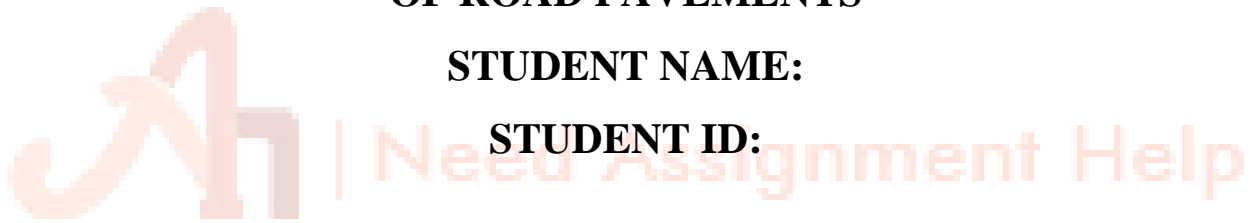


**PRIORITIZING PROJECT FOR PERIODIC MAINTENANCE
OF ROAD PAVEMENTS**

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Abstract

This research study throws light over prioritization project for periodic maintenance of road pavements. The researcher has done the research study based on the Prioritizing project for periodic maintenance of road pavements. Through the help of the research study the readers and researcher along with road development authorities has been able to evaluate and understand the issue that is present in the industry. It also helps them to evaluate the various methods which are present in prioritization through AHP process. It has also helped them to proceed with the recommendation provided to reduce the issue and improve the implementation of prioritization techniques. The study of the research has helped the pavement engineers to utilize the resources in an efficient manner and bring proper maintenance of pavement sections.

As per findings, the rising demand of people and low maintenance facility available made it difficult for road authorities to manage the pavement sections developed for public convenience. Number of vehicles in the roads is increasing day after day; this is putting in excessive stress on carrying capacity of pavements thus resulting in their distress. It is also becoming more difficult for maintenance engineers to identify pavement section which are under distress and requires immediate attention. This lack of proper facility along with low budget are hindering performance of pavement and reducing their longevity. This less allocation of budget makes it necessary for development of a prioritization schedule which is comprehensive, in order to choose areas of higher priority first. Through the AHP process and other techniques fulfillment of needs for pavement networks can be achieved. This thesis provides an overview of prioritization process through AHP or Analytic Hierarchy Process in order to develop a periodic schedule for maintenance of road on the basis of priority.

In this research study review of several literature works have been done in order to get a better understanding of need for prioritizing and timely maintenance of road. Identification of challenges present in the periodic scheduling of pavement maintenance has been done and recommendations are provided based on these challenges. This research study and recommendation is capable of providing help in mitigating the challenges or obstacles faced in order to enhance effective prioritization of road pavement maintenance. Moreover, spreading of awareness associated with benefits of prioritizing pavement helps in increasing pavement management efficiency.

Acknowledgement

For the completion of the research work, I would like to thank the professor of the college Mr. for providing such a knowledgeable research topic. I would also like to thank the professor for the continuous support throughout the research and help in the analysis portion of the various methods through which prioritization of pavement section for effective management can be achieved. I would also like to thank the professor for providing the researcher with the opportunity to work on such a vital topic. I would also like to thank parents and friends that provided support in completion of the research study. It can be said that without his continuous support I would not have been able to complete this research study in an effective manner. This research study has provided me with enough knowledge about prioritization process and techniques that are valuable. I would once again like to thank my professor for allowing me to work on such important topic and help me by guiding throughout the research.



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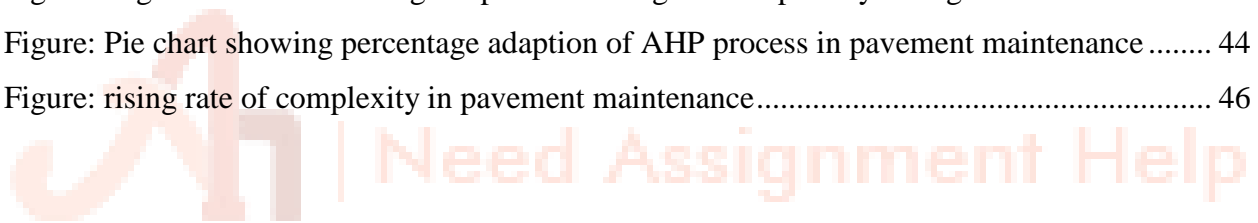
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Chapter- 1: Introduction

1.1 Overview

In today's world where technological advancement and development are going hand in hand, it is necessary to prioritize the maintenance of road pavements. According to the findings, it has been observed that roads are considered to be the most important public assets [1]. This is applicable for various countries. Making improvements in roads are capable of bringing dramatic changes and benefits to users. These benefits accounts for easy access to services like hospitals schools and other places. In order to provide these benefits it is necessary to develop a well planned road maintenance program. Proper and timely maintenance of road pavements prevents occurrence of miss-happenings and also reduces the cost of operation involved in repair. Postponing of pavements maintenance causes involvement of high direct and indirect cost. Proper repair of road keeps the construction cost modest. In case timely repairs are neglected, entire section of road may fail raising requirements for full reconstruction of particular stretch. Moreover, budget allocated for purpose of road maintenance operation is very less [2]. This less allocation of budget makes it necessary for development of a prioritization schedule which is comprehensive, in order to choose areas of higher priority first. Through this fulfillment of needs for pavement networks can be achieved. This thesis provides an overview of prioritization process through AHP or Analytic Hierarchy Process in order to develop a periodic schedule for maintenance of road on the basis of priority. In this research study review of several literature works have been done in order to get a better understanding of need for prioritizing and timely maintenance of road. Identification of challenges present in the periodic scheduling of pavement maintenance has been done and recommendations are provided based on these challenges. This research study and recommendation will help in mitigating the challenges or obstacles faced in order to enhance effective prioritization of road pavement maintenance. Use of AHP rating process has been done in this paper and modeling of prioritization is being done on the basis of pavement condition index (PCI) and traffic volume (TV).

1.2 Background of research

In contrast to treatments like routine maintenance, periodic maintenance treatments are considered to be ideal for application on pavements prior to their damage or distress. Application

of periodic maintenance treatments are done in order to increase the pavement's lifespan by restoring the properties missing or required. As per study this treatment is found to be cost effective and capable of delaying future deteriorations. Furthermore studies have indicated that roads are of considerable importance to public and needs to be maintained timely in order to maintain peace and harmony among public masses [3]. On the basis of findings, periodic maintenance work is divided into two categories or work types. The first type deals with preventive treatment while the second type deals with resurfacing. In this research study focus has been given surface renewable process.

Preventive treatment process- in this process addition of a thin film to the surface is done. This is done in order to improve integrity of surface and for waterproofing it without making any alteration in strength of pavements. Applying preventive maintenance technique is more effective when they are implemented on intact surfaces. In most cases preventive maintenance treatment involves an aggregate of 6.7 mm or no aggregate at all. However, findings have indicated that this kind of treatment is not effective for maintenance of pavements that are having structural deteriorations like rutting and crocodile cracking [6].

Resurfacing - it is considered to be the most effective process towards pavement development and maintenance. This is so because; it helps in improving the integrity of road surface and waterproofing. Along with these it also increases the resistance to skid without making any changes in pavement's strength [4]. This type of treatment is developed to enhance as well as restore the ability of roadways to serve its purpose. Through resurfacing only pavement conditions are improved and its longevity is increased however, no enhancement in load carrying capacity is done.

Bringing improvements in roads are capable of bringing dramatic changes and benefits to users. These benefits accounts for easy access to services like hospitals schools and other places. In order to provide these benefits it is necessary to develop a well planned road maintenance program. Effective and timely maintenance of road pavements prevents occurrence of accidents and also reduces the cost of operation involved in repair. Postponing of pavements maintenance causes involvement of high direct and indirect cost. Proper repair of road keeps the construction cost modest. Cases where timely repairs are neglected, entire section of road may fail raising requirements for full reconstruction of particular stretch. Moreover, budget allocated for purpose of road maintenance operation is very less [5]. This less allocation of budget makes it necessary

for development of a prioritization schedule which is comprehensive, in order to choose areas of higher priority first. Through this fulfillment of needs in pavement networks can be achieved. It is found that efficacy of pavement maintenance increases at a high ratio on proper maintenance with appropriate actions taken in time and in pre planned manner. After analysis of funding levels, locations and conditions of transport agency it has been found that it is management of pavement network is a highly complicated task. Occurrence of such complexity in managing pavement network emerges from the need for reliable prediction models related to pavement performance [5]. Distresses in pavements are found to be occurring since the time they were first introduced. However, since then a lot of cost has been involved in its maintenance. This case is common in various parts of the world. Proper maintenance of pavements has been seen as a tough task. This is so because most of the time adequate budget necessary maintenance of pavements is not provided. Increasing number of vehicles with advancement in time is also adding it to the worst in pavement maintenance [6]. This is so because large number of vehicles fleeing on road is putting more pressure on road thus testing the durability and strength of road surface. This in turn is reducing the lifespan of pavements and the damages caused are more severe, making it difficult for authorities to do timely repair.

1.3 Problem statement

The basic problem that has been identified in periodic maintenance of pavement deals with identification of pavement stretch which needs to be repaired first on the basis of their significance, pavement condition index and traffic volume in that particular stretch. Authorities of road development and safety are often face complexity in deciding over which stretch repair work needs to be started first. Due to this rising complexity they are unable to recognize the priority of maintenance and face huge cost inclusion towards resurfacing of entire road. Moreover, it has been observed that budgets which are allocated for development and maintenance of road are very less in comparison to actual requirement. This makes it crucial for pavement maintenance authorities to look forward towards periodic maintenance of road. Less allocation of budget often causes authorities to use materials which are cheaper and of poor quality for resurfacing. This so because, cost associated with labor is involved in maintenance and treatment of road. Apart from this municipal corporation and other owners of pavement

network face a basic question about how much cost is included in up keeping a road and about the process in which they can ensure that money is invested in repair where it is most needed.

1.4 Research Rationale

What is the issue?

One of the basic issue faced by municipal and other authorities deals with effective maintenance of pavement before they get distressed. As per the findings, it has been found that due to lack of knowledge associated with priority of a stretch that needs to be repaired first, money is invested in wrong place. Many cases have been observed from past studies, where investing money in stretch of pavement that is capable of working and bearing pressure of vehicles have taken place. Delaying of pavements maintenance causes involvement of high direct and indirect cost. Effective repair of road keeps the construction cost modest. If timely repairs are neglected, entire section of road may fail raising requirements for full reconstruction of particular stretch. Moreover, budget allocated for purpose of road maintenance operation is very less. This less allocation of budget makes it necessary for development of a prioritization schedule which is comprehensive, in order to choose areas of higher priority first. This deprives the road in critical condition of the necessary budget allocated for repair and availability of proper materials. This deprivation is causing critical condition of pavements having large traffic volumes. Proper allocation of budget for maintenance of road and a proper availability of a pavement management system for determining the priority of a stretch is major issue identified.

Why is it an issue?

Lack of prioritization in periodic maintenance of pavement is considered to be an issue because, the fund allocated for repairing pavements are very less in comparison to the demand or condition of pavements. Moreover if repairs are not made on time or before pavements get distressed, it may lead to inclusion of additional cost, adequate budget for which is never provided. This happens mainly because authorities while allocating budget are unable to estimate approx requirement of repair. Authorities of road development and safety are often facing complexity in deciding over which stretch repair work needs to be started first. As a reason of this rising complexity authorities are unable to recognize the priority of pavement section which requires maintenance and face huge cost inclusion towards resurfacing of entire road. Apart from this, less availability of budget forces authorities to use materials which are cheaper and of

lowers quality. This causes reduction in strength of road and also causes degradation in longevity of pavements repaired. In many cases it has been observed that pavements are left unrepaired for a longer period of time due to non availability of funds making public life miserable.

