PAVEMENT SURFACE CONDITION ATTRIBUTED TO TRAFFIC OPERATIONS ON FEDERAL ROADWAYS IN KUANTAN

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ABSTRAK

Kerosakan turapan jalan sentiasa dikaitkan dengan fungsi optimumnya dan mungkin menyumbang kepada kemalangan jalan raya. Sebilangan besar wang terus dibelanjakan untuk penyelenggaraan jalan raya kerana kerosakan turapan ini. Terdapat beberapa faktor yang mempengaruhi kerosakan turapan seperti perubahan cuaca, kualiti bahan dalam pembinaan, penyelenggaraan yang tidak wajar dan operasi trafik. Kajian ini dijalankan untuk meneroka kerosakan turapan faktor penyumbang berdasarkan operasi lalu lintas. Dari segi pemuatan lalu lintas dan jumlah lalu lintas sebagai pusat analisis kritis. Untuk mencapai matlamat ini, data diperoleh dari RoadCare dan JKR dengan menggunakan data sekunder dan taburan kuesioner. Terdapat tiga Laluan Persekutuan yang dipilih di Kuantan sebagai lokasi kajian yang merupakan Laluan Persekutuan 2, Jalan Persekutuan 3 dan Laluan Persekutuan 183. Untuk mencapai matlamat pertama kajian ini, statistik deskriptif telah digunakan. Daripada analisis data, kerosakan turapan corak yang paling biasa berlaku adalah berlubang berdasarkan data analisis. Bagi objektif kedua, data dianalisis dengan menggunakan statistik kesimpulan. Dari hasilnya, elemen pertama menunjukkan terdapat korelasi positif tetapi tidak signifikan antara volum lalu lintas dan kerosakan turapan dengan nilai tertinggi r ialah 0.987 pada FR3 dengan p-value 0.101 yang lebih daripada 0.05 dan tidak dapat diterima. Bagi elemen kedua, hasil menunjukkan hubungan positif dan signifikan antara beban lalu lintas dan kerosakan turapan untuk FR 183 dengan nilai r adalah 1.0 bermakna sangat positif dan nilai p paling rendah dengan 0.00. Hasilnya menunjukkan bahawa operasi lalulintas mempengaruhi kerosakan turapan tetapi tidak pasti kerana faktor lain seperti hujan lebat melemahkan struktur jalan dan kualiti bahan yang digunakan dalam pembinaan.

ABSTRACT

Pavement damages are always associated with its optimum function and may contribute to road crashes. A huge amount of money continuously spent on road maintenance due to this pavement damages. There are several factors that influenced the pavement damages such as weather changes, quality of material in construction, improper maintenance and traffic operations. This study was conducted to explore the pavement damage contribute factors based on traffic operations. In terms of traffic loading and traffic volume as a centre for critical analysis. To achieve this study, the data was obtained from RoadCare and JKR by using secondary data and questionnaire distribution. There were three selected Federal Route (FR) in Kuantan as the study location which are Federal Route 2, Federal Route 3 and Federal Route 183. To achieve the first objective of this study, descriptive statistic was used. From the data analyses, the most common pattern pavement damages occurred was potholes based on the data analyses. As for the second objective, the data was analyzed by using inferential statistics. From the result, the first element shows there is positive correlation but not significant between traffic volume and pavement damages with the highest value r is 0.987 on the FR3 with a p-value of 0.101 which is more than 0.05 and not acceptable. For the second element the result shows the positive relationship and significant between traffic loading and pavement damages for FR 183 with the r value is 1.0 means strongly positive and the lowest p-value with 0.00. The result shows that traffic operations influences to pavement damages but not certainly significant because of others factors such as heavy rainfall weakens road structure and low quality in materials used in construction

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LIST OF SYMBOLS

FR	Federal Roadways
PWD	Public Work Department
RTVM	Road Traffic Volume Malaysia
FR 2	Federal Route 2
FR 3	Federal Route 3
FR 183	Federal Route 183

LIST OF ABBREVIATIONS

PWD	Public Work Department
RTVM	Road Traffic Volume Malaysia
FR 2	Federal Route 2
FR 3	Federal Route 3
FR 183	Federal Route 183

CHAPTER 1

INTRODUCTION

1.0 Background

Malaysian country uses Federal Roadways (FR) as their road network for users since 21" century will desire a more stable transport system where they can be confident of arriving at their destination on schedule (Lida, 1999). All the Federal Roadways in Malaysia are under the purview of Ministry of Works (MOW). MOW have responsible to plan, build and maintain all Federal Route according to Minister's Function Act 1969. However, most of the Federal roadways project was built and maintained by the Malaysian Public Works Department (PWD) which are also one of the implementing agency under the MOW excepting Sabah and Sarawak, where by PWD in these two states were under respective state government. In Kuantan, PWD was responsible to build and maintained the Federal Roadways to give the great service of road network for their users. Then, for the selected area PWD assigning the private company such as Road Care to do the maintenance work for Federal Roadways in Kuantan City.

Road network analysis was generally based on mean values, using static traffic assignment techniques, such as travel time, travel distance or level of congestion. In traffic

assignment, traffic demand between origin and destinations is generally assume as constant, although actual traffic demand changes from time to time (Lida, 1999). Therefore, the worse pavement condition will interrupt their user trip and give the bad effect to their user such as traffic congestion and crashes. The worse pavement condition can be classifying as a pavement damages such as in pattern of potholes, rutting and cracking. All this damages may interrupt the efficiency of transportation by user for their traveler's activities. There are many reason will be considered influencing to road damages such as traffic volume and traffic loading in terms of traffic operations due to our modern technology nowadays. The traffic loading from the heavy vehicle load on the pavement subjects it to high stresses causing damages. However, not all tracks have the same harmful effects, the damage to the road pavement depends on wheel loads, number and location of axles, load distributions, 2 number of wheels, tire types, inflation pressure and other factors (Gillespie T.D., 1993). Heavy truckloads are the major cause of pavement damage. The size and configuration of vehicular loads together with the environment have an important impact on induced tensile stresses within flexible pavement (Yu H.T., 1998). This research is to identify the most common pattern pavement damages occur on Federal Roadways in Kuantan and evaluate the association between traffic operations towards pavement damages on Federal Roadways Kuantan.

1.2 Problem Statement

Roads are provided for the benefit to the road user, they also play a significant role in promoting economic growth and the living standards of the population (CSIR, 1997). With the increased growth nowadays, roads being the most important thing for social economics in order

to provide accessing to employment, social, health and education services with the nation grow and develop such as Kuantan City.

There were many roadways in Kuantan facing the high traffic volume traffic loading but for this study only three selected areas had been considered which were Federal Route 2 (Gambang to Kuantan), Federal Route 3 (Bypass East Bound) and Federal Route 183 (Tanjung Lumpur to Penor) because of the strategic area for daily uses and commercial vehicles accessing their travellers. All these Federal Roadways was developing as near to East Cost of Peninsular Malaysia and being the most famous roadway in Kuantan City. However, with the increased growth nowadays this area always facing the worse situation like traffic congestion and crashes because of the bad condition of pavement surface. The increasing vehicular road traffic year-on-year (Road Transport Department, 2011). Malaysia Federal roads are not well maintained and exhibit much surface damages, which causes difficulties for road users (Nizam, 2009) and means their overall performance is below that of highways and expressways (Mansor, 2010). Therefore, good road conditions must be maintained to encourage road safety, road damages not only lead to accidents but is also costly in terms of cyclic and responsive maintenance (Hashim and Rahim,2009).

In this study the problem had been evaluated influencing the pavement damages was traffic operations in terms of traffic volume and traffic loading. The evaluation would provide according to the data collection for three years within 2014 to 2016 of pavement damages on this selected route. Thus, there was no any research focusing on actions to sustain the pavement surface. Damage can be result from poor technical design, poor standards of construction, overloaded vehicles and poor subgrade (Abas, 2011). The pavement deterioration over time is caused by a combination of factors however, traffic loads play a key role in consumption of

pavement life (Karim Chatti, 2018) But, a high traffic demand also would considered as a factor influencing to pavement damages, an extensive road system, abundant and rapidly growing vehicular traffic, and a scattered literature indicating that some ecological effects of roads extend outward for >100 m ((Forman, 2000). These occurrences have raised an issues of pavement damages that can be associated with taffic characteristic.

1.3 Research Objective

The aim and objective of this case study was to evaluate the pavement damages on the Federal Roadways in Kuantan. To achieve the aim of this study, the following objectives have been set as:

i. To identify the common pavement damage patterns on the Federal Roadways in Kuantan.

ii. To evaluate the association of traffic loading and traffic volume towards pavement damages on Federal roadways in Kuantan.

