management since older roads are more prone to deterioration and may require more regular maintenance (Oke, A., Aigbavboa.2017). The following are some specific methods in which a road's age can impact road maintenance:

1. Frequency of maintenance: Older roads may require more regular maintenance to ensure that they are in excellent condition and able of supporting the transportation system's requirements..
2. Type of maintenance activities: The kind of maintenance tasks required may also be determined by a road's age. Older roads, for example, may require more costly repairs, such as resurfacing, to address degradation and guarantee that they can withstand traffic demands.
3. Impact on costs: The age of a road can also influence road maintenance expenses, since older roads may need more frequent and substantial repair operations, which can raise maintenance costs.
4. Impact on timing of maintenance: The age of a road can also influence when maintenance operations are performed, since it may be important to give preference to maintenance on older roads in order to address possible problems before they become more critical.

Overall, when managing road maintenance, it's crucial to take into account a road's age since it might impact the kind and frequency of maintenance tasks that are necessary as well as the resources needed to do them (Naji, H., Zehawi.2018).

3. METHODOLOGY

3.1 Introduction

This thesis aims to chart a path for the organizations responsible for the maintenance and sustainability of the road network by reviewing the literature concepts on both topics. and results. There has been some research into the literature. The survey was sent to a group of engineers and contractors working in the field of road construction and maintenance in Iraq, mostly in Baghdad and Basra in southern Iraq. By sending the online questionnaire by e-mail. In the fourth and fifth chapters of this thesis, the replies have been collected, reviewed, evaluated, and discussed.

3.2 How to Design a Questionnaire

The questionnaire is a commonly used scientific technique for obtaining information and data about the conditions, tendencies, or trends of individuals. The researcher suggests questions in order to Examining a group necessitate the extraction of pertinent primary data. (Nigel Mathers et al., 2009). Given the significance of understanding how to design a research questionnaire, we will attempt to cover topics pertaining to how the questionnaire collects the necessary data to address questions and hypotheses posed by a research problem. Questionnaires are the most cost-effective method for surveying a large population. You can use these data to conduct an analytical study on the topic in question. No matter how difficult the questionnaire is, the most important thing is to get solid data on the relevant questions. When conducting a survey using questionnaires, the first step is to choose which elements will be studied, followed by data collection. Because the result is dependent on each activity, the whole phase must be meticulously planned. The cost is low, but the approach is what really adds up (Nigel Mathers et al., 2009) since every data must go through a questionnaire first. After the survey's primary purpose has been established, the questionnaire may be written. The questionnaire's layout is crucial since it affects how much the user responds and engages with the survey. The survey questions were broken up into:

- Free-form Methodology
- The whole formula

First of all, the generous open form. There is open discussion, but no decision-making on next steps. Furthermore, as there is no definitive identification of the individuals who will answer the surveys, people have the opportunity to pick their own replies. Keep in mind that this approach will likely result in the receipt of some Odd or unexpected feedback. The fact that each of his queries can be answered separately and correctly is a flaw. Conducting a Statistical analysis of this kind is difficult. As it takes time to read the responses properly, and most significantly, it will take time for the participant, it is apparent that this kind is costly in terms of time, effort, and money (Gillham WEC, 2000). It was said that the longer the inquiries, the more bored and uninterested the person would get. We've covered open-ended questions; now we'll discuss closed-ended questions, where the respondent is given a number of possibilities from which to pick (Pallant, 2010).

There is no right answer, but your responses should account for all possibility. That they are not so huge as to introduce uncertainty is an important consideration. The typical number of possible responses is between five and 10. Long questionnaires benefit from having responses matched so that there are fewer "neutral" options. There are time and money savings associated with using the closed formula. Providing details about the answers makes it simpler to calculate them, extract percentages, and run advanced statistical analyses on a computer. The method is quick and simple. There are things to think about while drafting questions and answers, regardless of whether the format is open or closed (Gillham WEC, 2000).

3.3 Questionnaire Preparation

1. Determine the type of information required:

The questionnaire was developed using the Study structure since the survey is targeting engineers in the field of road construction and maintenance. The study's major and secondary findings are detailed, and Arrange these information in an order that makes sense. Depending on the specifics of the information requested, many question formats may be used. Requests about facts, such as those about views and trends, requests about one's own perceptions, or specifications,

2. Figure out how the questions will be laid up.
3. Decide on the kind, format, and order of the questions:

The researcher now decides on the precise Content and phrasing (essential or not?) questions that need to be asked. In addition, how many of each component part is required?

For this thesis, we used five-point Likert scales and closed-ended question formats. The purpose of the survey is to learn about the difficulties encountered by road maintenance employees and their thoughts on the evolution of the overall system. (Neuman, W. L.2006).

3.4 Procedures for Making a Questionnaire

1. Determining on research questions and deciding what information to include in a questionnaire.
2. Choose the categories (axes) that will be included in the survey.
3. Orienting inquiries around objectives.
4. Using the questionnaire to conduct a preliminary research.
5. Submitting the survey to a panel of experts for judgment
6. Determine the questionnaire's validity and reliability using statistical approaches.

Norms that were strictly adhered to while filling out the various sections of the questionnaire (Ibrahim Rasheed, 2017).

3.4.1 Rules that should follow when formulating questions

1. The items are comfortable, do not contain multiple meanings, and are easily understood.
2. The questionnaire begins with simple questions, followed by difficult questions.
3. Each item should highlight one specific aspect.
4. Avoid introducing extra questions.
5. Avoid cases that need honest responses.

6. Avoid asking difficult-to-answer, complex questions.

Regarding the time required to complete the questionnaire, there is no restriction; however, experts advise that it should not exceed a quarter of an hour for the individual questionnaire and a half hour for the group questionnaire. The number of questions varies based on the title, and experts recommend (25-45) questions. The duration of the problem should be as uncomplicated as feasible without impacting the respondent's ability to understand it (Ibrahim Rasheed, 2017).

There is a set of principles that must be followed for the formulation of questions:

a. The question language should be comprehensible and suited to the respondents' levels.
b. They exist Formulating queries such that they do not imply a specific answer.
c. That the question formulation is not susceptible to interpretation.
d. Avoid asking duplicate questions.
e. Steer clear of qualitative inquiries.
f. When answering requests of the specified variety, the researcher is required to provide all conceivable information.
g. It assured that respondents have access to the information and can therefore answer the queries.
h. Formulating some queries in multiple ways in order to guarantee accurate responses.
i. The questions do not necessitate critical thinking or complicated mathematical operations.
j. The required response form is specified.
k. Definitions of a few imprecise terms.
l. L .The quantity of questions is kept to a minimum.
m. Individuals are interested in a catalog of general to specific questions.
n. Separate queries into categories and provide subheadings for each group.
o. To be numbered in order. Begin with simple inquiries.

p. Make an effort to place sensitive or unresolved issues with the other.

q. Organizing the issues in a logical order and considering their interdependence (Ibrahim Rasheed, 2017).

Included among the requirements for an effective questionnaire are the following:

1. The title, researcher's name, and name of the supervisor
2. The research's aim
3. Thanking the reader for his assistance and assuring him of his privacy with a natural, three-sentence message.
4. Four personal details about the respondent.
5. Comply with directions.
6. Questions.

3.4.2 Finalizing the questionnaire

During this stage, the researcher effectively manages and presents the questionnaire in a manner that captures the attention of the participants. Several factors need to be evaluated during the output phase.

1. Placing the research title prominently at the beginning of the questionnaire.
2. Arrange the questions present on each page in a manner that facilitates a suitable response.
3. It is recommended that the questionnaire be concise in length.
4. The guidelines for the questionnaire must be unambiguous.
5. The paper ought to be impartial and composed solely on one side of the page.
6. It is recommended to categorize the questions into distinct groups and provide them with unambiguous headings.
7. At the end of the questionnaire, it is expected that the respondent will express gratitude for their cooperation.

Usually, a letter of introduction is included alongside the questionnaire, describing the study's significance, objective, and the confidential nature of the data. According

to Ibrahim Rasheed's (2017) statement, the usage of the aforementioned item is exclusively intended for scientific research purposes.

3.5 Receive Answers

The researcher has a strong desire to obtain a substantial quantity of questionnaires. An acceptable range for the rate of refusal would be between 30% and 40%. Questionnaires go through careful examination to verify the accuracy and validity of responses.

3.6 Analyzing the Questionnaire Results

The researcher decided to exclude incomplete questionnaire responses from the dataset prior to conducting statistical analysis using the SPSS software. The questionnaire was analyzed by first addressing each question individually, followed by a discussion of the overall results (Yap Jeffrey Boon, 2017).

3.7 The Validity and Reliability of the Questionnaire

This is not just a collection of different questions, but rather a systematic research. For the test to be deemed valid, it is imperative that the outcomes of these inquiries are congruent. The development and integration of accuracy and integrity are essential in the design of research tools. It is advisable to bear these considerations in mind. Numerous interpretations of the term "honest" have been posited, for instance, the aforementioned survey was conducted with the aim of identifying. Moreover, the questionnaire employs proportional weights. Generally speaking, honesty pertains to the subject matter or discourse that is pertinent to the objectives of the research. The individual lacks knowledge of the accurate response or may not have yet located the specific section. They lack ability for creativity and proficiency in articulating their thoughts with depth. It is conceivable that the individual may have misconstrued the directives. In the event that the respondent experiences concerns regarding the veracity of their response, they may opt to refrain from providing an answer. There exist numerous methodologies for validating the authenticity of a given tool. One possible method for evaluating the accuracy of the calculation is to assess the

proficiency of the individuals responsible for devising the questions utilized in the process, as suggested by (Ibrahim Rasheed et all.,2017).