Why is it an issue now?

Lack of prioritization in periodic maintenance of road is an issue at present because; with advancement in time and technology pavement networks are also increasing. This increase in pavement networks is putting a lot of pressure on municipal and road development authorities. Thus it is making it more difficult for them to manage periodic maintenance of pavements. It is becoming essential for authorities to think of pavement management system that will help in prioritizing the need of repair as per requirement.

What does the research sheds light on?

The research sheds light on determining various prioritization methods that can be applied in order to prioritize the need for effective maintenance towards pavement. It also focuses on using Analytical Hierarchy Process in order to develop priority model based on pavement condition index and traffic volume.

1.5 Aim of the Research

Aim of this research study deals with determination of various prioritization methods that can be applied in order to prioritize the need for effective maintenance towards pavement. It also focuses on using Analytical Hierarchy Process in order to develop priority model based on pavement condition index and traffic volume. Furthermore, identification of issues and challenges has also been done in order to provide adequate recommendation for mitigating the challenges and improving periodic maintenance of pavements.

1.6 Research objectives

Following objectives have been identified in order to achieve determined research aim.

- Identification of applications based on prioritization and optimization in pavement management
- Identification of prioritization techniques for pavement management
- Identification of methods involved in AHP process

- Determination of effectiveness for Analytical Hierarchy Process in prioritizing periodic maintenance of pavements
- Identification of challenges which are faced in periodic maintenance of pavements at present
- Identification of ways in which prioritization in periodic maintenance of pavements can be improved

1.7 Research Significance

The research topic selected is based on prioritization project for periodic maintenance of pavements. This research topic is of considerable importance because it allows the researcher and readers to gain knowledge in relation to significance of prioritizing pavement maintenance. Moreover from this study knowledge can be gained about the various prioritization models present. Analytical Hierarchy Process has been selected for this research in order to prioritize periodic maintenance of pavement. Furthermore this research study is significant because it will help in development of a pavement management system which will help in maintaining pavements on the basis of their distress level, pavement condition index and traffic volume.

1.8 Proposed structure of thesis

As per the proposed structure of thesis, chapter one will involve the discussion related to background of research study and research rationale highlighting major problems which led to selection of such an interesting topic. On the basis of issues and requirement, aim and objectives are formulated by researcher which helps in achieving the desired goal of project. In chapter two dealing with literature review, information are gathered from findings of various literary articles which helps researcher in conducting research in a proper manner. It also helps researcher in getting information which are valid and taken from authentic sources. The third chapter deals with research methodology which provides a framework for the researcher and provides details about the process in which research work will be carried out. It also helps the readers to understand the ways in which entire research study has been carried out. Furthermore chapter four deals with findings and analysis which provides information collected from the primary qualitative process and secondary quantitative process. On the basis of analysis done over findings, framing of conclusion is done in the final chapter and recommendations are also

provided which will help in mitigating challenges present in periodic maintenance of pavement. It will also help in increasing easy maintenance of pavements through priority project.

1.9 Summary

This chapter provides an overview about the background of research study dealing with development of a prioritization project for periodic maintenance of pavements so that repair cost can be mitigated and longevity of pavements can be increased before it gets distressed. Utilization of AHP process is done for development of priority project. In this chapter aim and objectives of research has been framed which will help researcher in carrying out the research work in an efficient manner. Findings based on objectives determined by researcher will help in proper analysis and framing of recommendation which will be helpful in mitigating the obstacles present in pavement maintenance. Detailed discussion of findings from literature works of various articles are carried out in the next chapter.



Chapter -2: Literature review

2.1 Introduction

In this chapter of research, the researcher has reviewed the existing literature works in terms of concepts, theories and models. In order to help the readers to understand the topic the researcher has provided a brief description of the Analytical Hierarchy Process which will be utilized in project development. The needs of prioritization project for periodic maintenance of pavements are discussed in this chapter by the researcher. Moreover, discussion of various prioritization techniques for pavement management is done in this study. Through this literature review, effectiveness of Analytical Hierarchy Process is also determined. The researcher also discusses issues which are faced by municipal and road development authorities towards maintenance of pavements. Existing literature works and the gaps in it has also been analyzed to proceed with the research study.

2.2 Need of prioritization project for periodic maintenance of pavements

As per the findings prioritization of resource allocation is found to be significantly vital because there is hardly enough fund available with road development authorities and municipal for addressing of entire pavement section [7]. As per the tradition followed, two most identifiable techniques in terms of network level decisions are optimization approach and prioritization approach. Prioritization approach involves the provision of rankings to competing sections of pavement which requires maintenance. The rankings to pavement sections are provided on the basis of pavement condition index. As per study, this index helps in determination of the pavement condition; if condition of a particular section of pavement is critical and needs immediate repair it is placed on top of priority list [8]. Henceforth, the rankings are provided on points represented in the index. Higher points in index represents more critical nature while lower points indicates that roads are below critical mark and time for repair can be postponed until necessary. As per findings, prioritization process generally begins with enlisting the pavement maintenance works or projects which are to be executed. After enlisting of maintenance project is done, the next step involves prioritizing the project depending on their need and urgency for renovation. Keeping the fund availability in mind project with high priority

is executed first until the entire fund gets exhausted and repair is complete [9]. Along with failure of timely maintenance, entire section of road may fail raising requirements for full reconstruction of particular stretch. Moreover, budget allocated for purpose of road maintenance operation is very less. This less allocation of budget makes it necessary for development of a prioritization schedule which is comprehensive, in order to choose areas of higher priority first. As per findings, monitoring of periodic pavement performance is essential for both, pavement network and project. This is so because it will help in keeping track of pavement condition. Moreover, according to literature works it has been observed that there exists a common practice which is known as worst first approach [10]. In reference to this approach, pavements with critical condition are repaired first regardless of the effect on entire pavement section. However it has been observed from findings that this approach is not beneficial as it does not consider the rate of deterioration which occurs in pavement section [11]. Moreover, this approach is not cost effective since placing focus on one pavement section may result in deterioration of other pavement section which will be difficult to manage.

2.3 Prioritization techniques for pavement management

Availability of accurate funds has always been a problem towards management of pavements. As per study introduction of prioritization techniques has enabled managers and engineers to identify critical condition of pavements which require immediate attention. According to literary findings, prioritization of current needs plays an important role in pavement management system [19]. Through this, it can be said that prioritization has become an effective tool for taking of decision related to maintenance of pavement. The management involved in pavement maintenance is trying their level best to derive benefits which are associated with prioritization technique. Based on the fund available, location, level and condition of transportation agency, different methods are used for determining priority [18]. The prioritization method may range from provision of subjective rankings to pavements based on their critical conditions and pavement condition index to a comprehensive technique of optimization [20]. The optimization technique involves use of mathematical programming models will help in determining the priority of a pavement section which needs immediate repair.

As per study, pavement management is considered to be a process which involves preserving and maintaining pavement assets over a certain level of performance in a manner which is cost

effective [12]. This pavement management provides road maintenance organizations and agencies with a tool that is effective in predicting future performance associated with pavement. This information gained from pavement management system can be utilized by municipal and road maintenance authorities for setting of budgets and for planning capital programs to be used in future. PMS is considered to be a working system that helps in designing, coordinating plans and programming's, construction and continuous monitoring of pavement performance. As per study of various literary articles, it has been observed that there two different level in which pavement management system operates [21]. Among the two level of pavement management project, one deals with network level while the other deals with project level. Through this pavement management system detailed information about pavement condition as well as performance is obtained [14]. The gathered information helps road authorities to develop a strategy which will be utilized for proper maintenance of pavement. As per findings 70% of complexity has been solved by implementation of Pavement Management System [17]. The availability of accurate data enables them to estimate critical nature of pavements and create framework through which pavements can be repaired in cost effective manner. This information also enables them to gain knowledge about the resources which will be required in repair and technologies that will be involved in it. Depending on the level, network level involves the development of a prioritization program along with asset group. Instance can be taken to have better understanding, where at network level decisions regarding preparation of maintenance and rehabilitation schedule takes place [22]. Rankings are also provided in this level to the pavements depending on the priority. Findings from several literature works have also indicated that each of the two levels in pavement management are equally important towards management of pavement assets [15]. It is also important to note that different kind of information are required by different people in organization and effectiveness of pavement management system depends on the extraction of all necessary information various users [16]. The main objective of pavement management system depends on provision of a process which involves preserving and maintaining pavement assets over a certain level of performance in a manner which is cost effective. This pavement management provides road maintenance organizations and agencies with a tool that is effective in predicting future performance associated with pavement. This information gained from pavement management system can be utilized by municipal and road maintenance authorities for setting of budgets and for planning capital programs to use in future.

2.4 Features of pavement management system

Pavement management system was designed to help pavement engineers and road construction authorities with a tool that is capable of analyzing the entire pavement network and provide recommendation for prioritized rehabilitation and maintenance alternatives to pavement sections that are in critical condition and needs repair. As per findings inventory also depends on the consistency and frequency associated with data collection [23]. In case the program is to be used only at network level then information related to type of material required and other details could not be obtained as they are not considered to be vital [24]. Application of network level technique is important as it helps in determination of cost which will be involved in maintenance of pavement based on their condition and priority. As per findings pavement management system has been divided into various levels [15]. Discussions related to various levels in different literary articles are as focused and provides valuable information. Some of them are to be discussed in this section.

Network identification - this level helps in identification of the network over which work is to be done. Further subdivision is there which are referred in order to reach out main target or section of pavement that requires maintenance and repair. Total area is divided into several networks or clusters [44]. This is so because it is not possible for authorities to maintain a single network for entire pavement section as it makes work more complicated [25]. It also makes it difficult for authorities to identify which section of pavement is under critical condition. Furthermore, if the pavements are divided into different branches and networks it becomes easier for location the section of pavement which requires attention.

Branch identification - after identification of network is complete, it is necessary for road authorities and pavement engineers to identify the branch which has been prioritized. Sub network allocation is provided to pavements in order to further simplify the work [14]. Example of an airside runway can be taken which has 31 branches which include runways, taxiways, aprons and runway shoulders. Usually as per findings, runways are identified by suffix RW which is followed by number. Like, RW 16L-32R this indicates that orientation of runway is 1500 to the North and 3200 to the other end. Similarly all pavements in streets are named accordingly followed by numbers to describe their exact location. In many cases names of streets are also used to locate a particular section of pavement. This level of pavement management

system has further reduced the complexity in periodic maintenance of pavement to a considerable extent.

Section identification - even after subdividing network into branches for easier identification and management of stretch it was found that branches are still too large and difficult to manage. This complexity made introduction of a new level termed as section which is considered to be the last sub division in pavement network. This concept of section almost solved the problem related to complexity and made it easier for identification of pavement section. It is very vital to consider the fact that consistency in branches is not present all throughout the entire area. Moreover, it is not possible for authorities to carry out survey over entire area to find possible need for pavement repair [13]. According to findings there are several factors that need to be monitored in order to divide branches into sections. Some of the most prominent factors which are considered while dividing branches into sections and deciding its priority are:

Structure of pavement - as per findings structure of pavement is considered to be one of the most important factors towards determination of criteria for providing priority and dividing branches into sections. A section generally consists of uniform thickness in layers. It also found to be constructed of same material [45]. At time when analysis of pavement structure is done it is checked that the roads are made using same construction method. Uniformity in the materials used, thickness of pavement and sub grade strengths provides basis for measurement of pavement behavior. On finding any change in thickness layer, strength and material used it is necessary for authorities to change the section.