1.4 Scope Of Work

The scope of this research was to focus on evaluating the pavement damages condition on the Federal Roadways in Kuantan. The selection study area involved in this study was Federal Roadways in Kuantan.

Meanwhile, for traffic operation in terms of traffic volume and traffic loading the data was obtained from Highway Planning Unit for FR2, FR3 and FR183.

The vehicle classes (C) of traffic volume will be consider in this study which are C1 for cars and taxis, C2 for small van and medium lorry, C3 for heavy lorry, for bus and C5 for motorcycle. Meanwhile, for the traffic loading the classes vehicles will be consider which are C2,C3 and C4.

1.5 Research Methodology

Chapter 1: Background of the study

This chapter was included of an introduction of the study, problem statement, objectives significant of the study, methodology, and arrangement of chapters.

Chapter 2: Literature Review

This chapter would outline the background of the study and the literature review related to the study issue. The information will comprise from the past research by other researcher and it will support the aim and destination of this study.

Chapter 3: Research Methodology

This chapter would briefly have explained the methodology and case work, which it will generate the information and data required to support the study in order to achieve the study objectives.

Chapter 4: Analysis and Finding

This chapter was about the data analysis and presenting the findings obtain from the study by setting out the result.

Chapter 5: Conclusion and Recommendation

This chapter would provide the conclusion of the study which the decision was made on the data analysis and the suitable recommendation can be made to resolve the problem of study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Roads in Malaysia are classified into two broad categories, namely Federal Roads and State Roads (Hamizan, 2009). Roads and streets are the most important transport communication medium in the country and are uses by almost everyone on a daily basis (CSIR, 1997). For example, user have access to markets, access to places of work, clinics and hospitality and transportation for commercial vehicles using the road as their accessing travellers. With the faster growth nowadays, the surface of pavement will be expose to damages because of the high demand in every day. In Kuantan, the half of their roadways are well maintained or well develop. Most of the roads in Kuantan are federal road because of the strategic and a huge location. It is extension from Kuala Lumpur to East Coast of Peninsular Malaysia. Kuantan have their own budget for road construction and maintenance to safeguards this capital asset. Research is in Kuantan to identify the associations of traffic characteristics in terms of traffic volume and loading with the pavement damages. Based on the previous research, (CSIR, 1997), damage to the road by axle loads exceeding the legal limit, increases out of all proportion to the loads: for example, an axle carrying double the legal load may cause from 4 to 60 times as much damage as one legal axle load, depending on the condition of the structure and type of road.

Because of its extreme importance, roadway safety is one of the most heavily studied topics in transport engineering, with the ultimate motivation of a majority of studies to reduce fatalities and injuries. There are a variety of research directions that may help to achieve this goal, including both reactive and proactive approaches, behavioural and engineering improvements, and vehicle design changes (Saman Roshandel, 2015).

2.1.1 Federal Road

Based on the previous study (Hamizan, 2009) Federal roads are declared under the Federal Roads Ordinace (1959) and the major interurban roads joining the state capitals and roads leading to points of entry to and exit from the country.

Table 1 : Administrative Agencies for Federal Road Maintenance

ROAD CATEGORY	GENERAL DESCRIPTION	RESPONSIBLE AUTHORITY
Toll Expressways	Inter-Urban Toll Expressways	Malaysia Highway Authority (Mha)
National Highways	Inter Urban Linking Federal Capitals	Pwd Malaysia
Regionalroad Schemes	Roads Forming Network in Rda	Pwd Malaysia Regional Units
Minor Roads (Acces to Gov's Building	Roads Lead to within Fed.Govt. Institution	State PWD

2.1.2 State Roads

State roads generally comprises of the primary roads providing intra-state travel between the district administrative centers. Other roads included in this category are the urban collector roads under the municipalities and other minor roads within the villages and the rural inhabited areas under the Districts Offices (Hamizan, 2009).

Table 2: Administrative Agencies for State Road Maintenance

(PWD ; Public Work Department of Malaysia)

ROAD CATEGORY	GENERAL DESCRIPTION	RESPONSIBLE AUTHORITY
Road within federal road	Roads other than the designed federal roads	City Hall of Kuala Lumpur
Primary road	Major roads forming the basic network within state and linking state capitals	State PWDs
Secondary roads	Road forming the network within a district.	State PWDs
Minor roads	Within a village or rural inhabited area	District officer
Urban collector roads	Roads serving as collector and distributors of traffic within a local authority	Respective local authority with assistance from state State PWDs
Local streets	Basic road network within an urban neighborhood	Respective local authority

In this study the Federal Route 2, Federal Route 3 and Federal Route 183 has been selected because of the strategic and popular route for daily used and transportations for commercial vehicle. It was a major east–west oriented federal highway in Malaysia. The 276.9 kilometres road connects Port Klang in Selangor to Kuantan Port in Pahang. All these three Federal Roadways became the backbone of the road system linking the east and west coasts of Peninsular Malaysia before being surpassed by the East Coast Expressway E8.

2.2 Traffic Data

Data collection and projections thereof of traffic volumes were basic requirements for planning of road development and management schemes. Traffic data forms an integral part in the science of descriptive national economics and such knowledge was essential in drawing up a rational transport policy for movement of passengers and goods by both government and the private sectors (Traffic Data Collection and Analysis, 2004).

2.3 TRAFFIC CHARACTERISTIC

Traffic characteristic play character with a very vital for designing the required geometric features in the roadway. (Nicholas J. Garber, 5th Edition). It is included the traffic volume, speed of traffic and traffic loading (focus on commercial vehicles only like a medium lorry, bus and truck). Furthermore, only two types of the traffic operations to be considered for this case study which are the traffic volume and the traffic loading. The traffic characteristic is broadly classified under two types such as:

i. **Road user characteristic :** the physical characteristic of driver like power of vision, hearing and reaction time of the driver shown during a traffic situation.

ii. **Vehicular characteristic :** Classified as a two types as follows, Static characteristic involving the vehicular dimensions (length, wheel base, width, and center clearance) and the dynamic characteristics (speed, power, acceleration).

2.3.1 Traffic Volume

Traffic volume was a one the parameter would be considered to achieved the objective for this study which was defined as the number of vehicles passing a point on highway or a given lane or direction of a highway in a specific time. The unit for this parameter which was vehicles per unit time. Usually expressed as vehicles / hour (veh/hr). Rate of Flow are generally expressed in units of (veh/hr) but represents flows that exists for period of time less than an hour.

To obtain the flow rate :

$$Vp = \frac{V}{PHF .N . fhv .fdp}$$

V = Volume in veh/h

PHF = peak – hour factor

N = number of lane ,

Fhv = heavy vehicle factor

Fdp = driver population factor

2.3.2 Traffic Loading

Traffic loading were involved determining the loading on the road to be carried forward to the pavement. But in this study, the value of traffic loading will considered only for commercial vehicle in classes of vehicles C2, C3 and C4 only. The types of vehicle classes as shows below.

Class	Type of Car
C1	Car, Taxi
C2	Small Van, Medium Lorry
C3	Heavy Lorry
C4	Bus
C5	Motorcycle

Table 3: Vehicles Classes

The Table 3 shown the types of class vehicles according to the type of vehicles, character and axle for each vehicles. In this study, the types of vehicles that would be considered only for commercial vehicles which were heavy lorry, bus and medium lorry.

2.4 Pavement

Pavement was the hard surface of a road. It is a durable surfacing of a road or path which facilitates the road users and also to support the vehicles load. Based on the previous study, (Sharad.S.Adlinge) said that with which anything is paved; a floor or covering of solid material, laid so as to make a hard and convenient surface for travel; a paved road or sidewalk, a decorative interior floor of tiles colored bricks. So that, all the layer covering the surface we know it as a paved, and for the federal roadways the layer covering the surface was pavement. Pavement have

two types of categories which were flexible and rigid pavement. It was composed of layers of different materials according to the types of pavement.

2.4.1 Flexible Pavement

Flexible pavement was composed of a bituminous material surface course and underlying base and subbase courses. The bituminous material was more often asphalt whose viscous nature allows significant plastic deformation. Most asphalt surfaces were built on a gravel base, although some 'full depth' asphalt surfaces are built directly on the subgrade. Depending on the temperature at which it is applied, asphalt is categorized as hot mix asphalt (HMA), warm mix asphalt, or cold mix asphalt. Flexible Pavement was so named as the pavement surface reflects the total deflection of all subsequent layers due to the traffic load acting upon it. The flexible pavement design is based on the load distributing characteristics of a layered system (Jamal, 2017).