4. FIELD STUDY AND DATA ANALYSIS

4.1 Introductions

The research design for this study is a quantitative approach. In this study, a field survey was conducted, and 102 respondents were categorized by their professional positions as architecture engineers, civil engineers, employers, and contractors. A questionnaire was constructed based on the factors found through the literature analysis and given to the respondents Figure 4.1 presents the general research plan. Engineering Bureaus, Construction Companies, Academic Institutions, Government Agencies, Manufactures, and Engineering Laboratories were among the places where they worked. The consensus approach among the respondents was expected to provide reliable and excellent data for this research. Participants were then sent the questionnaire through email and an online survey link. This was done in an effort to get a high enough response rate. The acceptable range of sample size (f) is $30 \leq f \leq 500$ for the most of researches (Roscoe, J. T., 1975). (Leech, N. L., Barrett, 2014).

4.2 Research Design

The completed questionnaire was divided into two parts. The purpose of the first section is to compile an overview of the responders. This pertains to their position on jobs, their highest level of education, their years of experience, and the location of the work they do. The second part involves the rating of the 6 main factors of effective road maintenance system.

4.2.1 Data analysis by statistical equations

The data of the responses were analyzed using a program SPSS-25 based on responses provided by the participants to determine the mean of response for each question by collecting the values of the answers for each question based on the five-point Likert scale (1=Ineffective, 2 = Low effect, 3 = medium effect, 4 = Effective, and 5 = Very Effective). After calculating, the obtained result can be normalized by dividing it with the total number of respondents.

$$Xi = \frac{1}{n}\left(\sum_{i=1}^{n} Xi\right) = \frac{x1 + x2 + \cdots + x3}{n} \quad \textbf{(4.1)}$$

The mean of a sample $\boldsymbol{x1 + x2 + \cdots + x3}$ usually denoted by Xi, $\sum$ is the summation of the sampled values, $\boldsymbol{n}$ number of items in the sample.

After calculating the Mean. The standard deviation (SD) was calculated for each question, which represents great importance for the comparison between the criteria in the case of equal importance.

$$SD = \sqrt{\frac{\sum (x - \bar{x})^2}{N}} \quad \textbf{(4.2)}$$

Where X = each value in the data set. $\bar{x}$ = mean of all values in the data set. N = number of values in the data set

Then the Relative Importance Index (RII) calculated for each question for the purpose of comparison later in order to determine the rank of importance from the highest importance to the relatively least.

$$RII = \Sigma W / (A * N) \quad \textbf{(4.3)}$$

Where W is the measure of weight that the respondents gave each factor, A is the highest weight and N is the total number of respondents. All data obtained from this study were analyzed using the Statistical Package for Social Science (SPSS) to get the mean and standard deviation (SD) In addition, the reliability analysis was used to make sure the data acquired was consistent and stable (Tan, Y., Shen, 2014).

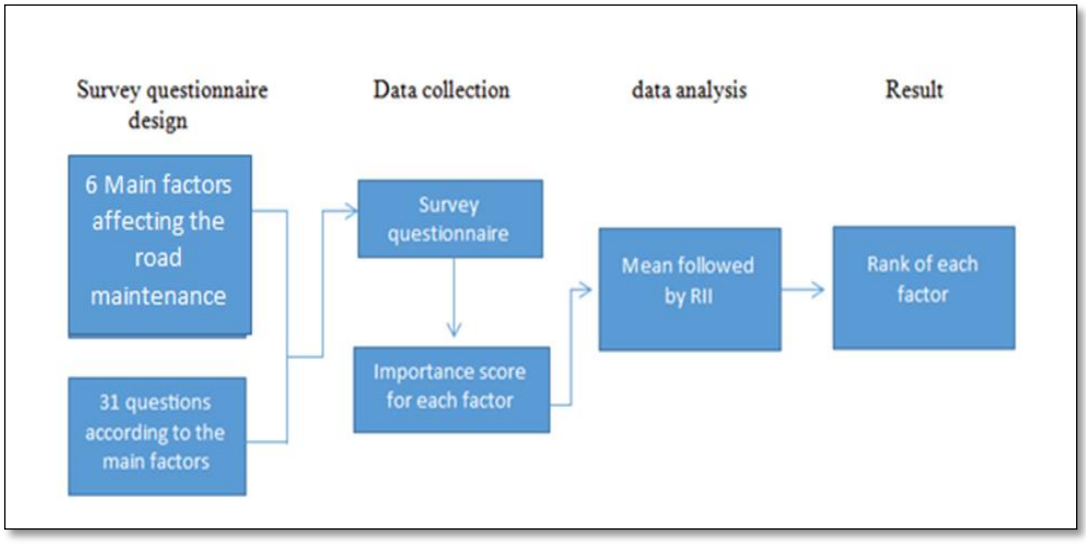

Figure 4.1: Research Design

4.2.2 Survey Questionnaire

A sample of participants having knowledge and experience in the domain of road construction and maintenance submitted a questionnaire consisting of 31 questions. As shown in the table 4.1, there are six essential factors that have an impact on the road maintenance system. A section with inquiries about the respondents' personal information came before this part. A total of 102 responds were received before the end of the survey period, achieving a response rate of 68%. Indicated that for a research survey, a response rate of 10% to 20% is acceptable (Tan, Y., Shen, 2014). Overall, 102 responses met the criteria for a proper response all questions were completely answered and there were no unclear answers.

Table 4.1: Questionnaire Factors and Questions

No.	Items	Code	Elements
1	Collecting data on the condition of the road network	F1	The budget and funding of the authorities that responsible for road maintenance
2	availability of labor and equipment for maintaining roads	F2	
3	The effect on the periodic maintenance of the road networks	F3	
4	Urgent maintenance when an emergency occurs that affects the road condition	F4	
5	The impact on the routine maintenance	F5	
6	Government system and source of funding, including whether it is central or federal	F6	
7	The economic conditions of the country in general	F7	
8	The demand for more road construction and, therefore, more maintenance work	F8	
9	Country's political considerations	F9	
10	Frequency of maintenance	F10	The effect of the traffic volume
11	Type of maintenance activities	F11	
12	Impact on costs	F12	
13	Impact on timing of maintenance	F13	
14	Impact on road conditions	F14	The effect of the weather
15	Impact on maintenance activities	F15	
16	Impact on timing of maintenance	F16	
17	Impact on costs	F17	
18	Frequency of maintenance	F18	The Age of the road
19	Type of maintenance activities	F19	
20	Impact on costs	F20	
21	Impact on timing of maintenance	F21	

Table 4.1: (Cont.) Questionnaire Factors and Questions

No.	Items	Code	Elements
22	Frequency of maintenance	F22	The effect of construction specifications
23	Type of maintenance activities	F23	
24	Impact on costs	F24	
25	Impact on timing of maintenance	F25	
26	Highways	F26	The effect of the roads type in terms of construction and functionality
27	The main roads of cities	F27	
28	Subsidiary roads	F28	
29	Roads rigid pavement	F29	
30	Flexible pavement roads	F30	
31	Composite pavement roads	F31	

4.3 Characteristics of the Responders

The target sample of engineers was located in Iraq, especially the capital, Baghdad, as well as Basra, the largest economic city in southern Iraq. The percentage of respondents was from Baghdad and its regions 71.5%. And respondents from Basra 28.5%, The sample respondents, with regard to practical specialization, 51% of civil engineers, who are the largest percentage, and the remaining percentages were distributed between contractors and architects, and 24.5% of them have experience from 5 to 10 years, and 19.6% had more than 15 years in the areas of road construction and maintenance. As for the engineering degree, 33 % of them are engineers and 27.4 % of them were assistant engineers. With regard to the academic qualification, 28 % of them have a master's degree, 47% of them hold a bachelor's degree, 58.8% H.Diploma and 9.8 % of them have PHD. Their work sites are distributed among the largest percentage in the Public sector 50% and 24.5% in construction companies as private sector. Tables and Figures 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, show all the percentages and categorization.

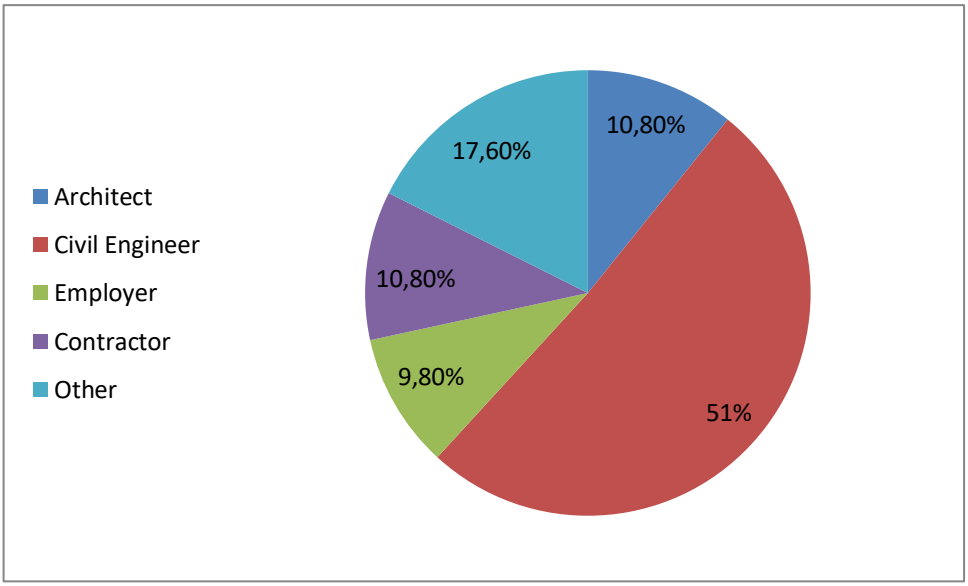

Figure 4.2: Practical Specialty

Table 4.2: Practical Specialty

	Frequency	Percent	Valid Percent	Cumulative Percent
Architect	11	10.8	10.8	10.8%
Civil Engineer	52	51.0	51.0	61.8%
Employer	10	9.8	9.8	71.6%
Contractor	11	10.8	10.8	82.4%
Other	18	17.6	17.6	100.0
Total	102	100.0	100.0	