Traffic volume - traffic is considered to be one of the most vital factors which are responsible for deterioration of road pavements. Increasing number of vehicles with advancement in time is also adding it to the worst in pavement maintenance [25]. This is so because large number of vehicles fleeing on road is putting more pressure on road thus testing the durability and strength of road surface. This in turn is reducing the lifespan of pavements and the damages caused are more severe, making it difficult for authorities to do timely repair [12]. Moreover it is necessary for authorities to maintain a consistency in traffic volume and load intensity of vehicles so that they do not cause damage to pavement [46]. The damage is mainly caused when heavily loaded vehicles enter into pavement section where its carrying capacity is much greater than its strength.

Construction history - As per findings, it has also been observed that history of construction plays an important role in dividing branches of pavements into sections. Pavements which are

divided into section need to have a consistent history of construction [26]. This consistent history will help the road authorities to keep proper information regarding each pavement section. As per findings, pavements which are constructed during different time period under different contractors are made from different construction materials. Therefore, it is necessary to consider pavements with different construction history under separate sections [27]. Major advanced strategies are also utilized in which areas which have received maximum repair are divided into different sections.

Pavement rank as per importance – After division of pavements into different sections, it is necessary for road authorities to divide each section into priority zones. This is done on the basis of their importance and traffic volume it contains on an average. According to findings, each pavement is ranked as primary, secondary or tertiary on the basis of their functionality. Prioritization of pavement maintenance is done depending on the ranking provided. Pavements falling under primary ranking category are provided with more maintenance priority than any other ranking [28]. The reason behind this lies in their significance and top of that less maintained pavements in high priority zones are capable of causing deep impact on normal life of public. It also bears an impact on budget of pavement construction and maintenance authorities. As per literary findings, time to time consideration of pavement maintenance can be taken as an effective measure for elimination of additional costs that associated with late maintenance or repair [41].

Shoulders and drainage facilities – according to findings from literature works, provision of shoulders and drainage facilities also affect the performance of pavements. It has been observed from past studies that poor drainage facilities causes rapid deterioration of pavements and reduces their lifespan. Many countries around the world, because of this fact have started giving more importance to proper construction of drainage system [49]. This helps them in increasing the longevity of pavement surface and also reduces frequency of resurfacing to a considerable extent. Similar fact goes for shoulder performance. In case proper shoulder facilities are not provided, pavements will require to be resurfaced more often.

Surface condition- Existing literature works suggest that, surface condition is one of the prime variables that considers several factors discussed above towards prioritization of pavement maintenance. It is only through this surface condition that performance of pavement can be measured. This is so because it indicates the level of distress over a particular section of

pavement [26]. Depending on the distress level and surface condition, priority ranking is given to each pavement section. As per findings, it is this surface condition on the basis of which repair works and pavement maintenance are carried out.

2.5 Pavement condition index

As per findings, in order to measure performance of pavements it is necessary to have a performance measurement tool. Pavement condition Index is considered as one such performance measurement tool used for determination of pavement condition. Pavement condition index in this research works on the principle of RSTM or Road Standard Test method [48]. This means that it utilizes the standard test method which has been recognized for effective measurement of pavement performance and its condition. This measurement tool, according to findings, consists of a numerical index ranging from 0 to 100 which helps in determining the pavement's condition. Pavements represented with PCI index as 0 are in critical condition and requires immediate resurfacing or repair [30]. On the other hand, pavements with PCI index being represented at 100, their condition are considerably good and do not require maintenance for the time being. As per findings, it has been observed that calculation of pavement condition index done by analyzing the results based on visual condition of pavement section. In this distress severity, type and density are taken in account. The (0-100) index of PCI represents structural integrity and pavement's surface condition [47]. Moreover, surface distress ratings are provided depending on the severity, density and type of pavement distress [40]. This rating helps the road authorities in determining the involved that will be involved in maintenance and repair of a particular pavement section. According to literary findings, this tool is one of the most commonly used tools by road authorities in modern generation in order to leverage the cost associated with pavement maintenance [31]. By focusing on deterioration rate and pavement history cost analysis for various maintenance and repair alternatives are performed. Depending on this analysis, best alternative method applicable as well as the optimal time required for implementation of this method is determined.

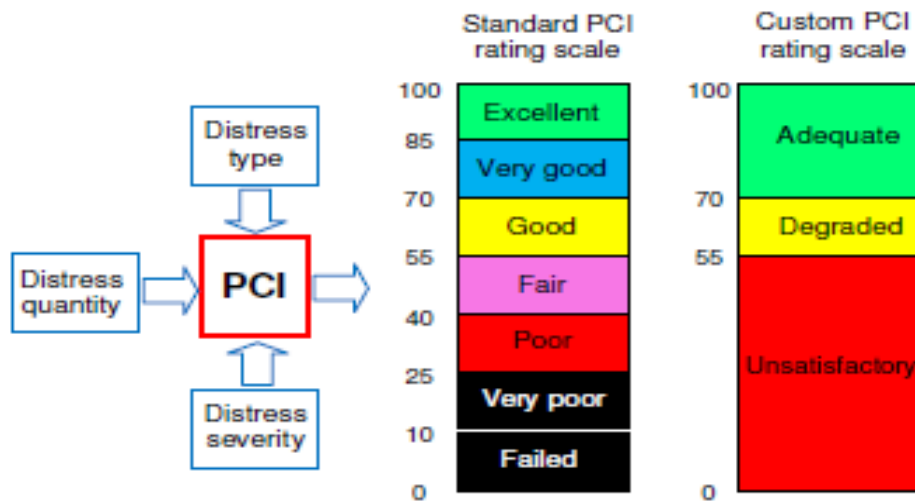


Figure: Numerical representation of PCI showing pavement quality

(Source: Pinto and Tighe, 2015)

As per findings priority programming process and pavement management system follow a particular procedure towards prioritization and maintenance of pavement [50]. Some of the prominent steps involved in maintaining pavement section on the basis of priority are as follows:

- Identifying the pavement section that requires maintenance or rehabilitated.
- Identification of the treatment type that needs to be applied in order to maintain and repair pavement section which is in critical condition.
- Determining time related to starting repair and maintenance work for pavement
- Determination of cost that will be involved in particular treatment identified for a pavement section.

2.6 Analytical Hierarchy Process and its effectiveness

As per study, analytical Hierarchy process has been identified as one of the most effective process involved in decision making towards prioritization of a particular section. In this technique pair wise comparison is done which enables the managers and other road construction authority in investigating various different criteria which are applicable [32]. It also allows in implementation of best alternative which are capable of causing cost reduction in maintenance and repair works [26]. It can be said that AHP process involves comparison of various criteria on ratio scale and also considers criteria that are qualitative and quantitative in order to facilitate

selection of most suitable alternative. As per findings, AHP process because of its simple and comprehensive characteristics is witnessed to be exploited in various fields by many experts. In many literature works reviewed for this research study, it has been observed that analytical hierarchy process is considered to be absolutely suitable and this method can be successfully applied in prioritization project [33]. AHP is known to be a multi-criteria decision making technique which helps in effective pavement management. According to literary findings, Analytical Hierarchy Process consists of several phases which are discussed in this section. The phases are as follows:

1. Phase dealing with structuring of hierarchy
2. Pair comparison phase on the basis of which prioritization of pavement is to be provided
3. Development of priority vector on the synthesis of pair wise priorities

As per findings, in structural hierarchy phase decomposition of problems into elements takes place which are independent and individual. This process is also considered as an abstraction of entire system which simplifies the relationship and working of each component. It also allows road construction authority to determine the impact of alternative chosen over the entire system. Through this effectiveness of method is determined which helps in leveraging cost to a considerable extent [34]. This process involves setting of goals in the beginning process of maintenance and repair which helps authorities to reach their desired goal in the last level. Setting of goals in first level helps authorities to set process in which the up taken project dealing with prioritizing of road maintenance can be identified. In this phase criteria are set accordingly in order to relate goal of AHP process with alternatives in mid level of execution. As per findings, in normal case criteria are broken down into sub criteria and sub-sub criteria depending on the complexity of pavement maintenance.

The Fundamental Scale for Pairwise Comparisons		
Intensity of Importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one element over another
5	Strong importance	Experience and judgment strongly favor one element over another
7	Very strong importance	One element is favored very strongly over another; its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation
Intensities of 2, 4, 6, and 8 can be used to express intermediate values. Intensities 1.1, 1.2, 1.3, etc. can be used for elements that are very close in importance.		

Figure: table showing pair wise comparison scale for AHP

(Source: Pinto and Tighe, 2015)

The next phase deals with comparison of pair wise criteria, as per study it has been observed that in most cases it is not possible for individuals to use seven point rating scale for effective comparison [35]. This AHP process provides nine point rating scale for effective comparison of individual elements. There are several relations which have been observed to be present in AHP process. However, at present only three of most common methods have been taken into consideration for this research study. They are:

- **Distributive mode relative AHP-** As per finding this is considered to be original AHP process developed and it involves relative comparison by application of distributive mode. According to this method, equation obtained from priority vector criteria are used to arrive at overall priorities over pavement section selected for maintenance and repair. This method is not often used or suggested by experts for use because it has some drawbacks. As per findings number of comparison increases at a faster rate with increase in size of problem [36]. Moreover in this method reversal of rank related to prioritization may take place which affects the entire system and makes the assessment illogical.

- Ideal mode relative AHP - As per study, it has been observed that development of this method was done to deal with drawback associated to distributive mode AHP. Major form of modifications were made in priority vector derivation
- Absolute AHP - this is the most feasible and widely used method in analytical hierarchy process. This is so because designing of this method was done to overcome problem related to large number of comparison in AHP process. The difference is observed at last level, where alternatives are analyzed on the basis of priority for evaluation. Alternatives are provided with degree of intensity on the basis of criteria.

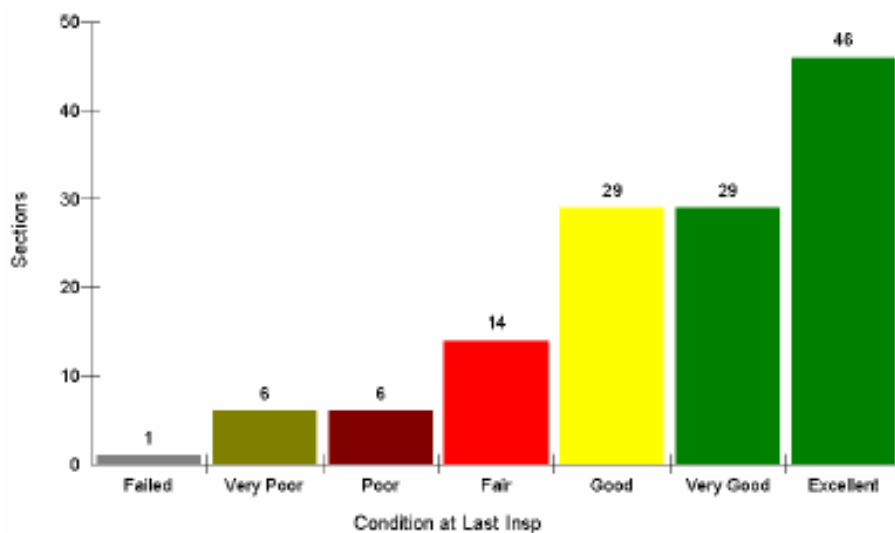


Figure: increase in pavement maintenance efficiency through AHP process

(Source: Shah *et al.* 2014)

As per findings of literature works, it has been observed that Analytical Hierarchy Process is quite effective in prioritizing pavement maintenance work [34]. This is so because it helps to address problems associated with periodic maintenance of pavement. Some of the prominently identified problems deals with identification of pavement stretch which needs to be repaired first on the basis of their significance, pavement condition index and traffic volume in that particular stretch. Authorities of road development and safety are often face complexity in deciding over which stretch repair work needs to be started first. Due to this rising complexity they are unable to recognize the priority of maintenance and face huge cost inclusion towards resurfacing of entire road. Moreover, it has been observed that budgets which are allocated for development and maintenance of road are very less in comparison to actual requirement. This makes it crucial

for pavement maintenance authorities to look forward towards periodic maintenance of road. Less allocation of budget often causes authorities to use materials which are cheaper and of poor quality for resurfacing. This is so because, cost associated with workforce is also involved in maintenance and repair of pavement sections. As per findings, occurrence of such complexity in managing pavement network emerges from the need for reliable prediction models related to pavement performance [39]. Distresses in pavements are found to be occurring since the time they were first introduced. However, since then a lot of cost has been involved in its maintenance. This case is common in various parts of the world. Proper maintenance of pavements has been seen as a tough task. This is so because most of the time adequate budget necessary maintenance of pavements is not provided. Increasing number of vehicles with advancement in time is also adding it to the worst in pavement maintenance.