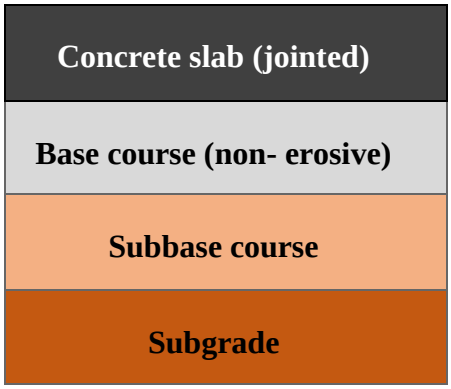


Figure 1 : Flexible Pavement Cross-section

Pavements are usually composed of layers of different materials by layering of a pavement has a significant effect on its performance. Composition, density and thickness of paving materials (bituminous materials, granular materials, unbound granular road base

and sub-base) shall be selected so that they perform as an integral structure and meet intended performance requirements.

2.4.1.1 Sub-Grade

Sub-grade was a soil or lock formation that forms the foundation of a pavement structure, it consists of a prepared cut or compacted fill. The pavement structure shall be designed so that stresses and strains due to traffic loads on the sub-grade remain within tolerable limits. These limits were a function of the elastic stiffness and bearing capacity of the sub-grade and of the traffic volume that a pavement is designed for.

When required and specified, weak sub-grade materials shall be replaced with selected materials or stabilised up to depth of at least 300 mm below sub-grade level to provide a suitable platform for construction traffic and a sound foundation for the pavement. Sub-grade improvement shall not be considered as a separate layer in mechanistic pavement design and is not shown in the catalogue of pavement structures.

2.4.1.2 Sub-Base

Sub-base shall consist of a layer of specified material composition, stiffness and thickness placed directly on the sub-grade. Sub-base shall be considered as lower road base that supports the upper road base and that aids in distributing traffic induced stresses. Because stress levels are lower in the sub-base course than in the road base, sub-base materials are usually of lower quality and stiffness than materials used as road base.

2.4.1.3 Base course

Base course was the main structural layer of a pavement. In flexible pavements, it shall consist of bituminous mixtures, or a granular layer stabilised with cement, emulsion, or similar materials, or mechanically stabilised but otherwise unbound crushed aggregate road base or wet mix road base. Its key function was to distribute traffic loads so that sub-base and sub-grade are not subjected to excessive stresses and strains.

2.4.1.4 Bituminous Binder Course

Bituminous binder course was usually considered part of the surface layers of a pavement. A binder course shall have good resistance to shear-induced distress, because shear stress is highest at a depth of about 0.9 times the radius of the contact area of a wheel load, which corresponds in the case of most commercial vehicles to a depth of about 8 to 12 cm below the pavement surface.

2.4.1.5 Bituminous Wearing Course

Bituminous wearing course shall meet both structural (resistance to stresses and strains imposed by traffic loads) and functional performance requirements; the latter includes adequate durability (resistance to the disintegrating effects of climate), good frictional characteristics and smoothness.

2.4.2 Rigid Pavement

A rigid pavement was constructed from cement concrete or reinforced concrete slabs. Grouted concrete roads are in the category of semi-rigid pavements. The design of rigid pavement was based on providing a structural cement concrete slab of sufficient strength to resists the loads from traffic. The rigid pavement has rigidity and high modulus of elasticity to distribute the load over a relatively wide area of soil. The concrete slab was capable of distributing the traffic load into a large area with small depth which minimizes the need for a number of layers to help reduce the stress (Chandra, Flexible Pavement versus Rigid Pavement, 2017). The most common type of rigid pavement consists of dowel bars and tie bars. Dowel bars were short steel bars that provided a mechanical connection between slabs without restricting horizontal jointed movement. Tie bars on the other hand, are either deformed steel bars or connectors used to hold the faces of abutting slabs in contact. Although they may provide some minimal amount of load transfer, they are not designed to act as load transfer devices and were simply used to tie the two concrete slabs together.

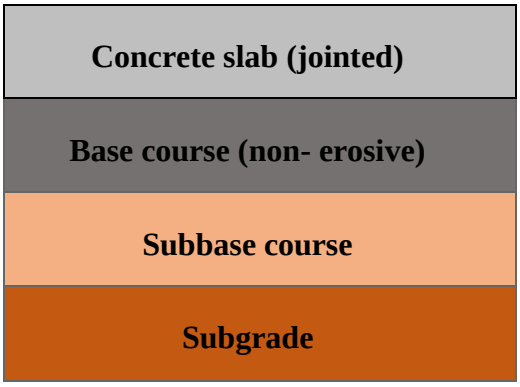


Figure 2 : Rigid Pavement Cross-section

2.5 Pattern of Pavement Damages

Patterns of pavement damages is the types of deterioration happened to pavement surface layer. Pavement deterioration is the process by which distress (defects) develop in the pavement under the combined effects of traffic loading and environmental conditions (Sharad.S.Adlinge). Other than that, pavement deterioration is the process by which distress develop in pavement under the combined effect of traffic loading (Magdi M. E. Zumrawi, 2016). There are three major categories can be considered influencing to pavement deterioration for this case study which are:

2.5.1 Cracking:

Pavement cracking severity was usually evaluated just by crack width in the past (Yang, 2017). It is occurring due to physical change of the pavement.

2.5.1.1 Fatigue cracking / alligator cracking

A series of interconnected cracks creating small, irregular shaped pieces of pavement. It is caused by failure of the surface layer or base due to repeated traffic loading (fatigue).

Figure 3 : Fatigue Cracking

2.5.1.2 Longitudinal cracking

A long crack that run parallel to the center line of the roadway. These may be caused by frost heaving or joint failures, or they may be load induced.

Figure 4 : Longitudinal Cracking

2.5.1.3 Transverse cracking

Transverse cracks form at approximately right angles to the centerline of the roadway. They are regularly spaced and have some of the same causes as longitudinal cracks.

Figure 5 : Transverse Cracking

2.5.1.4 Block cracking

Block cracking was an interconnected series of cracks that divides the pavement into irregular pieces.

Figure 6 : Block Cracking

2.5.1.5 Edge cracking

Edge cracks typically start as crescent shapes at the edge of the pavement. They will expand from the edge until they begin to resemble alligator cracking. This type of cracking results from lack of support of the shoulder due to weak material or excess moisture.

Figure 7 : Edge Cracking

2.5.2 Surface deformation

Pavement deformation was the result of weakness in one or more layers of the pavement that has experienced movement after construction. The deformation may be accompanied by cracking. Surface distortions can be a traffic hazard (Sharad.S.Adlinge). For this case study, the types of surface deformation can be considered to analysis is rutting.

2.5.2.1 Rutting

Rutting was the displacement of pavement material that creates channels in the wheel path. Very severe rutting will actually hold water in the rut. Rutting was usually a failure in one or more layers in the pavement. The width of the rut was a sign of which layer has failed.

Figure 8 : Rutting

2.5.3 Disintegration:

The progressive breaking up of the pavement into small, loose pieces was called disintegration (Sharad.S.Adlinge). If the integration was not repaired in its early stages, completed reconstruction of the pavement was needed. The two most common types of disintegration which were potholes and patching:

2.5.3.1 Potholes :

Potholes were formed when the pavement disintegrates under traffic loading, due to inadequate strength in one or more layers of the pavement, usually accompanied by the presence of water. Most potholes would not occur if the root cause was repaired before development of the pothole (Sharad.S.Adlinge).

Figure 9 : Potholes

2.5.3.1 Patches

A patch was defined as a portion of the pavement that has been removed and replaced. Patches are usually used to repair defects in a pavement or to cover a utility trench. Patch failure can lead to a more widespread failure of the surrounding pavement.

Figure 10 : Patching

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

In the case study the method that would be used to get more detailed information to analyzed. Through this chapter, it would give a better understanding about the research in detail, particularly how research was conducted and the information that had been discusses was a process and how the way to explain the correct data so that the research would conducted smoothly and the information provided were true and have their evidence. In general, there were two methods of carrying out the research which were Frequency Analysis to achieve the first objectives which was to identify the pattern damages on Federal roadways in Kuantan City. Then, the Correlations Analysis in achieving the second objective, which was to evaluate the association of traffic operations terms of traffic loading and traffic volume towards pavement damages on Federal roadways in Kuantan. The data was very useful to the study to gain more information to analyze. This chapter had been discussed briefly about the methodology that had been used in this study. It also describes the locations of the case study data collection, the statistical and mathematical analysis and the Highway Standard.