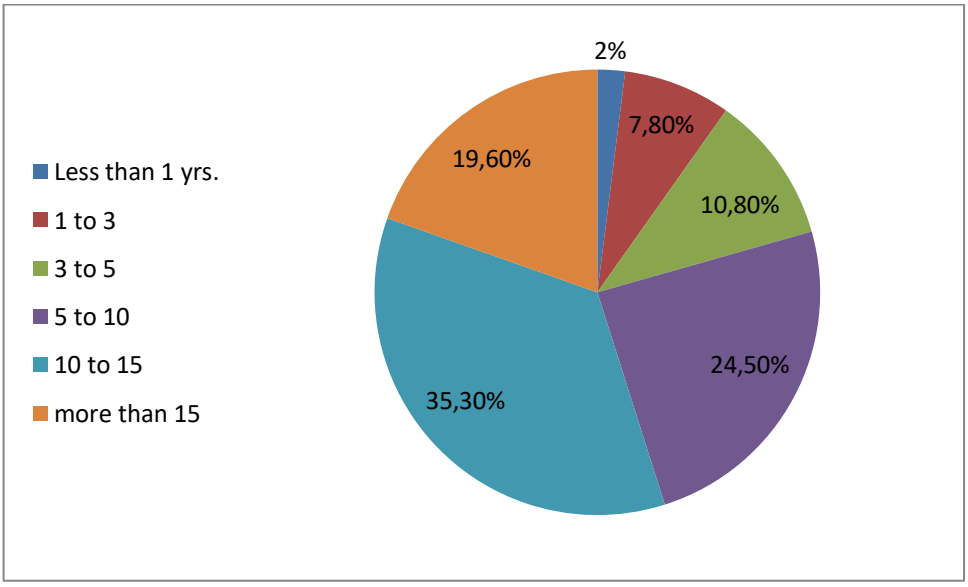

Figure 4.3: Years of Experience

Table 4.3: Years of Experience

	Frequency	Percent	Valid Percent	Cumulative Percent
Less than 1 yrs.	2	2.0	2.0	2.0%
1 to 3	8	7.8	7.8	9.8%
3 to 5	11	10.8	10.8	20.6%
5 to 10	25	24.5	24.5	45.1%
10 to 15	36	35.3	35.3	80.4%
more than 15	20	19.6	19.6	100.0
Total	102	100.0	100.0	

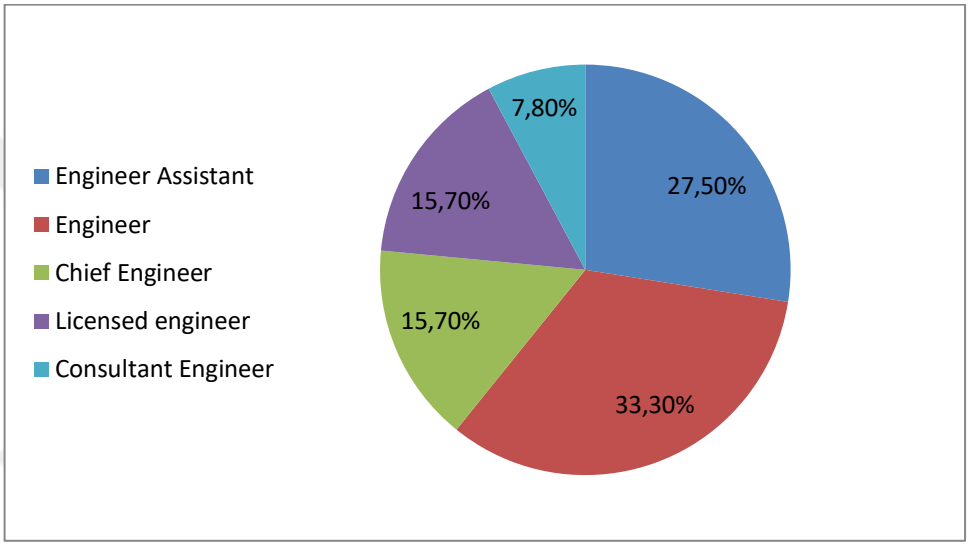

Figure 4.4: Engineering Level

Table 4.4: Engineering Level

	Frequency	Percent	Valid Percent	Cumulative Percent
Engineer Assistant	28	27.5	27.5	27.5%
Engineer	34	33.3	33.3	60.8%
Chief Engineer	16	15.7	15.7	76.5%
Licensed engineer	16	15.7	15.7	92.2%
Consultant Engineer	8	7.8	7.8	100.0
Total	102	100.0	100.0	

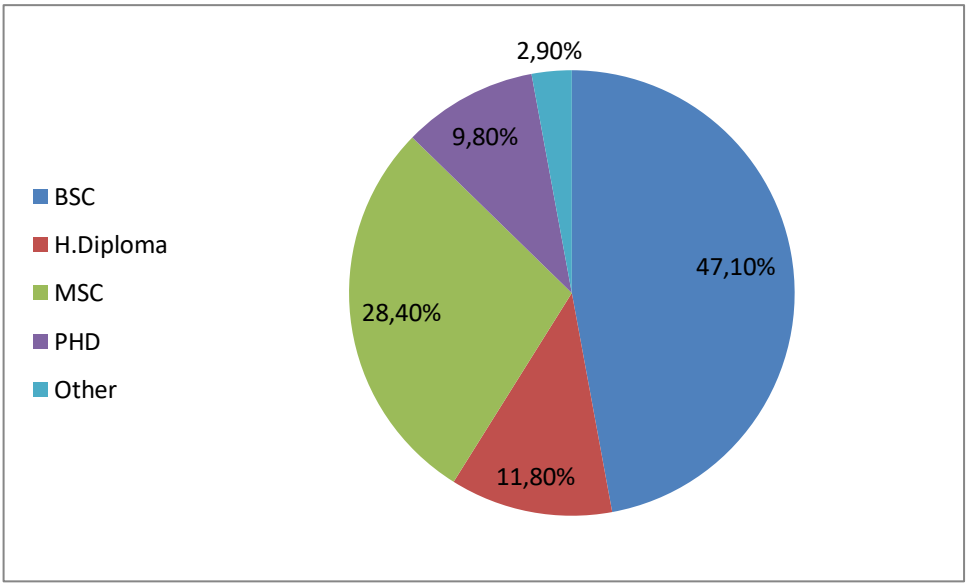

Figure 4.5: Qualifications of Education

Table 4.5: Qualifications of Education

	Frequency	Percent	Valid Percent	Cumulative Percent
BSC	48	47.1	47.1	47.1%
H. Diploma	12	11.8	11.8	58.8%
MSC	29	28.4	28.4	87.3%
PHD	10	9.8	9.8	97.1%
Other	3	2.9	2.9	100.0
Total	102	100.0	100.0	

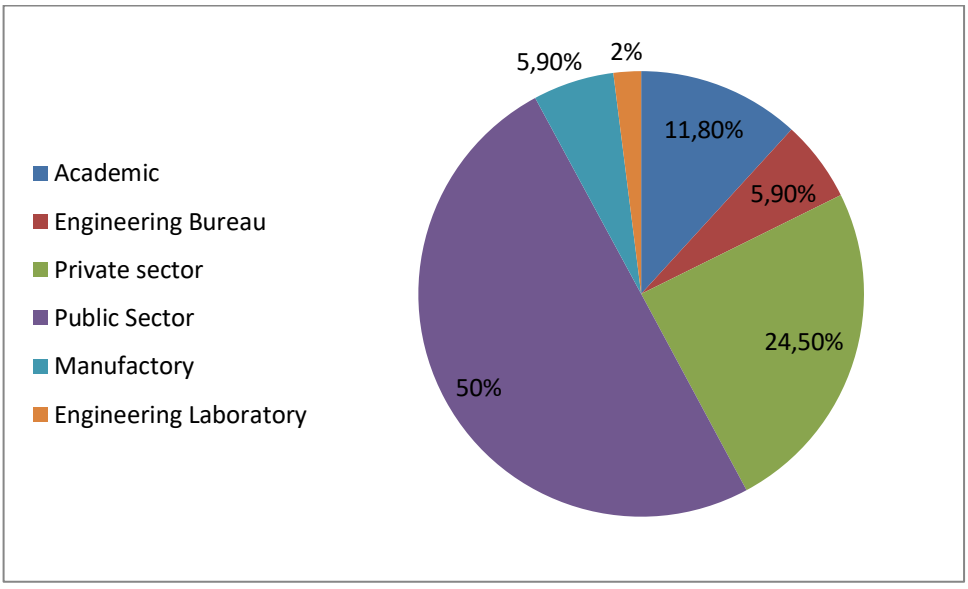

Figure 4.6: Work Sector

Table 4.6: Work Sector

	Frequency	Percent	Valid Percent	Cumulative Percent
Academic	12	11.8	11.8	11.8%
Engineering Bureau	6	5.9	5.9	17.6%
Private sector	25	24.5	24.5	42.2%
Public Sector	51	50.0	50.0	92.2%
Manufactory	6	5.9	5.9	98.0%
Engineering Laboratory	2	2.0	2.0	100.0%
Total	102	100.0	100.0	

Table 4.7: Regions of Respondents

	City	**No. respondents**	**percent**
Regions of respondents	Iraq, Baghdad	73	71.5%
	Iraq,Basrah	29	28.5%

4.4 Reliability Analysis

The range of acceptable Cronbach's alpha (α) values for all studies, according to different types of research, is 0.71 to 0.99 (Kamaruzzaman Syahrul, 2018). To check the scale's internal reliability, the alpha (α) value was calculated. The affect factors for the road maintenance system were 0.939 in this research.