2.7 Gap Analysis

Out of the several literature works available, the researcher has come across few of the research works that share information related to prioritization project for periodic maintenance of pavements. As per analysis, the literature work covers several issues which are faced by pavement engineers and road maintenance authorities. Moreover, information related to importance and need for periodic maintenance of pavements have also been discussed. After studying the existing researches, the researcher observed that in most of the cases the research works lack the complete or detailed information. The lack of detailed information does not leave any future scope for other researchers to take the research forward and provides inappropriate knowledge to the readers. Furthermore, some of the prominent gaps obtained from literature review of articles include lack of information related to ways through which periodic maintenance of pavements can be improved. Very less literature work discusses about prioritization of pavement maintenance system and the methods that can be used for the prioritization process. All these existing gaps in the research works have influenced the researcher to select prioritization project for periodic maintenance of pavements as research topic.

2.8 Summary

From this entire chapter it can be summarized that prioritization project for periodic maintenance of pavements. This will help the readers to gain knowledge about the importance of prioritization

process in pavement maintenance. Furthermore, knowledge will also be gained by readers over the application of Analytical Hierarchy process. Since as per findings, this process is identified to be one of the most effective processes in prioritizing of pavement maintenance. Knowledge gained and information obtained from this chapter will help the researcher in carrying out the research study effectively as it helps with adequate information required for meeting objectives of research.

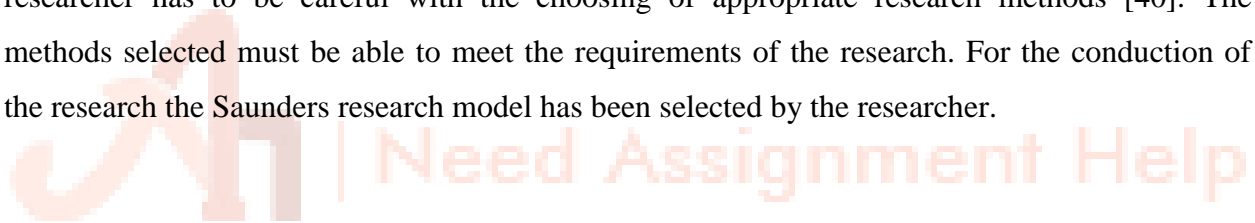


Chapter-3 Methodology

3.1 Introduction

The main objective of this research study deals with identification of methods for prioritization project in periodic maintenance of pavement sections through Analytical Hierarchy Process. It also focuses on issues that are faced by pavement engineers and road construction authorities. In order to meet the objectives set for achievement of research it is necessary for formulation research methodology [39]. This chapter enables the readers to get an overview of the process in which research study has been carried out.

In this chapter, the clarification and the justification for the selection of the research methods, techniques and tools are provided by the researcher. All the research methods and tools selected will be helpful for the researcher in meeting the objectives of the research. The researcher has made the use of Saunders model for the research methodology. According to the findings, the researcher has to be careful with the choosing of appropriate research methods [40]. The methods selected must be able to meet the requirements of the research. For the conduction of the research the Saunders research model has been selected by the researcher.



3.2 research onion

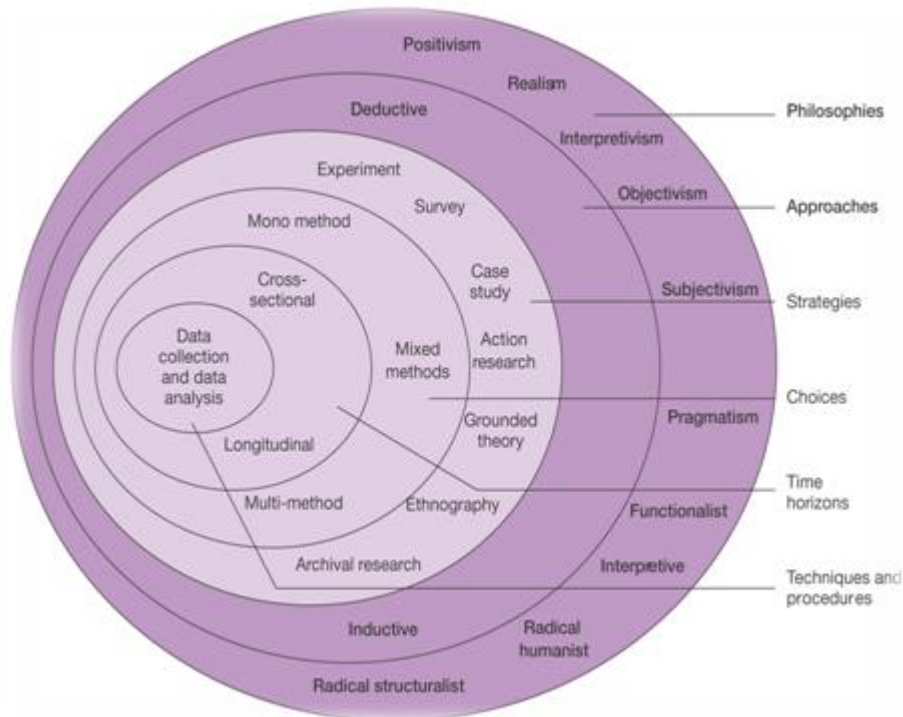


Figure: Research Onion

(Source: Saunders *et al.* 2009)

As per the findings research methodology is considered to be an effective tool in research study which helps in development of research strategy necessary for conduction of research work [40]. This methodology consists of several stages and each step helps the researcher in carrying out the study in a more effective manner. Through this methodology detailed stages related to research process are obtained. As per findings, a continuous and effective process related to research is being modeled [39]. The basic importance of research onion lies in the fact that only one type of research method is used in this process.

3.3 Research Approach

The research approach selected by the researcher for the conduction of research study deals with the deductive approach. These are the ways in which the research develops as the researcher progresses towards the completion of the thesis. As per study, there is only two type of research approach which is applied for proper analysis of research study. One type deals with inductive

approach. It is this approach which helps the researcher by enabling proper conduction of research study [39]. On the other deductive approach is one which allows researcher to carry forward the research with proper analysis of data which has been gathered for research study. In deductive approach the researcher starts with a general theoretical position that is tested by the researcher through the research. The deductive approach will help the researcher to gather the specific data needed for the research out of the general information available.

3.3.1 Justification for selection of Deductive approach

In this research, deductive approach has been selected by the researcher since it is based on the development of knowledge depending on several various models by which pavement maintenance project can be prioritized. The selection of such approach is preferred by researcher, because it examines the observations made by researcher in a particular pattern. One of the major reasons for selection of this approach lays in the fact that profound conclusion related to research study is obtainable from it. On the other hand use of inductive resource has not been done by the researcher because this approach consume a lot of time. Moreover, abundant resources are not available with this approach as provided in inductive approach. Some of the prominent reasons for not using inductive approach are as follows:

- The method or approach is very time consuming
- If the observation is incomplete the data collected may be compromised
- Several different causes can be obtained from the outcome
- The inductive research approach involves the presence of subjective research outcomes.

Proper analysis of information available over primary and secondary sources will enable the researcher to gain appropriate knowledge and understand the method in Analytical Hierarchy process works towards development of prioritization project for periodic maintenance of pavement.

3.4 Research Philosophy

As per study, research philosophy deals with the effective process of collecting, evaluating and using data in a proper manner. Research philosophy also deals with effective development of ideas and knowledge from authentic sources obtained during completion of study based on research topic. Research philosophy helps in framing of assumptions and beliefs for the purpose

of analyzing essential elements associated with research topic. It also helps in identification of core process for research strategy [39]. Through research philosophy it is possible to analyze the facts related to current findings and provide strong basis for formulating conclusion.

The researcher for the conduction of the research study has selected the use of post positivism philosophy. The post positivism philosophy is most commonly used by the scientists for observing the social reality as well as the end product of the results. The methods like survey and interviews are the norms of the post positivism philosophy. The researcher adopting this type of research philosophy believes in the factual data and gets an in depth knowledge of issues present in proper periodic maintenance of pavements. It also provides idea about the way in which Analytical Hierarchy Process works towards prioritization of pavement sections for periodic maintenance on the basis of their severity.

3.4.1 Justification for selection of research philosophy

Post positivism philosophy has been selected by researcher for this study because through this philosophy analysis of real life facts based on research topic. Proper analysis of pavement maintenance work will enable researcher to identify the issue which are hindering effective pavement management. It will also help in analyzing logical method in the form of AHP for prioritization of pavement sections.

3.5 Research Design

According to findings, research design refers to overall strategy which can be utilized by the researcher based on current study for the purpose of synchronizing various elements of research study in a logical manner [40]. Study indicates that there are three kind of research design which can be followed for research study as per requirement. Different kinds of research design are as follows:

Explanatory Design: this kind of design ensures proper identification of research requirements and solution that help in drawing out of proper and effective conclusion.

Exploratory design - Through this research design impediments associated with research study are identified based on current findings.

Descriptive design: this research design enables researcher to determine the data and participants of research study effectively. This research design is found to be used most often in research study, since it helps in drawing of proper conclusion.

The research design chosen by the researcher involves the use of descriptive design for the conduction of research work. The descriptive research is a design formulated for the depicting of the participants of the research in an accurate manner. In simpler words the descriptive design of the research helps in describing the number of people that are going to participate in research study.

3.5.1 Justification for selection of research design

By the use of the descriptive design in research methodology, the researcher will be able to describe the number of people or the size of the population that is involved in the research study.

The researcher can use the descriptive design in three ways:

- Through observation - which involves the method of viewing as well as recording of the participants
- Case study - this method involves the in depth study of the individual or a group of individuals selected as sample population of the research.
- Survey - this process involves the brief interview sessions with the individuals or group of individuals over the issue related to the topic of the research.

The descriptive design will help the researcher to select the specific population for the conduction of the research in prioritization project for periodic maintenance of pavement.

3.6 Data Sources

As per research study selection of both secondary and primary data collection method has been done by the researcher. Selection of primary and secondary data is being done by the researcher in order to extract all the necessary information from pavement maintenance employees and from secondary sources [39]. The collection of primary data is basically done by conduction of interview with the employees of municipal and road development associated with maintenance of pavement section. The interview process conducted is helping in analyzing the various methods through which prioritization project for periodic maintenance of pavement sections can be managed [40]. Furthermore it will also reflect the effectiveness of Analytical Hierarchy

Process. Through this interview process information related to working and recommendations based on which prioritization project for pavement maintenance can be improved are also provided by employees. On the other hand, collection of secondary data are done by referring to various journals, online articles, books and magazines related to prioritization method and AHP process.