3.2 Chart Review Methodology

In this study, the first step was provided a flow chart of the study as shown in Fiqure 11, to implement of the study. At the beginning of this study, related research had been studied to find the scope of case study, which was related with this topic. The location of the study determined before doing the next job processes. The next process was collect the routine inspection data by the agencies based on that selected roadways. Then, identify the data of traffic operations in terms of traffic volume and traffic loading. Results of collected data was gathered and analyzed. After analysed, the study are continue with discussed and finally conclusions and recommendations made.

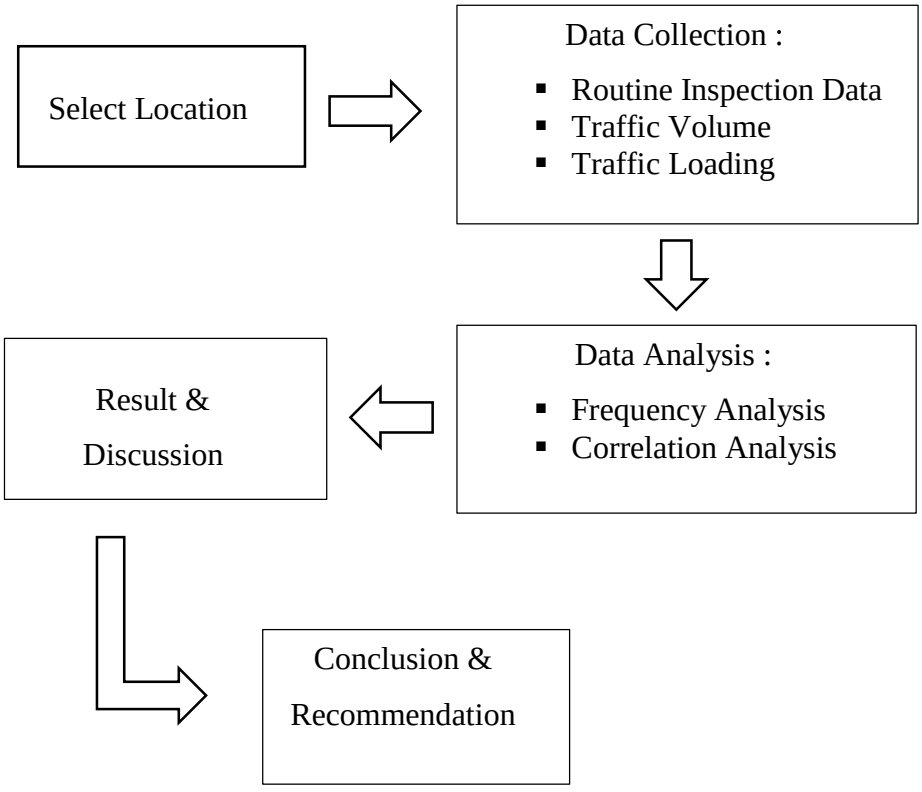


Figure 11**:** Flow Chart Methodology

3.3 Site Location

In accomplish research objectives, three types of Federal Roadways in Kuantan Pahang was selected to conduct the analysis such as Federal Route 2, Federal Route 3, and Federal Route 18. The selection criteria of the Federal Roadways were: (a) as a main road and regular roadways that heavy vehicles commonly used; and (b) available data because of this study was conducted according to the secondary data in years 2014 until 2016. The area was selected which are:

Figure 12 **:** Federal Route 2

Figure 13 **:** Federal Route 3

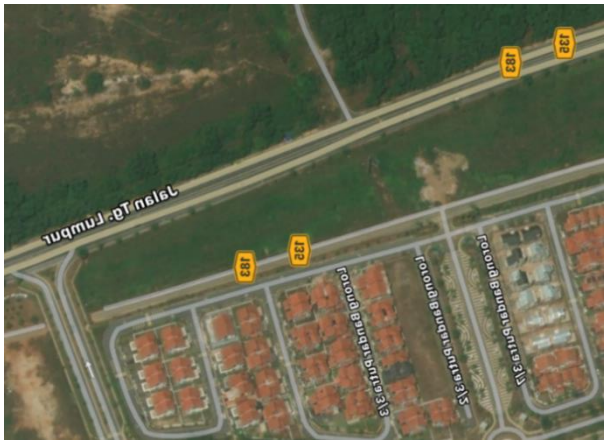


Figure 14 **:** Federal Route 183

3.5 Data Collection

In this study, the data collection involved was secondary data of routine inspection from Road Care. Other than that, the data for Traffic Volume was taken from Road Volume Traffic Malaysia (RVTM) including the data for the traffic loading. All these data were needed to achieve the aims of evaluation on pavement damages on Federal roadways and the total of traffic volume for each roadway.

3.5.1 Route Inspection Data

The route inspection data for this study were included the types of damages pattern such are rutting, cracking and potholes, length of road damages area, date the road was checked, and an actions had been conducted to solve the problem. This data was needed to help find out the types of common pavement damages pattern for the Federal Roadways in this study.

3.6.2 Traffic Operations Data

In this study, the parameter was involved for traffic operations data were traffic volume and traffic loading which was to find the probability have the association between pavement damages according to aims of this study. As mention earlier, the traffic volume will discuss for all types of class vehicles factors (C1, C2, C3, C4 and C5) and certain class vehicles focus on commercial vehicle (C2, C3 and C4) for traffic loading data. These two parameters of traffic operations were conducted in a same unit vehicles per hour that has been taken in the traffic volume data. The data of traffic volume was taken from Road Volume Traffic Malaysia (RVTM) to analyze the total of traffic volume. It was used to identify the association between of traffic volume and traffic loading towards pavement damages on Federal Roadways.

3.7 Data Analysis

The data analysis a process of transforming data and result determination according to data collected and the aims of study. In this study the data analyses were used to identify the damages pattern according to the first objectives of case study and the association of pavement damages with the traffic characteristic in terms of traffic volume and traffic loading towards pavement damages. In addition, in this case study, the types of data analysis were used which were Frequency Analysis and Correlation Analysis.

3.7.1 Frequency Analysis

Frequency Analysis a part of Descriptive Statistic which was the number of times an event occurs. In this study, this frequency analyses were used to identify the pavement damage patterns on the selected federal roadways in years 2014 until 2016 by using

Routine Inspection Data. Then, the analysis also was used for summarize the total of traffic loading and traffic volume according to the types of road. The result was obtained from the analysis would come out with histogram graph to conducted the discussion easier to conclude and recommend.

3.7.2 Correlation Analysis.

Correlation Analysis was used to study the strength of the association between the traffic characteristic traffic volume and traffic loading towards pavement damages. The strength of the association was defined based on the correlation coefficient value. The correlation coefficient value *(r)* was conducted with two parameters which were the dependent and independent to get their strength of association.

Table 4 : Strength of Correlation Coefficient

VALUE OF R	DESCRIPTION
$r = -0.1$	Perfect negative correlation
$-1.0 < r \leq -0.7$	Strong negative correlation
$-0.7 < r \leq -0.5$	Moderate negative correlation
$-0.5 < r < 0$	Weak negative correlation
$r = 0$	No correlation coefficient between two variables
$0.0 < r < 0.5$	Weak positive correlation
$0.5 < r < 0.7$	Moderate positive correlation
$0.7 \leq r < 1.0$	Strong positive correlation
$r = 1.0$	Perfect positive correlation

Correlation coefficient *(r)* = $\frac{Sxy}{\sqrt{SxxSyy}}$

Dependent (x) = Traffic volume /traffic loading

Independent (y) = Road damages

p-value < 0.05.

Using formula above, the value of *(r)* had been produced and the relationship for these parameters automatically known as shown in Table 4. The positive correlation has presented the positive association for these two parameters and the negative correlation association was otherwise. To analyses the parameter were significant or not the two hypotheses was produced in identify whether the correlation of this relationship is significant or not. The hypotheses such as below:

i. Ho = There is no correlation between two variables.

ii. H1 = There is a correlation between two variables.

Other than that, the significance value was used according in this study to interpret the significance and not significance association between traffic operations in terms of traffic volume and traffic loading towards pavement damages according to the number of p-value. For the significance association the value should be less than 0.05 unlike for not significance was otherwise.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter shows the analysis and results that had been done and obtained. After going through the literature review in Chapter 2 and the methodology of study in Chapter 3, the study was carried out at the selected area. The results were interpreted and analysed based on the formulated objectives. In this section the total of pavement damages by road for three consecutive years and the association between pavement damages and traffic operations was obtained and reported. The results of frequency and percentages for total pavement damages and correlation association between pavements and traffic operations in terms of traffic volume and traffic loading by using SPSS software are also presented.