4.5 The Budget and Funding

This group of survey questions covers the factors influencing the impact of budget and funding availability on the accessibility of an ideal and effective road maintenance system, as well as the impact of some factors on the funding budget.
Such as the requirement for urban expansion, the overall economic and political situation in the entire country. Following the calculation of the mean and SD for each element, ranked order analysis utilizing the RII value was performed. The higher rank is assumed when two or more factors have the same RII value and the SD values are compared. The same rank was assigned if the RII value and SD is both equal. (Tan, Y., Shen, 2014). As shown in the table 4.8. The respondents indicated that the availability of labor and equipment for road maintenance is the most

important issue affected by the budget and private funding for maintenance, RII (0.87), which is the highest importance at the level of the questionnaire. The second highest important is the economic conditions of the country in general, RII (0.864).

Table 4.8: The Impact of Budget and Funding **(**Importance and Ranking)

The budget and funding of the organizations that responsible for road maintenance	Mean	Std. Deviation	N	RII	Rank in Group	Rank overall
Availability of labor and equipment for maintaining roads	4.35	0.779	102	0.87	1	1
The effect of economic conditions of the country in general on the budget	4.32	0.81	102	0.864	2	2
Urgent maintenance when an emergency occurs that affects the road condition	4.32	0.869	102	0.864	3	3
Country's political considerations and their impact on the budget	4.3	0.92	102	0.86	4	5
The effect on the periodic maintenance of the road networks	4.25	0.838	102	0.85	5	7
The demand for more road construction therefore, more maintenance work	4.22	0.863	102	0.844	6	8
The impact on the routine maintenance	4.15	0.813	102	0.83	7	11
Government system and source of funding, including whether it is central or federal	4.13	0.875	102	0.826	8	13
Collecting data on the condition of the road network	4.04	0.974	102	0.808	9	21

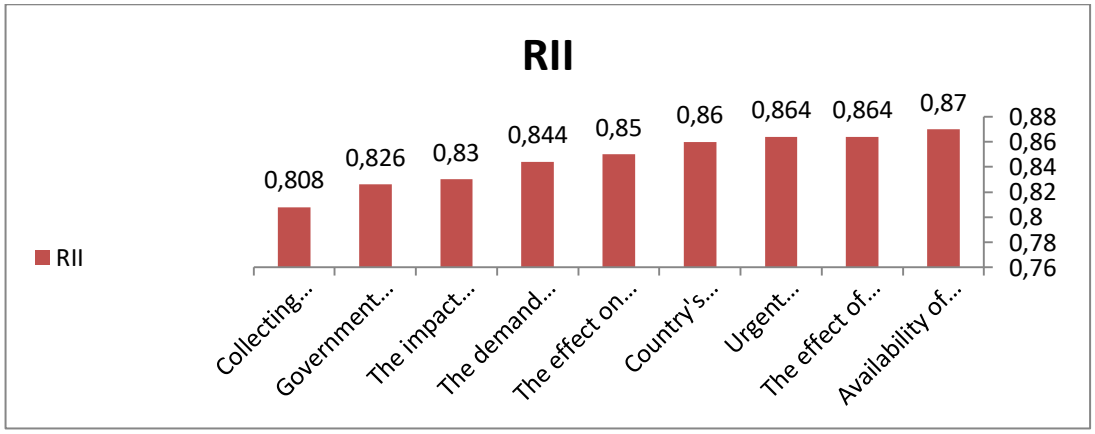

Figure 4.7: The Impact of Budget and Funding **(**Importance and Ranking)

4.6 The Effect of the Traffic Volume

Concerning the effect of traffic volume on the road maintenance system, the respondents confirmed that the type of maintenance activities RII (0.864). various types of maintenance that were previously characterized in the literature reviews is most impacted by traffic volume, followed by the impact on the cost of maintenance RII (0.840) due to high traffic volumes result lead to more damage and deterioration. As shown in the table 4.9.

Table 4.9: The Effect of the Traffic Volume (Importance and Ranking)

The effect of the traffic volume	Mean	Std. Deviation	N	RII	Rank in Group	Rank overall
1-Frequencyof maintenance	3.87	1.05	102	0.774	4	29
2-Type of maintenance activities	4.32	0.798	102	0.864	1	4
3-Impact on costs	4.2	0.934	102	0.840	2	9
4- Impact on timing of maintenance	4.02	1.108	102	0.804	3	23

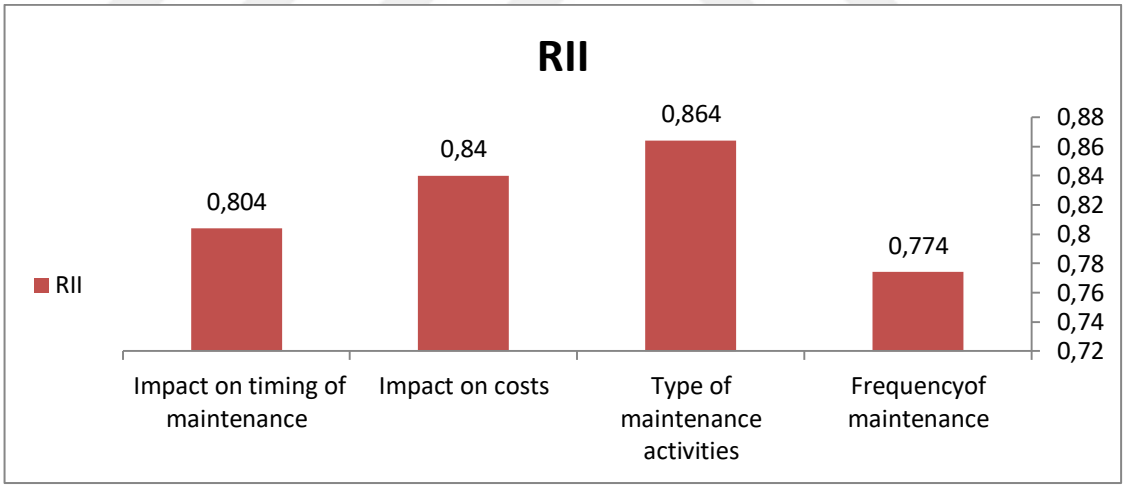

Figure 4.8: The Effect of the Traffic Volume (Importance and Ranking)

4.7 The Effect of the Weather

Heavy rain or snow might cause road damage and necessitate more regular maintenance. Respondents had an opinion regarding the effect of weather on the road maintenance system. The respondents have given the highest importance to the timing of maintenance activities RII (0.858), which mean the highest activity affected by the weather. Considering that the bad weather sometimes leads to the

postponement of the required activity. They also gave importance in the second classification to the effect of the road condition on the weather conditions RII (0.802), which means the need for more maintenance.

Table 4.10: The Effect of the Weather **(**Importance and Ranking)

The effect of the weather	Mean	Std. Deviation	N	RII	Rank in Group	Rank overall
1-Impact on road conditions	4.01	1.029	102	0.802	2	24
2-Type of maintenance activities	3.83	0.902	102	0.766	4	30
3-impact on timing of maintenance	4.29	0.897	102	0.858	1	6
4-Impact on costs	3.97	0.838	102	0.794	3	26

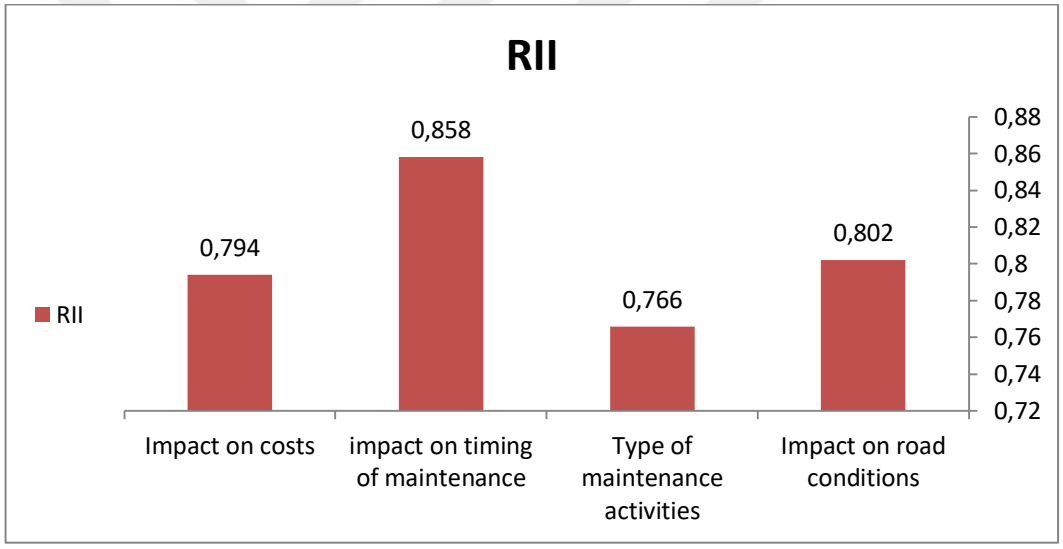

Figure 4.9: The Effect of the Weather (Importance and Ranking)

4.8 The Age of the Road

The age of a road can also have an impact on the requirement for maintenance, as older roads are more at risk for deterioration and might require greater frequency of repair. This is what the respondents emphasized as the most important factor RII (0.826), Std. Deviation (0.864), which is the frequency of maintenance activities. Followed by the importance of the type of maintenance activities RII (0.826), standard deviation (0.908), the older road probably needs a wide range of the required types of maintenance.