3.7 Sampling technique

The sampling technique selected for the research study involves the use of probability sampling technique. The probability sampling refers to the sampling technique or method in which the respondents get equal chance of selection as sample out of the entire population. The purposive sampling has been selected by the researcher, this so because the research topic is based on the prioritization project for periodic maintenance of pavement sections. The use of purposive sampling technique allows the researcher to select sample for information rich cases [40]. This sampling process generally involves selection of sample or individual that having knowledge about the various prioritization method effectiveness of Analytical Hierarchy Process. Along with the help of this sampling technique the researcher has selected employees that are in municipal and Road Development Corporation and is associated with repair and maintenance of pavement section.

The sample size chosen for conduction of interview and gathering of related information involves five employees that are working under municipal and road development corporation. They are involved in projects related to prioritization of pavement section for effective maintenance.

3.8 Data analysis technique

The primary data, as well as the secondary data collected from the various data sources, have been processed and analyzed by the researcher from several viewpoints [40]. The interview data has been represented in the form of charts and the secondary data collected for analysis has been represented in the form of graphs or statistical data. This collected data is vital and requires proper analysis in order to process out the necessary information that will help in effective conduction of research study and also help in drawing appropriate conclusion.

3.9 Ethical issue

The research ethics or the ethical considerations that need to be kept in mind by the researcher during the conduction of the research work and the process of the interview are:

- The researcher has not manipulated the data collected from the various sources for the research work.
- Respondents are to be used solely for the purpose of research. The usage of the findings from the data collected is restricted to the application in research work only.
- The respondents of the interview are not disclosed in any circumstances
- The data and information given are not provided to others
- The researcher guarantees the safety and security of the data of respondents.

3.10 Time table chart

Key Actions of Research	1 st week	2 nd week	3 rd week	4 th week	5 th week	6 th week	7 th week	8 th week	9 th week	10 th week
Selection of the topic of the research	✓									
Collection of data through Interview	✓	✓	✓							
Collection of the secondary data	✓	✓	✓							
Writing the literature review			✓	✓						
Selection of appropriate research tools				✓						
Data analysis					✓					
Writing of Conclusion and Recommendations						✓				

Editing the reference list							✓		
Draft creation								✓	
Final thesis									✓
Cross checking and the submission of the final work									✓

Table 1: Thesis time chart

3.11 Research limitation

The research study involves several limitations that prevent the researcher from conducting the research study more effectively. According to the researcher various challenges have been faced during the conduction of the research. The limitations involve the time constraints for the completion of the research and the gathering of more information. Since the research is based on the prioritization project for maintenance of pavement section on the basis of pavement condition it is very difficult for the researcher to gather all the information in such a short period of time. Another limitation deals with the budget that has been estimated for the research. The real cost involved is more than the estimated value which prevents the researcher from proper collection of information.

Chapter- 4 Findings and analysis

4.1 Introduction

This chapter involves the proper analysis of data which has been gathered from primary and secondary sources. Data collection involves use of qualitative and quantitative method respectively for proper analysis and processing of vital information. Both qualitative and quantitative method has been selected for this research. This is so because it will help in getting information which is relevant to prioritization process [43]. It will also provide relevant information related to effectiveness of Analytical Hierarchy Process. Use of quantitative data collection method is also done in this study, application of this data collection method helps in gathering as well as processing of data that are more significant in meeting aim of research. In this section it will be required to analyze the information processed and discuss the outcomes. The quantitative process of the secondary data collection method will involve the analysis of the information available for achieving the objectives of the research. This will help the readers to better understand the vitality of this research topic and to understand and evaluate the ways in which analytical hierarchy process works towards prioritization of pavements.

4.2 Qualitative Analysis of data

In order to conduct the research study, the researcher in this part will analyze the primary as well as the secondary data collected. The qualitative research method will help the researcher to get the authentic data and real issues of present pavement management system through the interview process. Interview process will involve employees working under municipal and road development corporation for pavement maintenance as respondents [44]. In qualitative analysis process, focus has been given over interview process of sample selected for research that will help in gathering of information which is not available in journals and online articles. Moreover, information gathered through qualitative data collection method is authentic and provides more in depth knowledge than any other sources. Findings from qualitative data collection method are discussed in this chapter that helps in meeting the objectives determined for this research study. Meeting of these objectives determined in earlier section of research study will help researcher in achieving goal of this research work.

Findings from Qualitative method or Interview process:

This section of data analysis involves findings which have been obtained from point of view of various employees. These employees are the ones who are working in pavement repair and maintenance section under municipal and road development corporation. They are working in prioritization project and are having knowledge about various methods and tools through which prioritization of pavement sections can be brought into effect [42]. Five interview questionnaires have been prepared that covers various section in order to gather vital information from employees. A face to face interview session was arranged by taking appointment over email for a particular date so that all employees can be assessed in a single approach.

Q1. How prioritization techniques are applied for pavement management?

As per the comment of 1st interviewee it was observed that *“the prioritization method may range from provision of subjective rankings to pavements based on their critical conditions and pavement condition index to a comprehensive technique of optimization.”* he also said that *“introduction of prioritization techniques has enabled managers and engineers to identify critical condition of pavements which require immediate attention.”* Over this 2nd interviewee added that *“prioritization techniques have enabled managers and engineers to identify critical condition of pavements which require immediate attention.”* 3rd interviewee commented that *“there are various ways through which prioritization techniques can be applied to pavement sections. However, most common way identified for priority listing of pavement deals with analysis of level of distress over a particular pavement section.”* On this 4th interviewee added that *“if more severity of distress is more for a particular pavement section in comparison to others then it necessary to list pavement with high distress level in top of priority list”*. The 5th interviewee commented that *“development of pavement management system can also be seen as an effective method for maintenance of pavement section. This pavement management provides road maintenance organizations and agencies with a tool that is effective in predicting future performance associated with pavement. This information gained from pavement management system can be utilized by municipal and road maintenance authorities for setting of budgets and for planning capital programs to be used in future. PMS is considered to be a working system that helps in designing, coordinating plans and programming, construction and continuous monitoring of pavement performance. The gathered information helps road authorities to develop a strategy which will be utilized for proper maintenance of pavement. As per recent data 70% of complexity has been solved by implementation of Pavement Management System”*.

Moreover, Analytical hierarchy process and pavement condition index are mostly used to development of priority list for pavement maintenance.

Q2. What steps are involved in prioritizing pavement section through Pavement Management System?

On basis of this question, the 1st interviewee commented that *“there are various step involved in management of pavement system. Some of the prominent steps which are involved in priority listing of pavement include network identification, branch identification and section identification.”* 2nd interviewee commented that *“these step of pavement management system are highly beneficial as they sub divide each pavement network into small branches and sections which allows road development authorities to get proper access to pavement section which are in critical condition and requires immediate maintenance. Failure to which may result in involvement of additional costs.”* the 3rd interviewee commented that *“network identification helps in analyzing the area which requires maintenance and repair attention. Division of entire pavement area into various networks is necessary because it is not possible for workers of maintenance and repair to identify the areas where pavements require repair from such a wide range of options. Subdividing the network into branches simplifies the work to a considerable extent.”* In context to this 4th interviewee commented that sub division till branches is not the end, pavements are further subdivided into sections which will allow them to reach exact area or pavement section which is under distress. As per comment of 5th employee *“section involves various factors which are vital in prioritizing work. The factors included in sections are structure, construction history, traffic volume capacity, significance and drainage system. Consideration of these factors helps the pavement engineers to keep track of works and other pavement details which are necessary for its maintenance. Moreover each pavement is ranked as primary, secondary or tertiary on the basis of their functionality. Prioritization of pavement maintenance is done depending on the ranking provided. Pavements falling under primary ranking category are provided with more maintenance priority than any other ranking.”*

Q3. How effective Analytical Hierarchy Process has been in prioritization of pavement according to your opinion?

On the basis of this question, 1st interviewee commented that *“Analytical Hierarchy Process is identified as one of the most effective process involved in decision making towards prioritization*

of a particular section. In this technique pair wise comparison is done which enables the managers and other road construction authority in investigating various different criteria which are applicable. It also allows in implementation of best alternative which are capable of causing cost reduction in maintenance and repair works.” In addition to this, 2nd employee commented that “AHP process consists of several phases through which prioritization work for pavement sections are achieved and they are development of structural hierarchy, pair comparison phase and development of priority vector ” 2nd interviewee further adds that “ in structural hierarchy phase decomposition of problems into elements takes place which are independent and individual. This process is also considered as an abstraction of entire system which simplifies the relationship and working of each component. It also allows road construction authority to determine the impact of alternative chosen over the entire system.” The 3rd interviewee comments that “the other two phases are of equal importance because next phase deals with comparison of pair wise criteria. It has been observed that in most cases it is not possible for individuals to use seven point rating scale for effective comparison. Moreover on the basis of prior two phase’s priority vectors are provided. This helps in analyzing the condition of pavements based on distress, location, severity and cost involved”. As per comment of 4th interviewee “priority vector are provided which develops the basis for priority listing of pavements. AHP process involves several methods of application, some of the commonly known methods are distributive mode relative AHP, ideal mode relative AHP and absolute AHP. Amongst these three methods, absolute mode is considered to be the most feasible and widely used method in analytical hierarchy process. This is so because designing of this method was done to overcome problem related to large number of comparison in AHP process.” 5th interviewee commented that “the difference is observed at last level, where alternatives are analyzed on the basis of priority for evaluation. Alternatives are provided with degree of intensity on the basis of criteria. Moreover, effectiveness of AHP process can be estimated from its impact towards work simplification and easier identification of pavements which are in critical condition and requires immediate repair and maintenance.”

Q4. What are the basic issues faced by road development authorities towards effective maintenance of pavements?

As an answer to this question, interviewee 1 commented that “there are several challenges which are present in periodic maintenance of pavements which are causing a lot of hindrance in

effective management of work.” He added to it that “the basic issue faced by municipal and other authorities deals with effective maintenance of pavement before they get distressed. This occurs mainly due to lack of knowledge associated with priority of a stretch that needs to be repaired first; money is invested in wrong place. Many cases have been observed from past studies, where investing money in stretch of pavement that is capable of working and bearing pressure of traffic have taken place. ” 2nd interviewee added to it by commenting that “lack of fund and proper management facility is acting as a major reason which is affecting the timely maintenance of pavement. Delay in pavements maintenance is causing involvement of high direct and indirect cost. Effective repair of road keeps the construction cost modest. If timely repairs are neglected, entire section of road may fail raising requirements for full reconstruction of particular stretch. ” 3rd interviewee commented that “budget being a major problem is holding pavement engineers and other authorities from timely maintenance work.” On contrary to this 4th interviewee commented that “budget and improper management system is not the only problem. However, proper analysis of pavement requiring maintenance and repair acts as a major challenge in prioritization of pavement section. ” In context to this 4th interviewee commented that “in most cases, due to availability of large network of pavement sections, employees and road development authorities are unable to identify the problems and their severity in various pavement sections. This is preventing them from identifying pavements of primary rankings which require immediate repairs. However, allocated budget which is already less in quantity are used in maintenance of pavements that are of secondary or less importance leading to running out of fund.” as per comment of 5th interviewee “this can be taken as major reason for delay in effective maintenance of pavements, despite of knowing the severity of distress level. ” he further added that “this less allocation of budget makes it necessary for development of a prioritization schedule which is comprehensive, in order to choose areas of higher priority first. This deprives the road in critical condition of the necessary budget allocated for repair and availability of proper materials. This deprivation is causing critical condition of pavements having large traffic volumes. ”

Q5. What are the ways in which prioritization of pavement sections for periodic maintenance can be enhanced?