4.2 Pavement Damages Pattern on Federal Roadways in Kuantan

The aim of this study was to identify the most common pavement damages occurred on Federal Roadways in Kuantan area. As mention in the previous chapter 3, this research has been conducted by using secondary data from Road Care consist of the three types of selected area within three years operations (2014, 2015 and 2016). Data analyses had been done for these three consecutive years to get the accurate result and the differences for each area. The data was analysed

by using frequency analyses of pavement damage by route. The figures 16 below shows the total of pavement damages for the three selected roadways in Kuantan.

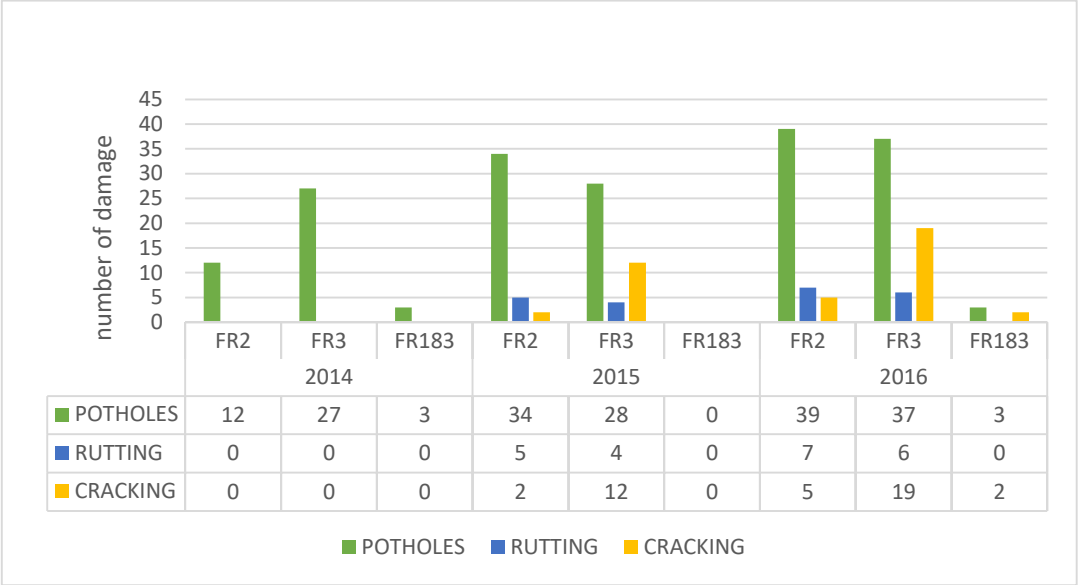


Figure 15 : Pavement Damages on Kuantan Federal Roadways

As a result, obtained in Figure 15 above, the high frequency of pavement damages pattern was potholes for the three consecutive year for all the three selected area with total 42 in year 2014, 62 for 2015 and 79 for 2016. Potholes was a one of the most dangerous damages to user because of the uneven shape. Hitting a pothole can dent or puncture the undercarriage of your ride (Erik. In other words, fluid leaks and wear leading to rust formation are just the beginning (David, 1965). From the result obtained, it was shows that all of these three types roadways have a same pattern of pavement damages which were potholes, cracking and rutting and the most common pattern of pavement damages was potholes. The highest total of potholes pattern damages was at Federal Route 2 with total value 85 potholes. This location was a most regular road in Kuantan and it was linked from Gambang to Kuantan and had a high traffic operation every day. For the

further explanation the data pavement damages will discussed based on each types of Federal Roadways.

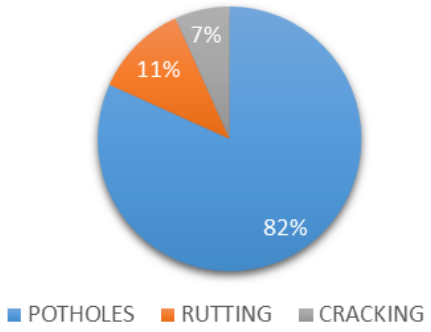


Figure 16 : Percentages of Pavement Damage at Federal Route 2

Referring to the Figure 16 above, it was shown the percentages of pavement damages along the Federal Route 2 in the three consecutive years started 2014 until 2016 was differences according to the types of damages pattern. From the tables, the percentages of potholes for this FR much higher compared to another pattern which were cracking and rutting. Based on the Figure 16 the result was obtained and shown the total percentages of potholes is 82% for the highest value this roadway. Meanwhile, the total percentages of rutting were 11% and the lowest percentages for damages pattern was cracking with value 7%. Other than that, by the frequency, the highest value of pavement damages is still on potholes patterns with value 85 damages for total of these three consecutive years and followed to rutting with frequency 23 and the lowest value was cracking with frequency value 7 numbers of damages based on the Figure 15.

As a main road from Gambang to Kuantan, FR 2 has to accommodating daily traffic expanses to meet the needs and activities of surrounding communities. Due to this in flight activity

and overload traffic from overpasses, road surfaces along this federal roadway has undergone many changes. One of the reasons due to this problem is the increases of traffic operations that need to support by this road. So that, this problem of pavement damages has become larger day by day according to the load of huge traffic operation that occurred along the route.

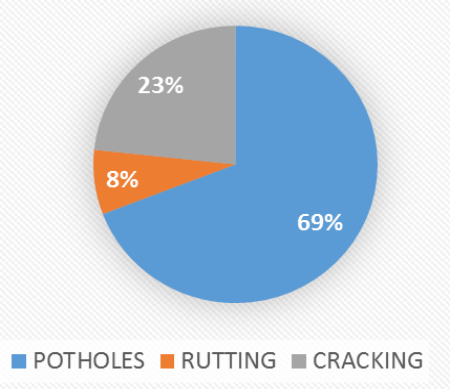


Figure 17 : Percentages of Pavement Damage at Federal Route 3

Based on the Figure 17 above, it was shown the percentages of pavement damages along the Federal Route 3 in these three consecutive years from 2014 until 2016 was slightly same Federal Route 2 which is have a differences value according to the types of damages pattern. From the Figure 17, the percentages of potholes much higher compared to another pattern like cracking and rutting. From the table and figure above, it was the total percentages of potholes was 69% which was the highest value for this section. Meanwhile, the lowest total of damage percentages was rutting with value 8% and the medium value for this percentages of damages pattern was cracking with value 23%. Furthermore, by the frequency, the highest number of pavement damages was still on potholes with value of 92 for total of three consecutive years and followed to cracking with frequency of 31 and the lowest value was rutting with frequency value of 10 numbers of damages for this Federal Roadways based on the Figure 15.

Then, FR 3 as a main road role located along the East Bound Kuantan Bypass, these Federal Roadways has to longsuffering daily traffic expanses for user do their activities as traveller. Other than that, as a strategic place connections road to Kuantan Port this FR also included as a need for heavy vehicles such as track and lorries to run their daily transfer and transport by using this road. Due to overload traffic from overpassed, road surfaces along this Federal Roadway has undergone many changes. So that, the size of pavement damages has become larger day by day according to the load transfer every day and sometime exceed the design pave limit and it may occur deterioration on the pavement surface. Based on the previous study, paved roads would permanently damage by design loads that exceed the fatigue limit of the material mixture, so at this stage the pavement life is exceeded (I Sholichin1, 2018). Planning limits of strain crack (tired/broken) and the magnitude of the repetitive load, meaning more and more loads passing, then the fatigue will occur quickly, let alone the repeated burden of greater weight will accelerate the process of fatigue of the material (I Sholichin1, 2018).

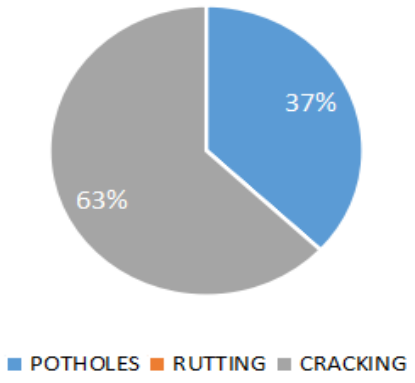


Figure 18 : Percentages of Pavement Damage at Federal Route 183

Based on the Figure 18, it was shown the percentages of pavement damages along the Federal Route 183 in the three consecutive years started from 2014 until 2016 were slightly same

with two previous data for Federal Route 2 and Federal Route 3 which was have a rare differences value consist of each types of damages pattern. From the Figure 18, the highest total percentages of pavement damages were potholes with total 63% which is the highest value for this section. Then, the second highest total of damage percentages was cracking with value 37% and 0% value for damages pattern of rutting. Furthermore, by the frequency according to Figure 15, the highest value of pavement damages was still on potholes with value of 6 for total of three consecutive years and followed to cracking with frequency of 2 and the zero value for rutting for the numbers of damages for this Federal Route. The total of this pavement for FR183 was difference compared to FR 2 and FR3 because of the area was near to the City. So that, this area location of FR 183 are not exposes to the heavy vehicles such as heavy truck, bus and lorries used for their activities.