Table 4.11: The Age of the Road **(**Importance and Ranking)

The Age of the road	Mean	Std. Deviation	N	RII	Rank in Group	Rank overall
1-Frequency of maintenance	4.13	0.864	102	0.826	1	12
2-Type of maintenance activities	4.13	0.908	102	0.826	2	14
3-Impact on costs	4.08	0.875	102	0.816	3	17
4- Impact on timing of maintenance	4.04	0.795	102	0.808	4	20

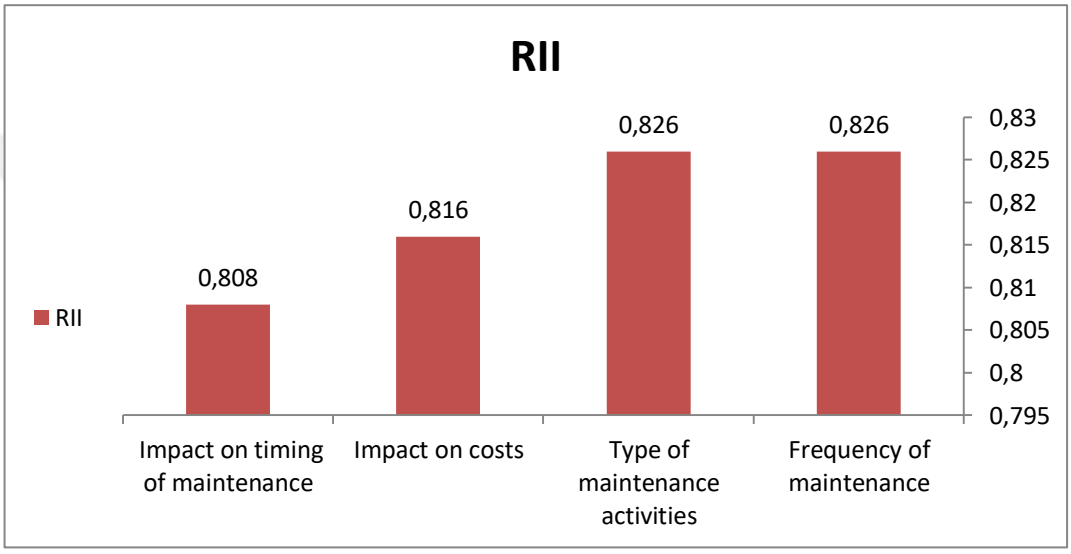

Figure 4.10: The Age of the Road (Importance and Ranking)

4.9 The Effect of Construction Specifications and Road Quality

The most important guarantee for a long operating life of the road without the need for major maintenance operations is compliance with the specifications during the construction of the roads. Because a road that is constructed in poor accordance with the standards will start to deteriorate quickly. The Respondents focus on the types of maintenance activities that are most negatively impacted by non-compliance with standards RII (0.832). Also, the frequency that maintenance is performed on roads with poor standards RII (0.822).

Table 4.12: The Effect of Specifications **(**Importance and Ranking)

The effect of construction and road quality	Mean	Std. Deviation	N	RII	Rank in Group	Rank overall
1-Frequency of maintenance	4.11	0.922	102	0.822	2	15
2-Type of maintenance activities	4.16	0.741	102	0.832	1	10
3-Impact on costs	3.97	1.038	102	0.794	4	27
4-Impact on timing of maintenance	4.07	1.017	102	0.814	3	19

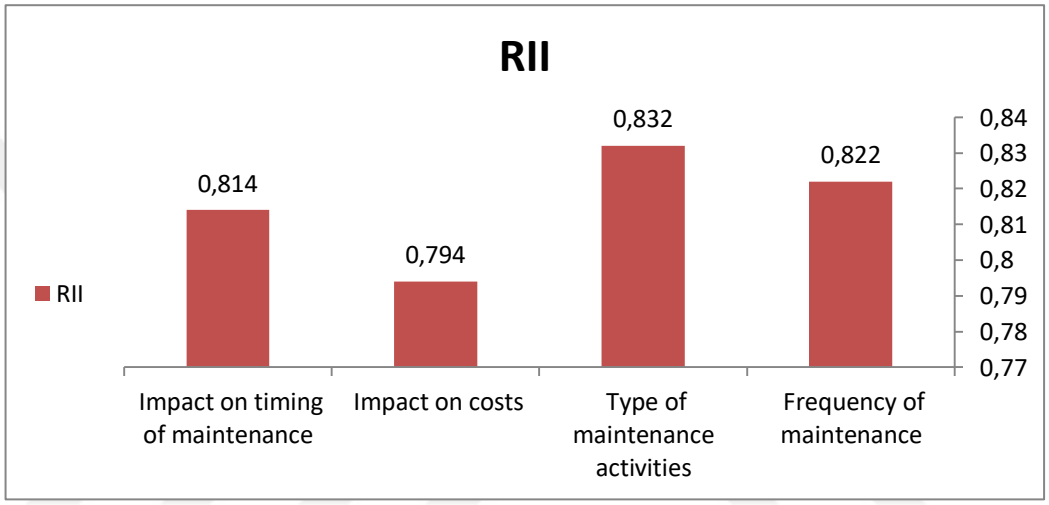

Figure 4.11: The Effect of Specifications (Importance and Ranking)

4.10 The effect of the roads type in terms of construction and functionality

In this group of the questionnaire, the types of roads were addressed in terms of functionality and construction, and how much the road type was affected based on its functional and structural type. With an overlap between these types, for example, the main roads can be of flexible, rigid or composite paving. But the main purpose of this part of the questionnaire is to know the most affected type and the need for more maintenance. The main roads of cities, in the view of the survey participants, may be the most impacted and required more maintenance than others RII (0.818). In addition, highways rank second in terms of maintenance requirements RII (0.814).

Table 4.13: The Effect of the Roads Type **(**Importance and Ranking)

The effect of the roads type in terms of construction and functionality	Mean	Std. Deviation	N	RII	Rank in Group	Rank overall
1-Highways	4.07	0.847	102	0.814	2	18
2-The main roads of cities	4.09	0.880	102	0.818	1	16
3-subsidiary roads	3.88	1.046	102	0.776	5	28
4-roads Rigid Pavement	4.03	0.789	102	0.806	3	22
5-Flexible Pavement roads	4	0.933	102	0.800	4	25
6-Composite Pavement roads	3.54	1.002	102	0.708	6	31

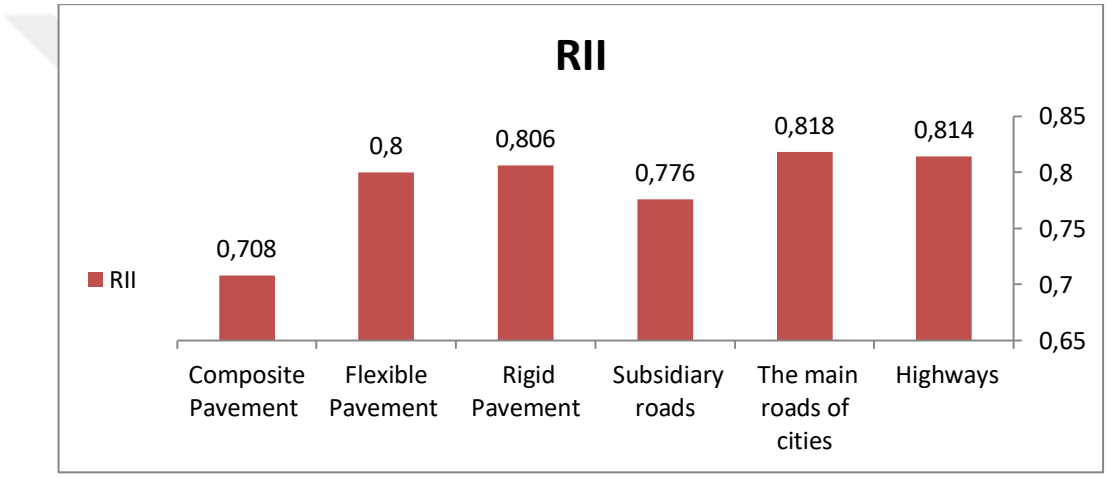

Figure 4.12: The Effect of the Roads Type (Importance and Ranking**)**

4.11 Main Factors Group

In terms of the main factors, the group mean average, as well as the average relative importance index for each group, was considered, assuming that each group represents one effective factor. When analyze ranking, we find that the factor of budget and funding for the agencies in charge of road maintenance had the highest importance index of all the criteria. RII (0.846). This means according to responders' view that this main factor is the most important factor that affecting positively or negatively on the road maintenance system. While traffic volume was ranked second, with an average relative importance index (0.8205). According to the answers, the amount of traffic and its impact on the roads may require additional maintenance. The age of the road is another crucial factor that respondents focused on, due to obtain the third rank and the index of relative importance (0.819). This confirms

what was stated in previous literature reviews about the impact of roads on their operational life on their need for maintenance, and susceptibility to degradation over time. The road construction quality factor ranked fourth with RII (0.8155), and the weather factor ranked fifth with RII (0.805).

Finally, the road type factor in terms of functionality and construction ranked sixth. and with the RII (0.787) as shown in Table 4.14 It is the least effect among the other criteria, which indicates that the type of road is less important than the other types. The fact that the type of road and its impact on the road maintenance system is not correlated to the same extent as other factors such as funding, traffic volume and age of the road causes a direct impact on the road maintenance system and puts the agencies responsible for maintenance under pressure to obtain the requirements of the actual demand for maintenance.