On the basis of this question, 1st interviewee commented that “in present modern world where technologies are advancing with advancement of time. Several methods or ways has been

identified through which prioritization of pavement section for periodic maintenance can be improved. Some of the prominent used method which is applicable in road development or civil construction industry is - use of pavement management system, this system will enable pavement engineers and road development authorities to segregate wide pavement chain into small network which are subdivided into branches and sections respectively. This is done in order to simplify pavement section accessibility so that severity of distress can be analyzed and priority listing can be done accordingly. ” To this 2nd interviewee added that “performance measurement of pavements on timely basis helps in reducing chances of additional cost involvement. This is an effective measure in improving pavement section prioritization.” In context to this question, 3rd interviewee commented that “few other methods are also there, utilization of which will help in pavement prioritization. Some commonly applicable methods are use of pavement condition index, Analytical Hierarchy Process and survey process. ” 4th interview commented that “all the methods or ways recommended by other interviewee are effective and are found to be in practices at various places for proper maintenance of road. Pavement Condition Index is a performance measurement tool used for determination of pavement condition. Moreover it utilizes the standard test method which has been recognized for effective measurement of pavement performance and its condition. This measurement tool consists of a numerical index ranging from 0 to 100 which helps in determining the pavement’s condition. Pavements represented with PCI index as 0 are in critical condition and requires immediate resurfacing or repair. On the other hand, pavements with PCI index being represented at 100, their condition are considerably good and do not require maintenance for the time being.” 5th interviewee commented that “if prioritization of pavement section for maintenance is to be enhanced, it is necessary for pavement engineers to think over effective utilization of budget. Use of allocated budget in proper and efficient manner by finding best alternative for repair and maintenance which is cost effective and help in utilization of budget on repair and maintenance of several pavements instead of a particular pavement.”

Analysis of Qualitative data

From the analysis of qualitative data it has observed that there is a great requirement for prioritization of pavement sections for their periodic maintenance. The main reason for occurrence of need for prioritization as per findings lies in the problems which are arising out of improper road maintenance. Some of the prominent problems identified in findings are delay in

pavement maintenance which are causing more distressing of pavement making travel path miserable. Improper road conditions also affect the performance of vehicles adding additional pinch to pocket over servicing. Moreover, according to findings it has been observed that chances of road accidents increase by many folds if pavements are not repaired and severity of its distress increases. Apart from this it has been analyzed from findings that there several challenges which are preventing road authorities from proper and timely maintenance of pavement sections. Few of the major problems affecting pavement maintenance are less allocation of budget in comparison to need of repair and maintenance work. Lack of proper management system and low application of priority technique are causing poor maintenance of pavement sections. From the findings, apart from challenges present, knowledge related to Analytical Hierarchy process and pavement condition index are also gained. Effectiveness of AHP process has been understood to a considerable extent from qualitative findings. This process has three methods which are used for priority listing; they are distributive mode relative AHP, ideal mode AHP which is a modified form and has mitigated the problem related to derivation of priority vector. The last mode deals with absolute AHP; this is the most feasible and widely used method in analytical hierarchy process. This is so because designing of this method was done to overcome problem related to large number of comparison in AHP process. The difference is observed at last level, where alternatives are analyzed on the basis of priority for evaluation. Alternatives are provided with degree of intensity on the basis of criteria. Several phases of Analytical Hierarchy process are also analyzed in this section. These are the phases through which prioritization work for pavement section are done. Priority vectors are provided in the last phase on basis of severity, location and cost involved. It is through this priority vector reading that priority listing to pavement sections is provided. In this data collection method recommendation for improvement of prioritization process have been provided which will help road development and pavement engineers to get appropriate idea related to pavement condition and severity of their distress. The knowledge and information obtained from prioritization process of pavement maintenance will enable repair and maintenance workers to pay attention to pavements that requires repair rather than spending it on less significant pavements. It also saves a considerable amount of less allocated budget so that it can be utilized in other pavement sections and areas of development.

4.3 Findings and analysis from Quantitative data sources

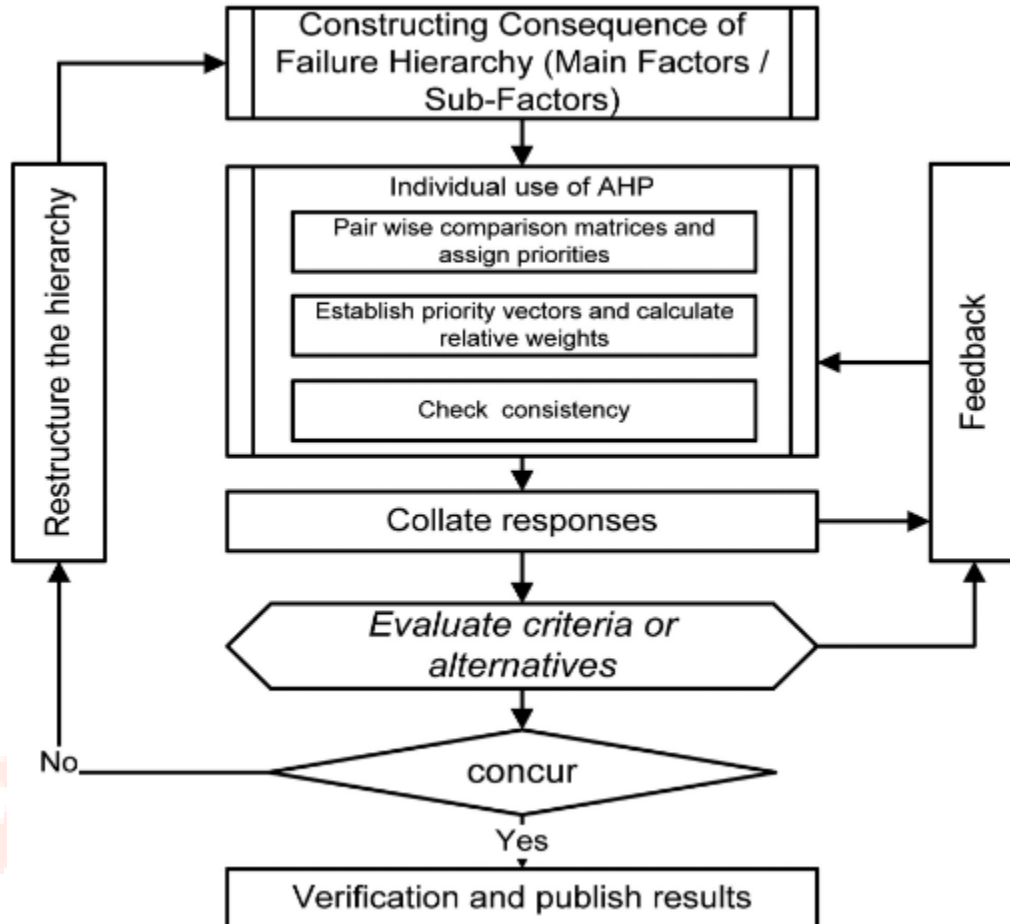


Figure: Algorithm chart showing the process through which priority listing is done

(Source: Ibraheem and Atia, 2017)

As per findings from literary articles and other valid sources, it has been observed that entire prioritization process of pavement section works in format of an algorithm [22]. This is mainly done to follow the sequence of task required for effective pavement management. Carrying out prioritization work in an algorithmic process allows pavement engineers and road development authorities to keep proper track of work and increase efficiency of process associated with proper and effective maintenance of pavement. As per findings, pavement management system involves development of this algorithm which can be referred by road maintenance authorities in order to locate pavements which are under distress. Findings related working of this algorithm is discussed in this section. As per literary work collected from secondary sources prioritization process for pavement maintenance consists of various steps. The first step is related to first phase

of Analytical Hierarchy Process where hierarchy structure formation takes place. On basis of this hierarchy structure, construction of consequence for failure in hierarchy developed is done. Thus, it can be said that first step helps us to analyze the risks that are existing in developed hierarchy. In the second step as per findings AHP process is applied on individual basis to the hierarchy structure. This step involves three sub-steps were pair wise comparison of matrices is done and priorities are assigned to pavements. It also involves establishment of priority vectors and calculation of relative weight which helps in determining the severity of pavement condition. After this consistency of the prioritization project is monitored in order to make necessary changes if required. According to findings, in structural hierarchy phase decomposition of problems into elements takes place which are independent and individual [35]. This process is also considered as an abstraction of entire system which simplifies the relationship and working of each component. It also allows road construction authority to determine the impact of alternative chosen over the entire system. Through this effectiveness of method is determined which helps in leveraging cost to a considerable extent. This process involves setting of goals in the beginning process of maintenance and repair which helps authorities to reach their desired goal in the last level. Setting of goals in first level helps authorities to set process in which the up taken project dealing with prioritizing of road maintenance can be identified. In this phase criteria are set accordingly in order to relate goal of AHP process with alternatives in mid level of execution. As per findings, in normal case criteria are broken down into sub criteria and sub-sub criteria depending on the complexity of pavement maintenance. The next phase deals with comparison of pair wise criteria, as per study it has been observed that in most cases it is not possible for individuals to use seven point rating scale for effective comparison. As per sources it has been observed that AHP process provides nine point rating scale for effective comparison of individual elements [13]. All this process taken together with proper working depicts the consistency in prioritization process of pavement sections. In third step, collation of responses is performed that provides feedback to the feedback system which is related to AHP process. On receiving negative feedback, response is sent to AHP process so that modification is made accordingly in order to increase efficiency of prioritization process. In case the feedback response received is positive, no changes are made and further proceeding is followed. On the basis of feedback received evaluation criteria for alternatives are checked if the alternatives are in concurrence with evaluation criteria verification and execution of project is initiated. In case,

no concurrence is found between the evaluation criteria and alternative selected for effective maintenance of pavement, hierarchy is sent for restructure.

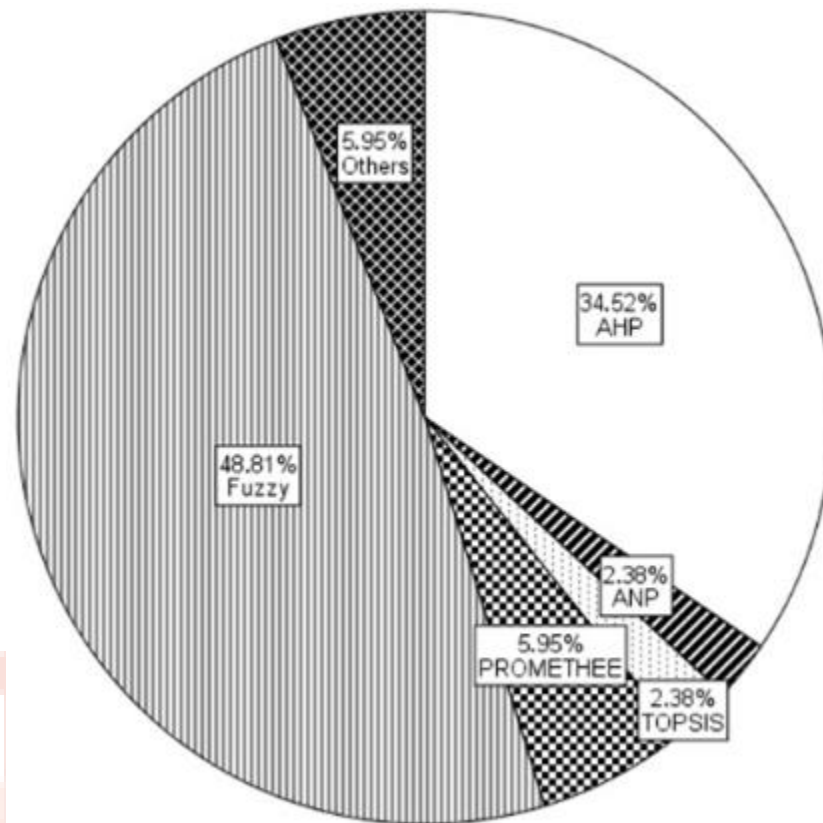


Figure: Pie chart showing percentage adaption of AHP process in pavement maintenance