According to these three selected roadways, the result obtained shown that the most common pattern of pavement damages occurred on the Federal Roadways in Kuantan was Potholes. For this three consecutive year 2014 until 2016 for all the selected roadways the total of potholes by frequency analysis of 189. It was a large value for road deterioration and surely effected to road congestion and give a bad condition for user to fix their traveller activities. Then, the second-high value of pavement damages was cracking pattern with the total frequency value of 39. Cracking is where the damages occur in the surfaces layer of the road (Rapar, 2018). Cracking can be integrated because the soil road base is not good paving material, which exceeds the load capacity of road traffic, in general, the location of occurrence of cracking is not extensive (Rapar, 2018).Other than that, the lowest total of pavement damages is Rutting pattern with value 24 of damages for all selected roadways in the three consecutive years. Rutting happened because of the repeated traffic loading movement. It was also happen because the low quality of materials and the poor sub base in construction. Rutting is a one of the most deterioration that always happen

on the Federal Roadways and categorize as an important defect to be considered for further actions (Ishamuddin, 2019).

4.3 Evaluation on The Association Between Traffic Operations (Traffic Volume and Traffic Loading) and Pavement Damages

Before proceeded with an evaluation the association between traffic operations (traffic volume and traffic loading) and pavement damages, the value of traffic operations (traffic volume and traffic loading data should be checked first to ensure the type of analysis that should be used and furthermore a correct association could be build.

4.3.1 Frequency Analysis

In this study, the traffic volume has been analysed before proceeded with evaluation the association between traffic operations (traffic volume and traffic loading) and pavement damages. In this stages all the types of vehicle classes have been considered to get the accurate result in evaluation. As mention in the previous chapter, the time period of traffic volume had been considered in achieving the aims of the study which were 2014, 2015 and 2016. Then, as shows in Figure 19 below, the y axis of the graph was presented the types of selected roadways in Kuantan that has been considered to achieve the goal of the study in evaluation of the traffic operations and pavement damages.

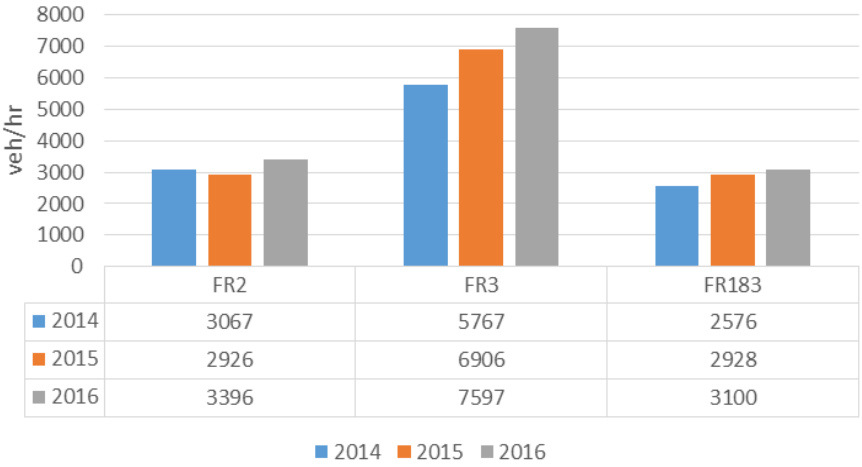


Figure 19: Traffic Volume on Kuantan Federal Roadways

As the result obtained in the Figure 19, the data was collected from RTVM for the three consecutive years started 2014 until 2016 on the three selected roadways in Kuantan. Based on the Figure 19, it shows that the highest traffic volume was on Federal Route 3 because of the most strategic area and as the main road for East Bound Kuantan Bypass. According to the data obtained, it was shows that there are moderately increased of the total traffic volume for FR3 and FR 183. But, difference to FR2 have a slightly decreased started from 2014 to 2015 and becoming increased from 2015 to 2016 like others roadways. The data shows there was not a large difference of total traffic volume for these three types of road and time of analysing.

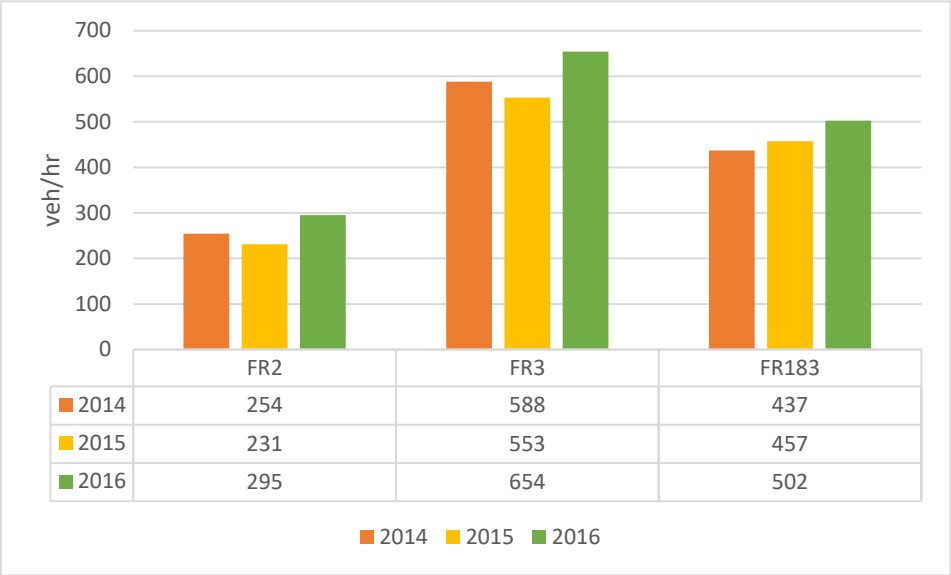


Figure 20: Traffic Loading on Kuantan Federal Roadways

According to the Figure 20 above, the classes of vehicle that has been considered in this study were C2, C3 and C4 presented as a commercial vehicle. Commercial vehicles were known to be as principles factor towards pavement damages. Damages on the roads are primarily caused by the heavier axle loads associated with large commercial vehicles (Kordi N. E., 2012). As a result obtained in the Figure 20 above there was a difference value of traffic loading according to the years and the types of roads observation. But the highest value of traffic volume was on FR 3 for all the three years observation which were 2014, 2015 and 2016. It is because of the criteria of this FR 3 as a backbone and main road for its communities and user on Kuantan City.

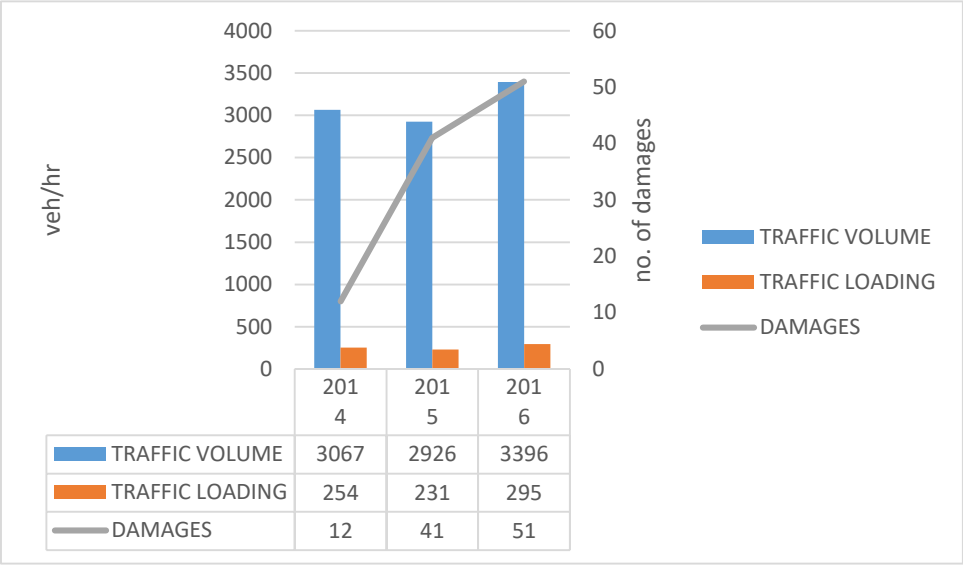
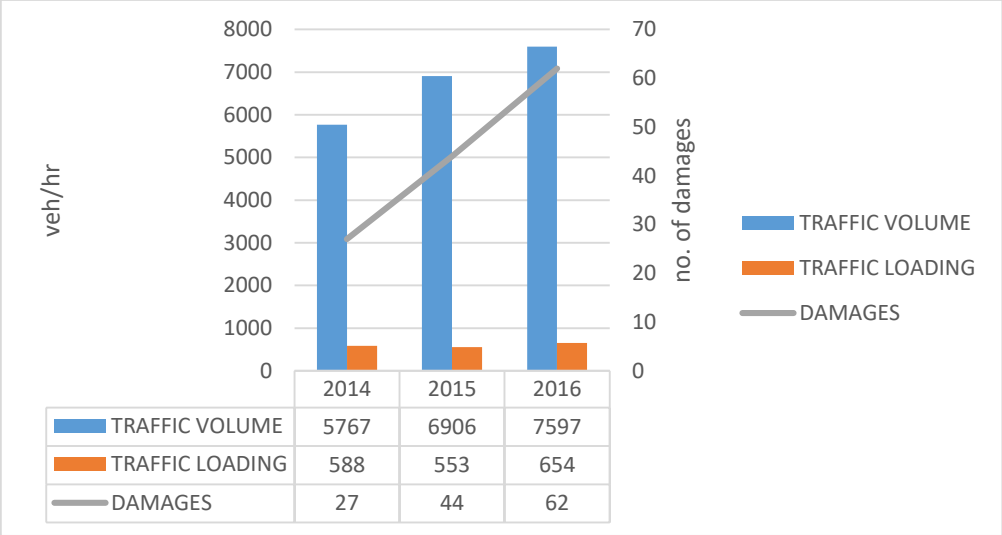