Table 4.14: Main factors group and Ranking

Main Factor	Group Mean	Group RII	Rank
The budget and funding of the authorities that responsible for road maintenance	4.232	0.846	1
The effect of the traffic volume	4.102	0.820	2
The Age of the road	4.095	0.819	3
The effect of construction specifications and road quality	4.077	0.815	4
The effect of the weather	4.025	0.805	5
The effect of the roads type in terms of construction and functionality	3.935	0.787	6

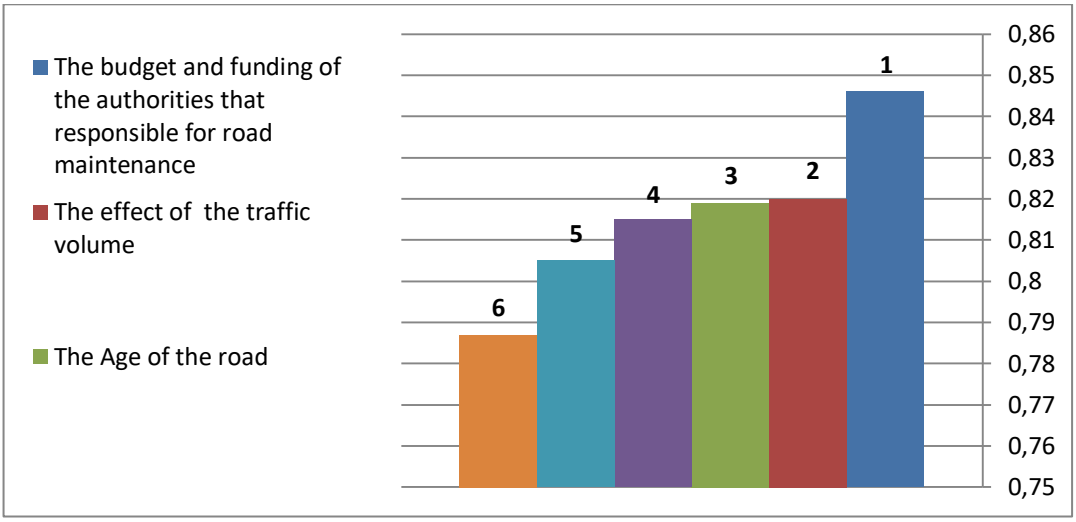

Figure 4.13: Ranking of the Main factors

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The results of the study highlight that the effectiveness of the road construction and maintenance system in Iraq is primarily influenced by the budget and the funding of the agencies that are responsible for road maintenance. The questionnaire responses obtained from individuals in this sector strongly emphasize the crucial significance of sufficient funding and resource allocation in ensuring the efficient maintenance of road infrastructure. Insufficient allocation of funds has been recognized as a significant restriction, resulting in below-par maintenance procedures, delay in completing maintenance, and put at risk road safety. The results emphasize the pressing requirement for policymakers and interested parties to prioritize the allocation of sufficient financial resources to road maintenance agencies, allowing them to perform prompt repairs, execute regular maintenance operations, and improve the overall standard of the road infrastructure. Furthermore, the findings suggest the significance of implementing transparent and efficient financial mechanisms to guarantee the efficient allocation of resources and avert corruption. the country have the potential to improve its infrastructure network, promote economic growth, and ensure safer travel for its citizens by managing the financial and economic challenges associated with its road maintenance system. As shown in the table 5.1, the importance index is presented for the highest three factors

The study additionally pointed out the importance of traffic volume as the primary factor affecting the road maintenance system in Iraq. The impact of traffic volume on maintenance demands and road deterioration is a crucial factor that warrants careful consideration and targeted interventions to effectively manage this problem. The research also findings indicate that road age has an important effect on the road maintenance system in the country. The duration of time that roads have been in existence can significantly influence their state and maintenance necessities. With the passage of time, roads usually to become more delicate to damage and deterioration, thus necessitating greater maintenance requirements. The consideration of this factor

is of utmost importance in guaranteeing the efficient durability of the roadway infrastructure.

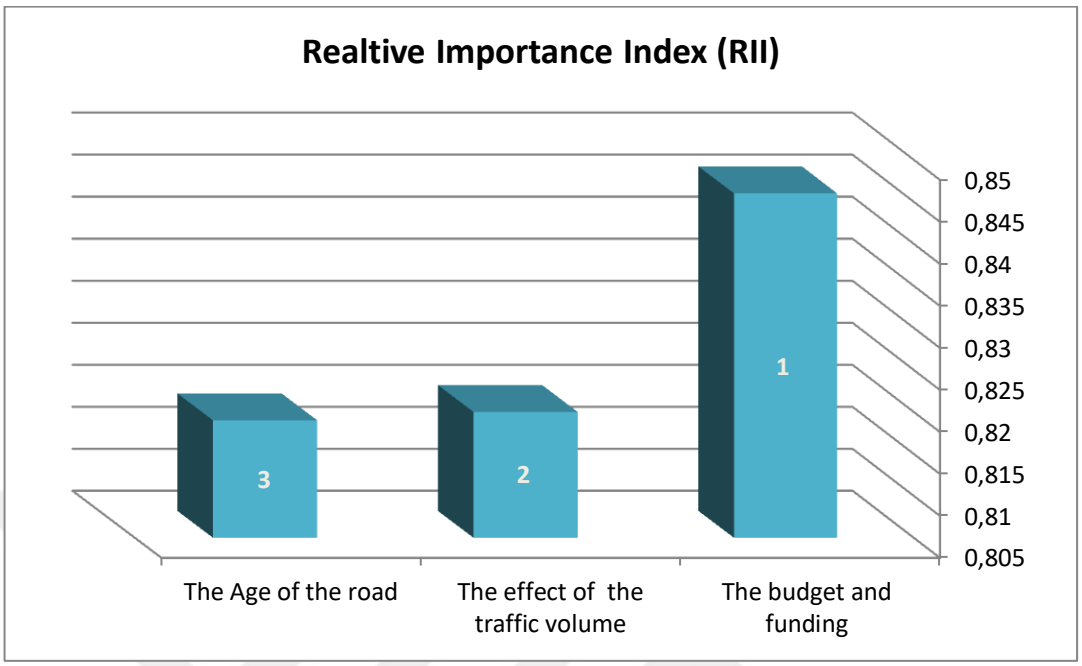

Figure 5.1: The Relative Importance Index Is Presented For the Highest Three Factors

5.2 Recommendations

Based on the contentious findings regarding the importance of budget and financing for the authorities responsible for road maintenance in Iraq, several recommendations can be proposed to improve and develop this crucial aspect:

1. Increase Funding: It is important to provide sufficient funding to the road maintenance authorities in order to deal with the massive backlog of maintenance, routine maintenance, and infrastructure improvements. It is recommended that the government allocate priority to the road sector within the national budget and investigate alternative means of financing, such as public-private partnerships or international aid initiatives.
2. Transparent Budgeting: Processes implementing transparent and accountable budgeting mechanisms is crucial to ensure the effective use of funds. The implementation of unambiguous protocols for the distribution of funds, frequent financial evaluations, and honest distribution of spending records are essential measures to reduce the occurrence of corruption and illegal business operations.

3. Long-Term Planning: Develop sustainable strategies for the maintenance of roads that are in accordance with the expected demands and growth of this country. The implementation of this strategic approach facilitates improved budget forecasting, which guarantees the timely allocation of sufficient funds for the purpose of maintenance and reconstruction.
4. Prioritize Preventive Maintenance: focusing on the significance of preventive maintenance actions, such as periodic evaluations, prompt maintenance, and proactive maintenance of roadway infrastructure. The timely resolution of minor issues may reduce the requirement for expensive and extensive repairs, therefore resulting in saving resources over a long time.
5. Capacity Building: Provide resources towards training programs and professional development programs for road maintenance authorities and individuals. Improving knowledge and abilities can lead to increased efficiency in using resources and higher quality maintenance practices.
6. Public-Private Partnerships (PPPs): Exploring possible partnerships with the private sector to take advantage on additional assets and proficiency in the maintenance of roads. Public-private partnerships (PPPs) have the potential to facilitate access to financial resources, advanced technological solutions, and streamlined management strategies, which could improve the efficiency and durability of maintenance operations.
7. Performance-Based Contracts: To ensure accountability and incentivize efficient maintenance practices, it is recommended to implement performance-based contracts that include well-defined objectives, achievements, and penalties. This methodology pushes contractors to conform to standards of quality and achieve projects within the assigned financial parameters.
8. Stakeholder Engagement: Encourage cooperation and involvement among various parties, such as government agencies, organizations responsible for road maintenance, business groups, and nearby populations. The involvement of all pertinent stakeholders in decision-making procedures can facilitate the development of a collective knowledge of challenges and priorities, resulting in improved resource allocation efficacy.

Through the implementation of these recommendations, Authorities responsible for road maintenance in Iraq can effectively address the contentious problem related to budget allocation and financing for road maintenance authorities. The implementation of a strong, durable, and adequately financed road maintenance infrastructure will promote the creation of more secure, properly maintained roads, and improve the economic and social advancement of the nation.

Regarding the effect of traffic volume:

1. Traffic Management and Planning: Develop comprehensive traffic management strategies that take into account the present and anticipated volume of traffic across various sections of the roadway. The aforementioned activities encompass the examination of vehicular movement trends, detection of areas with high traffic volume, and execution of strategies such as intelligent transportation systems, traffic signal optimization
2. Design Standards: It is important to ensure that road construction and maintenance conform to suitable design standards that take into consideration the expected traffic volume. The process involves taking into account multiple factors such as the dimensions of the road, the quality of the pavement, and its durability, in order to guarantee that the roads are constructed to endure the expected volume of traffic and reduce the necessity for frequent maintenance.
3. Regular Monitoring and Assessment: Establish and use a full system to consistently evaluate and appraise the state of roadways, covering factors such as the standard of pavement, soundness of structure, and volume of vehicular activity. The utilization of a data-centric methodology facilitates the identification of heavily frequented regions that necessitate expeditious maintenance interventions, thereby enabling prompt repairs and rehabilitation.
4. Strategic Maintenance Scheduling: Formulate maintenance schedules that take into account the patterns of traffic volume in order to mitigate disturbances and inconvenience to individuals utilizing the roadway. The impact on traffic flow can be reduced by strategically scheduling

maintenance activities during non-peak hours or by employing alternative routes.