(Source: Pinto and Tighe, 2015)

As per findings from secondary sources, resources are collected in relation to research topic which is valid and authentic. Studies have indicated that AHP process is gaining popularity in several countries over construction and maintenance of pavement sections. Findings are represented in the form of graph which depicts the rate of adaption of Analytical Hierarchy Process in construction work across the world. As per statistical data collected it has been found the almost 48.81% of prioritization technique utilized for pavement maintenance are fuzzy. Moreover, data study also indicates that AHP process is the most commonly used process determined for prioritization of pavement works which are essential. According to data, its application on worldwide basis stands at around 34.52% which is comparatively greater than other techniques [12]. The other techniques found to be in use are PROMETHEE process which

is having a worldwide application of around 5.95%. This is followed by technique named TOPSIS having its contribution in prioritization work at around 2.38% and is followed by ANP process which is also having its worldwide contribution at around 2.38%. The remaining 5.95% depicts the use of miscellaneous process. Through this graphical study, it can be analyzed that the world is still to recognize the benefits which are associated with prioritization of pavement sections. The study indicates that 48.81% of road development and maintenance authorities are still to adopt prioritization techniques which help in effective and periodic maintenance of pavement sections. This percentage of population still fails to use advance technologies and rely on old tradition method for maintenance of pavement. Basically the maintenance and repair format followed by them involves selection of a particular network for pavement maintenance and carrying out work in that particular section till roads are fully repaired. It is only after, work completion over a particular section that pavement engineers look forward towards development of other pavement network [42]. This action delays the time involved in proper repair and maintenance of roads that are in critical condition. Moreover, improper attention due to budget constraints also results in further distressing of pavement section that are of primary importance. Thus, from this graph and study an effective need for development of prioritization project towards priority listing of pavement section depending on their condition and severity is essential. This graph also depicts the success rate of AHP process application in road maintenance and repair work, since almost 34.52% of road development and maintenance organizations around the world have utilized it and gained possible success. It is expected for the percentage to increase with time as awareness related to benefit associated with priority listing of pavements increases.

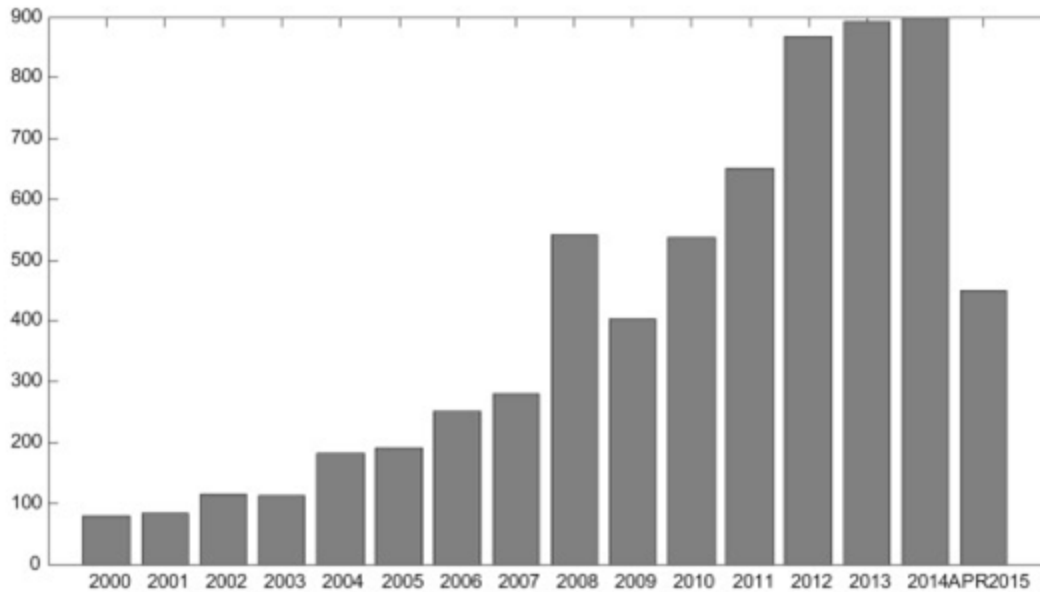


Figure: rising rate of complexity in pavement maintenance

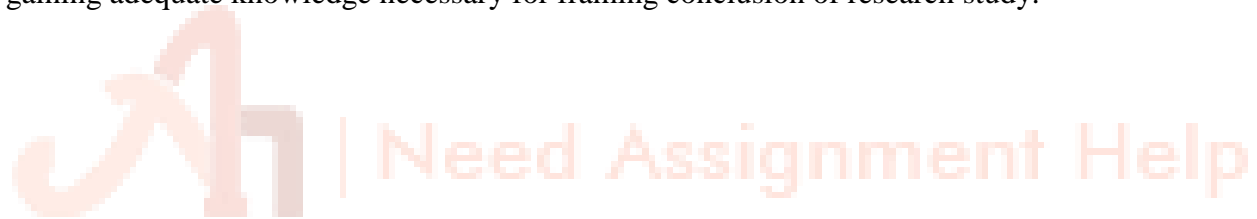
(Source: Ibraheem and Atia, 2017)

As per statistical findings, it has been analyzed that problems related to road maintenance were less in the year of 2000. However, with increasing technology and development as well as rapid growth in population, the demand for proper infrastructure also increased. This was mainly an attempt taken to improve living condition of people. Along with improvement in living condition, complexity associated with maintenance of infrastructure also occurred. The rising demand of people and low maintenance facility available made it difficult for road authorities to manage the pavement sections developed for public convenience. Number of vehicles in the roads is increasing day after day; this is putting in excessive stress on carrying capacity of pavements thus resulting in their distress. It is also becoming more difficult for maintenance engineers to identify pavement section which are under distress and requires immediate attention [28]. This lack of proper facility along with low budget are hindering performance of pavement and reducing their longevity. From the year 2000, it has been analyzed that the graph is under continuous rise because of increasing pressure and lack of proper management system. Few downward curves were also observed in between 2008 and 2009, this is so because a rise in price of automobile was witnessed in that year. After a time, when price became affordable and per capita income of people increased, a sharp rise in complexity level was witnessed due to increasing pressure on carrying capacity of pavements and large number of distresses [16].

Recently as per findings, it have been analyzed that rising level of complexity in maintenance has reduced to a considerable extent. This reduction in complexity level towards effective repair and maintenance of pavement has been possible only after prioritization techniques have been adapted by development authorities around the world. This further showcases the effectiveness of AHP process in prioritization of pavement section for maintenance.

4.4 Conclusion

This chapter of research study is entirely based on qualitative and quantitative data analysis where point of view related to various challenges in pavement maintenance and prioritization process are obtained from employees working in road development and maintenance corporation. These employees selected as respondents for qualitative data analysis provide adequate information needed for carrying out the study. Furthermore, graphs and charts available from authentic secondary sources have been analysed in quantitative data analysis which help in gaining adequate knowledge necessary for framing conclusion of research study.



Chapter - 5 Conclusions

5.1 Summary

The conclusion drawn from the overall finding and analysis of the research study provides the reader with the knowledge of several priority methods that are present in pavement maintenance. It also provides knowledge related to effectiveness of Analytical Hierarchy Process in prioritization of pavement sections which are under severe distress. As per findings it has been observed that, AHP process have been quite effective in priority listing of pavement sections and it provides road authorities with best alternatives that helps in reducing extra cost involved in pavement maintenance. It also helps in providing details related to pavements in an arranged or organized manner that enables them for proper identification of pavements which requires immediate repair. Furthermore, from findings it has also been observed that around 48.8% of road maintenance authorities across world are still unaware of advantages related to AHP process and prioritization of pavement. This lack of knowledge is resulting in occurrence of financial crisis for pavement maintenance. This section provides linking of research objectives with research findings that help in achieving aim of research study. Moreover, recommendations are also discussed in this section which helps in improving prioritization process of pavement section and mitigates the issues.

5.2 Linking with objectives

Linking objective 1: Identification of applications based on prioritization and optimization in pavement maintenance

In order to link this objective with the practical field of this research study, the researcher has developed a connection with literature review as well as findings and analysis. In literature review, one can find a section where the need for prioritization project for pavement maintenance has been discussed. Prioritization and optimization of efficient resource allocation is very much important as road development authorities most of the time lack with funds for addressing effective pavement maintenance. **If proper resource allocation is not available, then effective identification of applications in pavement maintenance is not possible. In findings and analysis, one can link this objective with quantitative data where it has been said that entire prioritization of pavement maintenance works in accordance to algorithm.** Through this process,

application identification is possible for road development authorities when they lack with funds. Approach of prioritization includes rankings provision to compete pavement sections that needs proper maintenance. It can be found in the findings and analysis section addressing that for carrying out optimization and prioritization work through algorithmic process helps road development authorities to keep proper track of work. This would help in increasing efficiency with effective pavement maintenance.

Linking objective 2: Identification of prioritization techniques for pavement maintenance

The researcher has developed a connection with literature review as well as findings and analysis for linking this objective with the main research study. In literature review, a detailed description about the techniques of prioritization for maintenance of pavement has been provided. It has been said that for pavement maintenance, introduction of proper techniques of prioritization is very much important. This is because the techniques will enable road development authorities to identify the critical condition of pavements and engage their attention to develop the pavement. The benefits of prioritization approaches are to be focused by the development team in order to effectively carry out pavement maintenance. Maintenance of pavement depends on the condition of the pavement and also the fund available to the road development authorities. In findings and analysis, one can link this objective where information of about prioritization techniques has been gathered through qualitative process. The employees of road construction companies are interviewed to gather information about the prioritization techniques that they apply in pavement maintenance. The employees have provided researcher varieties of opinion about the prioritization techniques that are applicable in effective pavement maintenance.

Linking objective 3: Identification of methods involved in AHP process

In order to link this objective with the practical field of this research study, the researcher has developed a connection with literature review as well as findings and analysis. Researcher has consider a portion of literature review where discussion about the AHP process and its effectiveness in pavement maintenance. Information about the phases of AHP has been provided considering which this objective can be linked. Consideration of those phases of AHP helps in managing the pavement properly. Methods that are involved in AHP are described in details in literature review and those are Distributive mode relative AHP, Ideal mode relative AHP, and Absolute AHP. This objective of the research study gets fulfilled if researcher considers these three methods. In findings and analysis also, discussion about the methods can be found. The

employees of road construction companies have provided information about the methods involved in AHP through which this objective of the research study gets fulfilled. The employees have provided researcher different answers prior to the question that researcher has put in front of them about AHP methods of identification. Different employees have provided different opinion as pavement maintenance differs from companies to companies.

Linking objective 4: Determination of effectiveness for Analytical Hierarchy Process in prioritizing periodic maintenance of pavement

Researcher while linking this objective with the practical field of the research study has considered a little portion of literature review as well as findings and analysis. Effectiveness of AHP in prioritizing periodic maintenance of pavement has been discussed in literature review. It has been described that effectiveness of AHP is higher over decision making for idealize pavement maintenance through prioritizing periodically. Being simple and comprehensive, AHP process is very much effective in maintenance of payment. The effectiveness of AHP in pavement maintenance is high because it helps in addressing several problems and drawbacks that are directly related to periodic pavement maintenance. In findings and analysis also, discussion about AHP effectiveness on pavement maintenance can be found. The employees of road construction companies have provided information to the researcher when they are asked about the effectiveness of AHP in maintenance of pavements. Different employees have different opinion about the effectiveness and gathering of all these information the researcher can figure out effective outcomes or results of this research. However, gathering all the opinion of the respondents, researcher can effectively get to know about this objective is getting fulfilled and thereby reach to final outcome.