Figure 21: Traffic volume and Traffic loading towards Pavement Damages on FR 2.

As the result obtained based on the Figure 21. There was a linearity association between traffic operations in terms of traffic volume and traffic loading for all the types of parameter measured. Based on the Figure 21, it was proved that according to the data was analyzed on the FR 2, when the total of traffic volume increased the number of pavement damages also increased. It was clearly shows that there was a linearity association between traffic volume and pavement on the FR2 especially in years 2014 and 2016. A large value of total volume give a huge number of pavement damages as we can see in the Figure 21 in year 2014, the value of the traffic volume is 3067 veh/hr and followed to the number of pavement damages was 12 and then for 2016 the value traffic volume is 3396 veh/hr and the number of pavement damages was 51, this value clearly shows that the high traffic volume value gave a high value of pavement damages.

Other than that, there were same case for the traffic loading parameter in result of evaluation the association between traffic loading and pavement damages. According to the result was obtained in the Figure 21 for FR 2 in years 2015 and 2016, the traffic loading in 2015 was 231 veh/hr then slightly increased in the year 2016 with the total traffic loading 295 veh/hr. Meanwhile, the number of pavement damages also shown the similarity with 41 total of damages in 2015 then slightly increased to 51 total of damages in 2016. It is clearly shows there was as a similar increment trend for traffic loading and number of pavement damages for FR 2.



	2014	2015	2016
TRAFFIC VOLUME	5767	6906	7597
TRAFFIC LOADING	588	553	654
DAMAGES	27	44	62

Figure 22 : Traffic volume and Traffic loading towards Pavement Damages on FR3.

Then, for the FR 3 there was a similar case with FR 2 consist of to the graph interpret in the Figure 22. Linearity association between traffic operations (traffic volume and traffic loading) was obtained for all the parameter measured. Based on the analyses it was shows that when the traffic operations increased the number of damages also increased similar with FR 2. As the result obtained for the for the FR 3 in year 2015 and

2016, the value of the total traffic volume in 2015 was 6806 veh/hr then moderately increased in the year 2016 with the total traffic loading 7597 veh/hr. Meanwhile, the number of pavement damages also shown the similarity with 44 total of damages in 2015 then slightly increased to 62 total of damages in 2016. It is shows there is as a similar increment trend for traffic loading and number of pavement damages for FR 3.

Furthermore, there were a same case for the traffic loading parameter in result of evaluation the association between traffic loading and pavement damages. According to the result was obtained in the Figure 22 as data analyses for FR 3 in years 2015 and 2016, the total traffic loading in 2015 was 553 veh/hr then slightly increased in the year 2016 with the total traffic loading 654 veh/hr. Meanwhile, the number of pavement damages also shown the similarity trend increment number of pavement damages with 44 total of damages in 2015 then slightly increased to 62 total of damages in 2016. According to the data obtained, there was a similar increment trend for total of traffic loading and number of pavement damages for FR 3.

As a result, obtained from the analyses, there were an association traffic operation (traffic volume and traffic loading) towards pavement damages on the FR 3 because of the similar incremental value and graph trend was slightly same and interpret that when the total value of the traffic loading increased the number of pavement damages also increased.

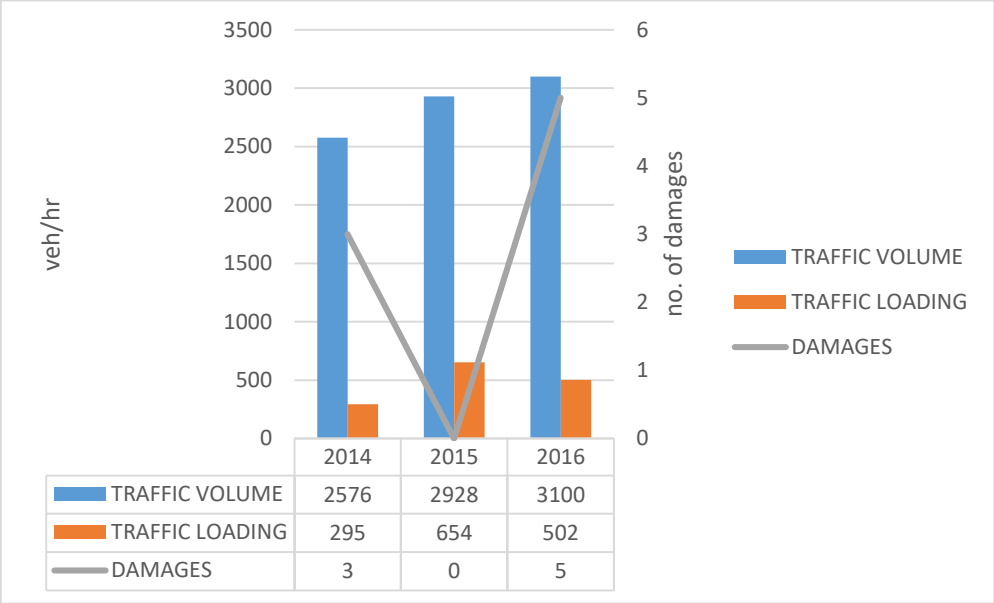


Figure 23: Traffic volume and Traffic loading towards Pavement Damages on FR183.

Based on the result obtained, Figure 23 interpret that FR183 have a slightly differences result obtained for association of traffic volume and pavement damages compared to FR 2 and FR 3 based on the line graph and histogram chart created. The line trend for number of damages shows that there was no association between traffic operations in terms of traffic volume with number of pavement damage for FR 3. According to the result obtained, in years 2014 and 2015 when the total of traffic volume increased the number of pavement damages was decreased unlike the result for 2015 and 2016, when the total of traffic volume increased the number of pavement damages was increased dramatically. Here, it was proved there no association between traffic volume and pavement on the FR 183 especially in years 2014 until 2016, there was a hit trend of graph as presented in the Figure 23. The result shows the value of the total traffic volume in 2015 was 2928 veh/hr then moderately increased in the year 2016 with the total traffic

loading 3100 veh/hr. Meanwhile, the number of pavement damages was slightly decreased with number of damages with zero damage in 2015 then slightly increased to 5 in 2016. It was shows there was not a smooth increment trend for traffic loading and number of pavement damages for FR 183.

Then, there were a same case for the traffic loading parameter in result of evaluation the association between traffic loading and pavement damages. According to the result obtained in the Figure 23 as data analyses for FR 183 in years 2015 and 2016, the total traffic loading in 2015 was 654 veh/hr then slightly decreased in the year 2016 with the total traffic loading 502 veh/hr. Meanwhile, the number of pavement damages also shown there was no similarity trend increment number of pavement damages and traffic loading. It would can be cause of the location of the roadways area and the lowest of traffic loading occurred on FR183.

As a result, obtained from the analyses of FR 183, there were no association between traffic operations (traffic volume and traffic loading) towards pavement damages on FR 183 because of the trend for all parameters (traffic volume, traffic loading and pavement damages was difference for FR 183.