Through the implementation of these recommendations, Iraq can improve the resilience and longevity of its road infrastructure by mitigating the impact of traffic volume on the maintenance system. The implementation of this measure is expected to result in enhanced cars movement, reduced traffic buildup, heightened road security, and reduced maintenance costs in the future.

Regarding the effect of road age:

1. Asset Management: Establish a proficient asset management protocol that encompasses periodic inspections and evaluations of road conditions. The implementation of a proactive approach enables the timely identification of road deterioration and facilitates the prioritization of maintenance interventions, taking into account the age and condition of the roads.
2. Pavement Rehabilitation and Reconstruction the aim is to establish a methodical strategy for the rehabilitation and reconstruction of pavements, taking into account the age and state of the roadways. Developing a set of protocols for determining the appropriate timing and methodology for conducting significant repairs or full-scale reconstruction of roads is imperative to ensure their revitalization prior to reaching a state of advanced decay.
3. Regular Maintenance Practices: In order to prevent minor defects from escalating into major issues, it is recommended to implement routine maintenance practices such as crack sealing, pothole patching, and resurfacing. Performing routine maintenance tasks can effectively prolong the durability of road infrastructure and mitigate the necessity for expensive reconstruction efforts.

By implementing these recommendations, the authorities can mitigate the impact of road age on the road maintenance system. This will result in a well-maintained road network with improved safety, reduced congestion, and enhanced user satisfaction. Additionally, it will help optimize maintenance resources by focusing efforts on roads that are at a higher risk due to age-related deterioration

5.3 Future Studies

Future studies should to go further on the discoveries of this research to more thoroughly examine and improve our knowledge of the road construction and maintenance framework in Iraq. A potential area for further examination is to explore the relationship among budget and financing, traffic volume, road age, and other variables identified in this study. A thorough evaluation of the detailed interrelationships and interactions can facilitate an improved understanding of the challenges encountered by the road maintenance system and enable the identification of effective development approaches. Furthermore, an analysis of the function of technological progressions, such as intelligent transportation systems and data analysis, in the optimization of road maintenance operations may provide valuable perspectives on improving efficiency and resource distribution. In addition, conducting comparative analyses to investigate the experiences and optimal strategies of other nations that have effectively implemented road maintenance systems can offer significant benchmarks and insights for Iraq.

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APPENDIX

Appendix -A: Questionnaire

1. Improving of the Road Maintenance Management System in Iraq

1) Personal Information						
Practical specialty	Architect	Civil Engineer	Employer	Contractor	Other	
Years of Experience	Non	(3-1)	(5-3)	(10-5)	(15-10)	More than 15
Engineering Level	Engineer Assistant	Engineer	Chief Engineer	Licensed engineer	Consultant Engineer	
Qualifications of Education	BSC	H.Diploma	MSC	PHD	Other	
Work Sector	Academic	Engineering Bureau	Private sector	Public Sector	Manufactory	Engineering Laboratory
Regions Of Respondents						

2. Factors that affect the management system for road maintenance

2.1 The budget and funding of the organizations that responsible for road maintenance

	Ineffective	Low Effect	Medium Effect	Effective	Very Effective
Collecting data on the condition of the road network					
Availability of labor and equipment for maintaining roads					
The effect on the periodic maintenance of the road networks					
Urgent maintenance when an emergency occurs that affects the road condition					
The impact on the routine maintenance					
Government system and source of funding, including whether it is central or federal					
The economic conditions of the country in general					
The demand for more road construction and, therefore, more maintenance work					
Country's political considerations					

2.2 The effect of the traffic volume

	Ineffective	Low effect	Medium Effect	Effective	Very Effective
Frequency of maintenance					
Type of maintenance activities					
Impact on costs					
Impact on timing of maintenance					

2.3 The Effect of the Weather

	Ineffective	Low effect	Medium Effect	Effective	Very Effective
Impact on road conditions					
Impact on maintenance activities					
Impact on timing of maintenance					
Impact on costs					

2.4 The Age of the Road

	Ineffective	Low effect	Medium Effect	Effective	Very Effective
Frequency of maintenance					
Type of maintenance activities					
Impact on costs					
Impact on timing of maintenance					

2.5 The Effect of Construction Specifications and Road Quality

	Ineffective	Low effect	Medium Effect	Effective	Very Effective
Frequency of maintenance					
Type of maintenance activities					
Impact on costs					
Impact on timing of maintenance					

2.6 The effect of the roads type in terms of construction and functionality

	Ineffective	Low Effect	Medium effect	Effective	Very Effective
Highways					
The main roads of cities					
subsidiary roads					
roads Rigid Pavement					
Flexible Pavement roads					
Composite Pavement roads					

Appendix- B: Questionnaire Answers

Practical Specialty	Scale
Architecture Engineer	1
Civil Engineer	2
Employer	3
Contractor	4
Other	5
Years of Experience	Scale
Less than 1 yrs.	1
1 to 3	2
3 to 5	3
5 to 10	4
10 to 15	5
more than 15	6
Engineering Level	Scale
Engineer Assistant	1
Engineer	2
Chief Engineer	3
Licensed engineer	4
Consultant Engineer	5
Qualifications of Education	Scale
BSC	1
H.Diploma	2
MSC	3
PHD	4
Other	5
Work sector	Scale
Academic	1
Engineering Bureau	2
Construction Company	3
Government Sector	4
Manufactory	5
Engineering Laboratory	6

No.	Practical specialty	Years of Experience	Engineering Level	Qualifications of Education	Work Location
1	2	5	2	3	4
2	4	5	3	1	3
3	5	1	1	3	5
4	1	6	4	3	2
5	5	6	3	1	3
6	4	6	4	3	3
7	2	4	3	1	2
8	1	4	2	3	2
9	3	3	2	3	4
10	2	3	2	1	3
11	4	4	4	3	4
12	1	3	2	1	1
13	5	2	2	3	1
14	2	4	2	3	1
15	2	4	4	3	1
16	2	6	5	1	4
17	5	1	1	2	4
18	3	5	4	1	4
19	1	6	3	1	4
20	3	6	5	3	5
21	2	5	3	1	5
22	1	5	2	3	4
23	2	6	4	3	4
24	5	5	3	1	4
25	2	6	3	1	4
26	5	5	3	1	4
27	2	6	3	1	4
28	2	6	3	2	4
29	5	5	2	1	4
30	5	6	4	2	4
31	2	6	3	3	4
32	3	4	2	1	4
33	2	3	2	1	1
34	1	5	5	1	4
35	2	6	3	1	4
36	2	5	2	3	4
37	1	6	2	1	3
38	4	6	5	1	3
39	2	5	2	3	4
40	2	6	3	2	6
41	2	5	2	1	4
42	4	6	2	1	3
43	2	4	2	1	3
44	2	5	2	1	4
45	2	3	1	1	3

No.	Practical specialty	Years of Experience	Engineering Level	Qualifications of Education	Work Location
46	2	4	2	1	1
47	4	5	3	3	3
48	3	4	2	2	4
49	1	4	2	3	3
50	2	4	2	1	3
51	5	5	2	3	4
52	2	6	2	1	3
53	2	4	1	1	5
54	3	3	2	1	2
55	5	4	1	1	3
56	2	5	2	1	3
57	2	6	1	4	2
58	2	2	2	3	2
59	2	2	1	3	4
60	2	2	1	4	3
61	2	5	2	1	4
62	3	2	1	3	1
63	2	5	2	2	1
64	2	4	1	3	1
65	5	5	5	1	1
66	4	5	3	1	4
67	4	6	4	4	4
68	2	2	4	2	4
69	2	5	1	2	4
70	5	4	1	1	5
71	2	5	2	2	5
72	2	4	2	3	4
73	2	5	5	4	4
74	2	4	2	3	4
75	2	4	2	4	4
76	5	5	5	2	4
77	2	5	4	3	4
78	2	5	4	2	4
79	1	5	1	4	4
80	2	4	3	1	4
81	2	5	4	4	4
82	2	5	1	4	4
83	5	5	2	3	1
84	2	4	1	1	4
85	2	5	1	1	4
86	2	5	1	1	4
87	1	4	1	2	3
88	2	4	4	3	3
89	1	2	1	1	4
90	2	3	1	1	6

No.	Practical specialty	Years of Experience	Engineering Level	Qualifications of Education	Work Location
91	2	2	1	1	4
92	5	3	1	5	3
93	5	4	5	1	3
94	4	3	1	1	4
95	4	4	4	4	3
96	3	5	1	5	1
97	5	3	1	4	3
98	3	5	4	3	4
99	5	5	1	1	3
100	3	4	1	1	3
101	4	3	1	1	4
102	2	5	4	5	3

Answers presented by Likert Scale

Evaluation	Very effective	5
	Effective	4
	Medium effect	3
	Low effece	2
	Ineffective	1