Linking objective 5: Identification of challenges which are faced in periodic maintenance of pavements at present

In order to link this objective with the main study of this research, researcher has taken into consideration several discussions from literature review as well as findings and analysis. As per the findings, road development authorities face several challenges in pavement maintenance at present. Due to insufficient available of funds, the authorities of road development at present faces a plenty of challenges. Increase in day to day population has increased the number of vehicles in the road. Due to this increase in vehicle and transport facilities, proper development and maintenance of road as well as pavement is not possible for the authorities of road

development. Another challenge has been discussed that due to lack of proper planning of how to execute the maintenance process of pavements is a challenging situation that now-a-days every road development authorities face. Information about the challenges has also been gathered from findings and analysis where employees of road construction companies have provided some opinion based on this. They have provided different type of answers to the researcher prior to the question that was presented in front of them. They have provided information that different types of challenges the road construction companies at present faces while maintenance of pavements.

Linking objective 6: Identification of ways in which prioritization in periodic maintenance of pavements can be improved

Linking this objective with the main text of this research study, consideration of discussion provided in literature review and findings and analysis is important. Researcher has gathered quality information from literature review for identifying the ways through which pavement maintenance can be improved periodically. Only after gathering information in respect to this objective, the research study can be made an effective one. In literature review, steps to improve the prioritization in periodic maintenance of pavements have been discussed. Information about the steps or ways has also been gathered from findings and analysis where employees of road construction companies have provided some opinion based on this. They have provided different type of answers to the researcher prior to the question that was presented in front of them. They have provided information that consideration of proper steps has helped them in successfully prioritize pavement maintenance periodically.

5.3 Recommendations

Some of the prominent recommendations based on literary findings and information obtained from interview process of employees are discussed in this section. These recommendations are found to be effective in improving prioritization of pavement sections. Recommendations addressing the problems related prioritization work and effective pavement maintenance are as follows:

Recommendation 1:

Spreading awareness related to efficiency of priority listing of pavement section

S (Specific)	This recommendation provided is specific as it addresses the major issue faced by road maintenance authority. As per findings it has been observed that a major section of world population is still to adopt AHP and other prioritization techniques.
M (Measureable)	This recommendation is measurable since the performance of pavement based on this AHP process and PCI can be measured. Moreover, overall increase in adaptation rate will also act as a measurement.
A (Achievable)	The recommended task is achievable this is so because it has been applied by various road construction authorities across the world and efficiency have been gained.
R (Realistic)	The recommended solution is realistic as it is achievable and based on issues and process of prioritization of pavements.
T (Time required)	The time identified for execution of this recommendation effectively is approximately six months

Table 2: SMART Recommendation

Recommendation 2:

Development of effective Pavement Management System

S (Specific)	This recommendation provided is specific as it addresses the major issue faced by road
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	<p>maintenance authority. Moreover there is a requirement for presence of effective pavement management system.</p>
M (Measureable)	<p>This recommendation is measurable since the performance of pavement can be measured depending on its longevity and condition. Moreover, overall increase in adaptation rate will also act as a measurement.</p>
A (Achievable)	<p>The recommended task is achievable this is so because it has been applied by various road construction authorities across the world and efficiency have been gained.</p>
R (Realistic)	<p>The recommended solution is realistic as it is achievable and based on issues and process of prioritization of pavements.</p>
T (Time required)	<p>The time identified for execution of this recommendation effectively is approximately four months</p>

Table 3: SMART Recommendation

Recommendation 3:

Increasing fund allocation for proper and effective maintenance of pavements

S (Specific)	<p>This recommendation provided is specific as it shows the effectiveness of fund in proper maintenance.</p>
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M (Measureable)	This recommendation is measurable since the proper allocation of budget will enable workers to avail best alternatives available and carry forward the work.
A (Achievable)	The recommended task is achievable this is so because it has been applied by various road construction authorities across the world and efficiency have been gained.
R (Realistic)	The recommended solution is realistic as it is achievable and based on issues and process of prioritization of pavements.
T (Time required)	The time identified for execution of this recommendation effectively is approximately three months

Table 4: SMART Recommendation

Recommendation 4:

Using AHP process and Pavement condition index in order to determine priority of pavements

S (Specific)	Use of this recommendation is found to be specific and effective since it indicates the way through pavement condition can be monitored without visiting site of occurrence.
M (Measureable)	This solution is measurable since success rate and index number are present to determine severity of pavements.

A (Achievable)	Evidences from statistical study shows that this task is achievable.
R (Realistic)	This recommendation is realistic since it has been applied earlier.
T (Time required)	Time estimated for this recommendation is six months

Table 5: SMART Recommendation

5.4 Future scope of study

The researcher has done the research study based on the Prioritizing project for periodic maintenance of road pavements. Through the help of the research study the readers and researcher along with road development authorities will be able to evaluate and understand the issue that is present in the industry. It also helps them to evaluate the various methods which are present in prioritization through AHP process. It will also help them to proceed with the recommendation provided to reduce the issue and improve the implementation of prioritization techniques. The study of the research will help the pavement engineers to utilize the resources in an efficient manner and bring proper maintenance of pavement sections. The proper knowledge will help the researchers to carry the research forward.

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Appendix

Transcript

Q1. What prioritization techniques are applied for pavement management?

1 st Employee	2 nd Employee	3 rd Employee	4 th Employee	5 th Employee
<p><i>“The prioritization method may range from provision of subjective rankings to pavements based on their critical conditions and pavement condition index to a comprehensive technique of optimization.”</i></p>	<p><i>“Prioritization techniques have enabled managers and engineers to identify critical condition of pavements which require immediate attention.”</i></p>	<p><i>“There are various ways through which prioritization techniques can be applied to pavement sections. However, most common way identified for priority listing of pavement deals with analysis of level of distress over a particular pavement section.”</i></p>	<p><i>“If more severity of distress is more for a particular pavement section in comparison to others then it necessary to list pavement with high distress level in top of priority list”</i></p>	<p><i>“Development of pavement management system can also be seen as an effective method for maintenance of pavement section. This pavement management provides road maintenance organizations and agencies with a tool that is effective in predicting future performance associated with pavement. This information gained from pavement management</i></p>

				<p>system can be utilized by municipal and road maintenance authorities for setting of budgets and for planning capital programs to be used in future.”</p>
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Q2. What ways are involved in prioritizing pavement section through Analytical Hierarchy Process?

1 st Employee	2 nd Employee	3 rd Employee	4 th Employee	5 th Employee
<p>“There are various step involved in management of pavement system. Some of the prominent steps which are involved in priority listing of pavement include network”</p>	<p>“These steps of pavement management system are highly beneficial as they sub divide each pavement network into small branches and sections which allows road development authorities to get proper access to</p>	<p>“Network identification helps in analyzing the area which requires maintenance and repair attention. Division of entire pavement area into various networks is necessary because it is not</p>	<p>“Subdivision till branches is not the end; pavements are further subdivided into sections which will allow them to reach exact area or pavement section which is under distress.”</p>	<p>“Section involves various factors which are vital in prioritizing work. The factors included in sections are structure, construction history, traffic volume capacity, significance and drainage system. Consideration of</p>

<p>identification, branch identification and section identification.”</p>	<p>pavement section which are in critical condition and requires immediate maintenance. Failure to which may result in involvement of additional costs.”</p>	<p>possible for workers of maintenance and repair to identify the areas where pavements require repair from such a wide range of options. Subdividing the network into branches simplifies the work to a considerable extent. ”</p>		<p>these factors helps the pavement engineers to keep track of works and other pavement details which are necessary for its maintenance.”</p>
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Q3. How effective Analytical Hierarchy Process has been in prioritization of pavement according to your opinion?

1 st Employee	2 nd Employee	3 rd Employee	4 th Employee	5 th Employee
<p>“Analytical Hierarchy Process is identified as one of the most effective process</p>	<p>“AHP process consists of several phases through which prioritization work for pavement sections is</p>	<p>“The other two phases are of equal importance because next phase deals with comparison of pair wise criteria. It has been</p>	<p>“Interviewee priority vector are provided which develops the basis for priority listing of pavements. AHP process involves several methods of</p>	<p>“The difference is observed at last level, were alternatives are analyzed on the basis of priority for evaluation. Alternatives are</p>

<p>involved in decision making towards prioritization of a particular section. In this technique pair wise comparison is done which enables the managers and other road construction authority in investigating various different criteria which are applicable.”</p>	<p>achieved and they are development of structural hierarchy, pair comparison phase and development of priority vector.”</p>	<p>observed that in most cases it is not possible for individuals to use seven point rating scale for effective comparison.”</p>	<p>application, some of the commonly known methods are distributive mode relative AHP, ideal mode relative AHP and absolute AHP. Of these three methods, absolute mode is considered to be the most feasible and widely used method in analytical hierarchy process.”</p>	<p>provided with degree of intensity on the basis of criteria.”</p>
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Q4. What are the basic issues faced by road development authorities towards effective maintenance of pavements?

1 st Employee	2 nd Employee	3 rd Employee	4 th Employee	5 th Employee
<p><i>“There are several challenges which are present in periodic maintenance of pavements which are causing a lot of hindrance in effective management of work.”</i></p>	<p><i>“Lack of fund and proper management facility is acting as a major reason which is affecting the timely maintenance of pavement. Delay in pavements maintenance is causing involvement of high direct and indirect cost. Effective repair of road keeps the construction cost modest. If timely repairs are neglected, entire section of road may fail raising requirements for full reconstruction of particular stretch.”</i></p>	<p><i>“Budget being a major problem is holding pavement engineers and other authorities from timely maintenance work.”</i></p>	<p><i>“Budget and improper management system is not the only problem. However, proper analysis of pavement requiring maintenance and repair acts as a major challenge in prioritization of pavement section.”</i></p>	<p><i>“This can be taken as major reason for delay in effective maintenance of pavements, despite of knowing the severity of distress level.”</i></p>

Q5. What are the ways in which prioritization of pavement sections for periodic maintenance can be enhanced?

1 st Employee	2 nd Employee	3 rd Employee	4 th Employee	5 th Employee
<p><i>“In present</i></p>	<p><i>“Performance</i></p>	<p><i>“Few other</i></p>	<p><i>“Pavement</i></p>	<p><i>“If prioritization</i></p>

<p>modern world where technologies are advancing with advancement of time. Several methods or ways has been identified through which prioritization of pavement section for periodic maintenance can be improved. Some of the prominent used method which is applicable in road development or civil</p>	<p>measurement of pavements on timely basis helps in reducing chances of additional cost involvement. This is an effective measure in improving pavement section prioritization.”</p>	<p>methods are also there, utilization of which will help in pavement prioritization. Some commonly applicable methods are use of pavement condition index, Analytical Hierarchy Process and survey process.”</p>	<p>Condition Index is a performance measurement tool used for determination of pavement condition. Moreover it utilizes the standard test method which has been recognized for effective measurement of pavement performance and its condition.”</p>	<p>of pavement section for maintenance is to be enhanced, it is necessary for pavement engineers to think over effective utilization of budget. Use of allocated budget in proper and efficient manner by finding best alternative for repair and maintenance which is cost effective and help in utilization of budget on repair and maintenance of several pavements instead of a particular pavement.”</p>
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construction industry is - use of pavement management system, this system will enable pavement engineers and road development authorities to segregate wide pavement chain into small network which are subdivided into branches and sections respectively.”

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