4.3.2 Correlation Analysis

In addition, to prove the result was reliable the correlation analysis was used in order to evaluate the association between traffic operations in terms of traffic loading and traffic volume towards pavement damages. The result of correlation was defined by using

SPSS software which was when (r) more than 0.1 there is positive association between parameters. The strong association of the correlation is within 0.7 to 1.0 for r value. The hypothesis for the correlation analysis test can be stated as bellows:

i. Ho = There is no correlation between two variables.
ii. H1 = There is a correlation between two variables.

When r value close to 1 it was a strong correlation between parameters. Then, when significant value (p-value) less than 0.05 we reject Ho and accept H1.

Based on the result obtained from the Table 5 below, it was shows the r value for the FR 2 is 0.456 it is means this a weak positive correlation relationship between traffic operations in terms of traffic volume towards pavements damages but not significant because the p-value for these two relationship was more than 0.05 which is p-value 0.697 so we reject Ho. Then, for traffic loading the r value for traffic loading less than 0.01 which was -0.059 and p-value 0.227 greater than 0.05 so we reject ho. Since both of these types of associations reject Ho it was means there was a correlation between two variables which was the associations between (traffic volume and traffic loading) towards pavement damages on FR 2. It was shown when the traffic parameter increased the number of potholes also increased.

Table 5 : Matrix of correlation (r) and significant (p-value) among variables for Federal Route 2

FEDERAL ROUTE 2	NO. OF DAMAGES	TRAFFIC VOLUME	TRAFFIC LOADING
NO. OF DAMAGES	-	0.456	-0.059
(P-VALUE)	-	(0.697)	(0.227)

Other than that, based on the result obtained in Table 6 below, it was shows the r value for the FR 2 was 0.987 it was means this a strong positive correlation between traffic operations in terms of traffic volume towards pavements damages and p-value more than 0.05 which was p-value 0.101. Since the p-value for traffic volume and pavement damages greater than 0.05 Ho was rejected. When the Ho rejected, there was no correlation between correlations between traffic volume towards pavement damages. Meanwhile, for r value for traffic loading obtained was 1.000 which was strong positive correlation and significant with p-value 0.004 less than 0.05 so Ho was accepted. Since the Ho accepted, there was no correlation between traffic loading towards pavement damages for FR3.

Table 6: Matrix of correlation and significant (p-value) among variables for Federal Route 3.

FEDERAL ROUTE 3	NO. OF DAMAGES	TRAFFIC VOLUME	TRAFFIC LOADING
NO. OF DAMAGES	-	0.987	1.000
(P-VALUE)	-	(0.101)	(0.004)

According to the result obtained in Table 7 below, it was shows the r value for the FR 2 was 0.926 it is means this a strong positive correlation between traffic operations in terms of traffic volume towards pavements damages but not significant because the p-value for these two relationship was more than 0.05 which is p-value 0.246 so Ho was rejected. It was shows there is a correlation between traffic volumes towards pavement damages for FR183 since the Ho was rejected. Meanwhile, for the traffic loading on FR 183, Ho was acceptance because of the r value for traffic loading obtained is 1.000 and p-value 0.00 which is less than 0.05 for Federal Route 183. Since the Ho was accepted, there no correlation between traffic loading towards pavement damages for FR 183.

Table 7 : Matrix of correlation and significant (p-value) among variables for Federal Route 183

FEDERAL ROUTE 183	NO. OF DAMAGES	TRAFFIC VOLUME	TRAFFIC LOADING
NO OF DAMAGES	-	0.926	1.000
(P-VALUE)		(0.246)	(0.000)

Since most of the analysis of association between traffic operations in terms of traffic volume and traffic loading towards pavement damages rejected Ho, the H1 was accepted there was a correlation between (traffic volume and traffic loading) towards pavement damages because most of the variables presented p-value more than 0.005. As a result, there was an association between traffic operations (traffic volume and traffic loading) towards pavements damages. It was because of there is a same incremental value of traffic operations towards pavements damages.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter would summarize the studies that have been conducted and concluded based on the analysis and the results already obtained. Through the collected data from Roadcare for Routine Inspection data for FR2, FR3 and FR183 and Traffic volume data from RVTM a results and discussion was conducted and various findings and results are obtained. Analysis based on common pattern damages on the Federal Roadways in Kuantan and the association between traffic operations and pavements damages has been done. All types of Federal Route have a same highest for total value of pavements damages which was potholes and it was because the all these road was maintained from the same agency and play a same role as a main road for Kuantan City. Then, for association for the traffic operations and pavements damages there were an association between traffic operations (traffic volume and traffic loading) towards pavements damages It was because of there was a same incremental value of traffic operations towards pavements damages. Other than that, there were another factor that was influencing the pavement damage because of Kuantan City was one of the location that always facing with a climate problem and monsoon session. In addition, the problems faced during the study were presented and some suggestions to improve the study of the future has been made.

5.2 Conclusion

This study was done to study on pavement surface condition attributed to traffic operations on federal roadways in Kuantan. As stated before in chapter one, the objective of this study were:-

i. To identify the common pavement damage patterns on the Federal Roadways in Kuantan.

ii.To evaluate the association of traffic loading and traffic volume towards pavement damages on Federal roadways in Kuantan.

Pavement surface condition attributed to traffic operations on the Federal Roadways in Kuantan was successful determined. The challenging part of this study was to analysis the secondary data. From the finding, it can be concluding that this study was achieved all of the objectives. Based on the analysis that has been done in chapter four, the road defect and overload traffic from overpassed, road surfaces along Federal roadway has undergone many changes. This situation could arise due to new commercial facilities bringing additional vehicles heavy vehicles required for some major construction activities for the new residential area, changes weather, and the quality of the materials there are used for pavement structure.

According to the result obtained in achieving for the first objective of the case study there was shows that most common pavement damages pattern occurred on the Federal Roadways in Kuantan which was Potholes. It was because of the site location for the three types of Federal Roadways was chosen have same role play as backbone for Kuantan City and the most regular route for the heavy vehicles user. The large of total heavy vehicles used may contribute to the pavement damages. A particular deleterious aspect of this increased relates to heavier commercial vehicles and heavier vehicular loads (Judin, 2011). Furthermore, the lack of maintenance has a

potential factor may have affected the Potholes. In general, the road damages can be caused by the water flow, pavement construction materials, climate, unstable soil conditions and poor compaction process on layer above the subgrade (Achmad Wicaksono, 2015).

Then, the result was obtained for the second objectives according to the histogram graph it was shows that there was an association between (traffic volume and traffic loading) towards pavement damages because two types of FR consist of three types FR interpret when the value of traffic operations increased the number of pavement damages also increased. It is clearly show there an association between traffic operations in terms of (traffic volume and traffic loading) towards pavement damages. Furthermore, it was proved when the correct association between traffic operations (traffic volume and traffic loading) towards pavement damages was presented using the statistical approach in terms of correlation analysis has been proceeded.

By using the correlation analysis, the result of parameters gave a similar trend with histogram chart there was an association between traffic operations (traffic volume and traffic loading) towards pavements damages since most of the analysis was rejected Ho.

It was presented since the result shown between the highest value r is 0.987 on the FR3 with a p-value of 0.101 which is more than 0.05 and not acceptable. But for FR 183 the Ho was rejected and the H1 was accepted since the positive correlation and significant between traffic loading and pavement damages for FR 183 with the r value is 1.0 with the lowest p-value with 0.00. But most of the result presented there were an association between the two variables. As a conclusion, traffic operations was influenced to pavement damages but not certainly significant because most of the p-value was greater than 0.05. Another factors have been considered may

influences the association such as heavy rainfall weakens road structure and low quality in materials used in construction.

5.3 Recommendation

During the data collection, there were some problems that had been faced in obtaining the data. The local authorities and private agency does not give total cooperation to provide the route inspection data. This is because of this data was under controlled document so there are many procedures should be taken to get the data. Then, many consultations should be involving because all of the data was from and saved by Technical Assistant from HQ. Other than that the staff at the agency was too busy with their site work. That's why they don't have a lot of time to entertained outsiders and not giving cooperation. This problem was effected the researcher take a long time to get the data.

Furthermore, for the data analyses, lack of knowledge on using the software complicate the situation in analysing data. The data should be analysing by using software to make the analyses easier but, the lack of knowledge make the process of data analyses more difficult. It is may drag a long time and difficulty for researcher to complete the task.

Therefore, there were few recommendations for future study purposes that stated below: -

i. Make a preliminary study on pavement damages so that it may be can easily help to get the idea in writing.
ii. Always prepared the knowledge about the study especially the parameter involving to make the data collection and data analyses easier.

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APPENDICES