No.	Factors that affect the management system for road maintenance																														
	F1	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**	**F11**	**F12**	**F13**	**F14**	**F15**	**F16**	**F17**	**F18**	**F19**	**F20**	**F21**	**F22**	**F23**	**F24**	**F25**	**F26**	**F27**	**F28**	**F29**	**F30**	**F31**
1	4	4	4	4	4	4	4	5	5	4	4	4	5	5	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
2	4	4	4	4	4	4	4	5	5	4	4	4	5	5	3	3	4	4	4	3	4	4	4	4	5	4	4	4	4	4	4
3	2	2	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	4	4	4	4	4	4	4	4	4
4	5	5	4	4	5	5	4	4	4	4	4	5	5	5	5	4	4	5	5	3	4	4	5	5	5	5	5	4	4	5	4
5	4	4	5	5	5	5	5	4	5	5	5	5	5	5	5	5	4	4	4	4	3	3	4	4	4	4	4	3	4	4	3
6	5	5	5	4	5	5	5	4	5	4	5	5	5	5	5	4	4	5	5	4	4	4	4	4	4	4	4	4	4	4	4
7	4	5	4	5	4	4	5	4	4	4	4	3	5	4	3	4	4	5	4	3	4	4	4	4	4	4	5	5	4	5	4
8	4	5	5	4	4	4	5	4	4	3	4	5	3	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4
9	5	3	3	5	5	5	5	5	5	4	4	3	5	5	4	5	4	5	5	5	5	5	5	5	4	5	5	5	4	5	3
10	4	5	5	5	4	4	5	5	4	4	5	4	5	4	4	5	5	4	4	4	5	5	5	4	4	4	4	4	4	4	4
11	3	5	5	4	4	4	4	5	4	3	5	4	3	3	2	4	4	5	5	4	4	4	5	5	5	5	5	5	5	5	4
12	3	4	5	3	4	5	4	4	4	4	5	4	3	5	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4
13	4	4	4	5	4	4	4	3	5	4	4	5	3	4	3	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4
14	4	4	4	5	4	4	4	3	5	4	4	5	3	4	3	5	4	4	4	3	4	4	5	5	3	5	5	4	4	2	2
15	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	4	4	4	5	5	4	4	5	5	4	4	4	5	4
16	3	4	4	4	5	5	5	5	5	5	4	5	3	3	3	3	5	4	5	5	5	5	4	5	5	5	5	4	5	5	4
17	4	5	4	5	4	4	5	3	4	4	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
18	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
19	5	5	4	5	4	4	5	5	5	4	4	2	3	3	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4
20	4	4	4	5	4	4	5	4	4	5	5	5	5	4	3	5	4	3	4	4	5	5	4	4	4	4	4	4	5	4	4
21	4	5	4	5	4	4	4	5	5	5	5	5	4	3	3	5	3	4	4	4	4	4	4	3	4	4	4	4	4	4	4
22	4	4	4	4	4	4	4	4	4	5	5	5	3	3	3	4	3	4	4	4	4	4	4	5	4	4	4	4	4	4	4
23	4	5	5	4	4	4	5	5	3	5	5	4	3	5	4	5	3	4	4	4	4	4	4	4	5	4	4	4	4	4	4
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25	5	3	4	4	3	3	5	4	5	5	4	5	5	5	4	4	4	5	4	5	4	4	4	4	4	4	5	5	5	5	4

No.	Factors that affect the management system for road maintenance																														
	F1	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**	**F11**	**F12**	**F13**	**F14**	**F15**	**F16**	**F17**	**F18**	**F19**	**F20**	**F21**	**F22**	**F23**	**F24**	**F25**	**F26**	**F27**	**F28**	**F29**	**F30**	**F31**
26	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	5	5	3	3	5	4	4	4	4	4	4	4	3
27	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
28	2	4	5	4	3	3	4	3	5	4	4	3	4	3	4	4	4	4	5	4	4	5	4	4	4	4	4	4	4	4	4
29	4	4	5	5	5	5	5	4	5	5	5	5	5	5	5	5	3	4	4	5	4	4	4	4	5	4	4	4	4	4	3
30	5	4	4	5	3	3	3	4	4	3	3	4	3	4	2	2	5	5	5	4	5	5	5	5	5	4	5	4	3	3	4
31	4	5	4	4	4	4	3	4	5	3	4	4	5	4	4	3	5	5	4	4	4	5	5	5	4	4	5	4	5	4	4
32	4	5	2	5	4	4	4	5	4	3	4	5	4	5	4	4	4	5	4	4	4	4	3	4	5	3	4	4	5	4	4
33	5	5	5	5	5	5	4	5	5	5	5	5	4	3	3	5	3	4	4	3	4	4	4	3	3	4	4	4	4	4	4
34	4	5	4	4	5	5	4	4	4	4	5	4	4	4	4	5	3	4	4	3	4	4	4	4	4	4	4	3	4	4	4
35	4	4	5	4	4	4	5	4	5	4	5	4	4	4	4	5	5	5	5	5	5	5	3	3	5	5	5	3	3	3	3
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39	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
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42	5	5	5	5	4	4	5	5	5	4	5	4	5	5	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
43	5	5	4	4	4	4	4	4	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
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45	4	4	3	4	5	5	3	4	4	3	3	4	2	4	3	5	3	4	4	3	4	4	4	4	4	4	4	4	4	4	4
46	4	4	4	4	4	4	5	5	4	4	5	5	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4
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49	4	4	4	4	4	4	4	4	4	5	5	4	4	4	4	3	3	3	3	3	4	4	4	4	4	4	5	4	2	3	3
50	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	5	5	5	4	5	5	4	5	5	5	4	5	5	5

No.	Factors that affect the management system for road maintenance																														
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24	F25	F26	F27	F28	F29	F30	F31
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53	5	4	4	4	3	3	4	4	5	5	5	5	4	5	3	5	5	4	5	5	4	5	4	4	3	5	5	4	3	3	3
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56	2	4	5	5	4	4	5	4	5	3	4	3	5	4	4	5	4	4	5	5	4	5	5	5	5	5	4	4	4	5	5
57	4	4	4	5	4	4	5	5	4	4	4	4	4	4	4	4	4	3	4	4	3	4	4	4	4	5	4	3	4	4	4
58	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	5	4	5	4	4	4	4	5	4	4	5	4
59	4	4	4	4	5	5	3	3	4	4	4	4	4	3	3	4	4	5	4	5	4	4	5	5	5	5	4	4	4	4	3
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61	4	5	5	5	5	5	5	4	4	4	5	5	5	5	4	5	3	4	4	5	5	5	5	4	4	4	4	3	5	4	3
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63	5	4	5	5	4	4	4	3	4	4	3	4	5	5	3	5	4	3	5	4	3	3	4	5	5	5	5	3	5	2	2
64	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	5	5	2	4	4	4	3	4	5	5	5	3
65	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	4	5	5	4	5	5	5	5	5	4	4	4	5	5
66	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	3	3	4	3	3	5	5	4	5	3	5	2	2
67	4	4	3	4	4	4	4	4	3	4	4	4	4	4	4	4	4	5	5	5	5	5	5	4	5	4	4	5	5	3	5
68	4	5	4	5	4	4	5	5	4	5	5	4	4	5	5	5	4	3	4	4	5	4	2	3	3	4	4	3	3	3	3
69	4	5	4	4	4	4	4	4	5	4	4	5	5	4	4	4	5	4	4	4	4	4	5	5	5	4	4	3	4	4	4
70	4	5	4	5	4	4	5	3	4	4	5	5	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
71	5	5	4	4	3	3	4	4	5	3	4	3	5	3	4	4	4	4	4	2	3	4	4	4	4	3	4	4	4	4	3
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73	4	4	4	4	4	4	3	4	4	4	4	3	5	4	5	4	5	5	5	4	4	5	5	5	5	4	4	5	4	3	4
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75	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	5	4	4	4	4	5	5	4	4	5

No.	Factors that affect the management system for road maintenance																														
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24	F25	F26	F27	F28	F29	F30	F31
76	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4	5	5	5	4	5	5	5	5	4	5	5	3
77	4	4	4	4	4	4	4	4	3	5	4	4	5	4	4	3	4	4	5	4	4	5	4	4	5	4	4	4	5	4	4
78	3	4	4	4	4	4	4	5	5	3	4	3	5	4	2	4	2	3	3	3	3	4	4	4	4	4	4	4	4	4	4
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81	4	5	5	5	5	5	5	4	4	4	5	5	5	5	4	5	4	5	5	4	4	4	5	5	5	4	5	5	4	5	4
82	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	4	5	4	3	3	4	4	3	3	4
83	5	5	4	5	4	4	4	5	5	3	4	4	5	4	4	5	4	5	4	5	4	5	5	4	5	4	5	5	4	4	4
84	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	5	5	4	5	5	5	4	3	3	4	5	4	5	3	5	2
85	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	5	5	5	5	5	5	4	4
86	4	4	5	5	5	5	5	5	5	4	4	5	5	5	4	5	4	5	5	4	5	5	4	5	4	4	4	5	5	4	5
87	5	5	5	4	3	3	5	4	4	5	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
88	4	4	4	5	4	4	5	5	5	5	5	5	4	5	4	5	4	4	4	3	4	4	4	4	5	4	4	4	4	4	4
89	3	4	5	2	2	2	4	5	4	5	5	5	5	5	5	5	5	4	4	5	5	5	4	4	4	4	4	4	4	4	4
90	3	5	4	4	5	5	4	4	3	3	3	5	5	5	4	4	4	5	5	3	4	4	5	5	5	5	5	4	4	5	4
91	5	5	5	5	5	5	4	4	5	4	4	4	5	5	4	4	4	4	4	4	3	3	4	4	4	4	4	3	4	4	3
92	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	4	4	4	4	4	4	4	4	4	4	4	4
93	5	5	4	4	4	4	5	5	5	4	4	4	4	4	4	4	4	5	4	3	4	4	4	4	4	4	5	5	4	5	4
94	4	4	4	5	4	4	5	4	5	4	5	4	3	4	4	5	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4
95	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	4	5	5	5	4	5	3
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97	4	5	4	4	5	5	5	5	4	5	4	4	3	4	4	5	4	5	5	4	4	4	5	5	5	5	5	5	5	5	4
98	5	5	5	5	5	5	4	4	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4
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RESUME

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