

A STUDY OF THE LEVEL OF
SATISFACTION OF USER ON BRIDGE
MANAGEMENT SYSTEM – CASE STUDY,
PENANG SECOND BRIDGE

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A STUDY OF THE LEVEL OF SATISFACTION OF USER ON BRIDGE
MANAGEMENT SYSTEM – CASE STUDY, PENANG SECOND BRIDGE

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ABSTRAK

Jambatan adalah satu struktur yang memerlukan pemerhatian yang berterusan dan pemeriksaan yang tersusun untuk mengelakkan kemalangan. Langkah-langkah pencegahan yang komprehensif dan penyelenggaraan yang dilaburkan pasti akan membantu mengurangkan kos yang ditanggung bukan sahaja pada pembaikan tetapi kerugian lain yang mungkin disebabkan keruntuhan struktur. Oleh itu, pengurusan penyelenggaraan adalah penting dan amat diperlukan untuk mengekalkan fungsi mereka dan untuk keselamatan semua pengguna dan mengekalkan keselesaan dan keyakinan mereka semasa menggunakan jambatan. Sehubungan dengan itu, satu kajian mengenai prosedur dan pemeriksaan jambatan dijalankan untuk mengenal pasti kerosakan pada struktur jambatan dan juga mengukur tahap kepuasan pengguna Jambatan Kedua Pulau Pinang. Data dikumpulkan melalui soal selidik yang dibangunkan bagi pengguna jambatan dan juga unit pengurusan penyelenggaraan Jambatan Kedua Sdn. Bhd. (JKSB). Berdasarkan kajian kes, kerja-kerja penyelenggaraan adalah penyelenggaraan rutin, kerja-kerja pembaikan berat, kerja menaik taraf, dan pemeriksaan jambatan. Pengurusan penyelenggaraan JKSB menggunakan Integrated Asset Management System (IAMS) untuk mengekalkan jambatan tersebut. Keputusan kajian ini mengenal pasti kerosakan utama di jambatan adalah lubang di jalan dan serpihan. Ia juga menunjukkan bahawa majoriti pengguna jambatan berpuas hati dengan kerja-kerja penyelenggaraan yang dijalankan.

ABSTRACT

Bridge are structures that require continual, arduous attentions and organized inspections in order to prevent calamity. Comprehensive preventative measures and maintenance that were invested will definitely help to diminish the cost incurred not only repair but also on other losses that might be caused due to structural collapse. Therefore, maintenance management is vital and greatly needed to sustain their functions for the safety of all users and in maintaining their comfort and confidence while using the bridge. With regards to this, a study on procedure and bridge inspection was conducted to identify damages in bridge structure and also gauge the level of satisfaction of users of the Penang Second Bridge. The data was collected via questionnaires develop for the bridge users and also the maintenance management unit of JKSB. Based on the case study, work maintenance on the bridge constitutes are routine maintenance, heavy repair work, upgrading work, and bridge inspection. JKSB maintenance management was using Integrated Asset Management System (IAMS) to maintain their bridge. The study identified the main damage on the bridge are pothole and spalling. It also showed that majority of the bridge users are satisfied with the maintenance work carried out.

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LIST OF ABBREVIATIONS

JSAHMS	Jambatan Sultan Abdul Halim Mu'adzam Shah
PBSB	Penang Bridge Sdn. Bhd
FHWA	Federal Highway Administration
JKR	Jabatan Kerja Raya
JKSB	Jambatan Kedua Sdn. Bhd
MHA	Malaysian Highway Authority
SPSS	Statistical Package for Social Science

CHAPTER 1

INTRODUCTION

1.1 Introduction

Penang Second Bridge or its other name Jambatan Sultan Abdul Halim Mu'adzam Shah (JSAHMS), is a dual carriageway toll bridge in Penang connecting Batu Kawan (Penang Mainland) to Batu Maung (Penang Island). This 24-kilometer bridge was officially opened to public on 2 March 2014 by our 6th Prime Minister, Datuk Seri Najib Tun Razak and renamed after the reigning Yang di-Pertuan Agong of Malaysia, Tunku Abdul Halim Muadzam Shah.

After the bridge was fully constructed, the bridge management system play a vital role to sustain their functions to improve the safety and reliability of the bridge. The effectiveness of way of usage and budget estimation in the control of work, scheduling of work system and planning, standards used, material and cooperation of all parties are all depending on a good management system.

Inspection and observation are the most vital factor in asset management system. Inventory are the important information needed so that every maintenance works can be monitored with more efficient and well organized according to the bridge management system for every item and renewal of the item from time to time according to the requirement.

Besides that, the main objective of the bridge management system is to make sure all the maintenance activities are well planned and controlled in perfect condition so the lifespan of the bridge can be extended. By saying that, the bridge management system should be ascertained always in a good condition so the bridge built will always be safer to use.

1.2 Problem Statement

Through monitoring and scheduled inspection conducted, the early signs of damage on asset will be able to identify thus the maintenance work can be done immediately to ensure the safety of the bridge user. There a lot of bridge collapse incident that claimed innocent life consequent from the action of some parties who underestimate about maintenance of an asset.

Among the famous bridge collapse incident are a highway bridge at Seoul, South Korea which collapsed and claimed 32 lives on 21 October 1992. The tragedy happen during peak hour and on overcrowded situation on Seongsu Bridge which crossing the Han River (The New York Times, 1994). Cause of the collapse were because of rusty extension hinges and connections on steel structures causing the bridge failed to support the excessive load.

In United States, the Minneapolis I-35W Bridge which crossing the Mississippi River built on 1967 collapsed on 1 August 2007. This 579 meter and eight lanes bridge have claimed 5 lives, 111 were injured, 5 were badly injured and the other 8 civilian was missing (A. Weeks III, 2009). The investigation later showed that there are no comprehensive inspection and maintenance on the bridge even knowing that the age of the bridge has been nearly 40 years.

In our country, there is also few bridge collapse incident but only a minor incident and smaller compared to the long highway bridge such as Penang Bridge and Penang Second Bridge. Both of the superstructure were design to withstand heavy loads, earthquake and have long lifespan but still expose to other factors such as bad weather, accident and etc. The 2004 Indian Ocean earthquake affect Penang and also the first bridge. The cracks were inspected by expert consultants, T-Corp Engineer Sdn Bhd, and their report was presented to the Malaysian Highway Authority (MHA). The MHA had instructed Penang Bridge Sdn. Bhd. (PBSB) to intensify inspections on the bridge structure from time to time (The Sun Daily, 2005)

Other problems such as settlement that occurs on the embankment of the bridge, also can affect the road user and give doubts to others to use the bridge. The new Penang Second Bridge also was no exception. There is a sudden ‘dipping’ on the road surface at KM3.1 of the bridge, which may cause the undercarriage of vehicles to scrape the road surface. The road condition may also be dangerous for vehicles travelling at high speed (The Star Online, 2016).

Aware of the situation, all the incident could be avoided and prevented if the bridge were maintained by a good management system and inspection of the bridge were done from time to time.

1.3 Research Objectives

The main goals are to study the bridge maintenance management on Penang Second Bridge which linking the mainland (Prai) to the island (Pulau Pinang). The following are the objectives that have been identified as a guide to ensure the study conducted is consistent with the title of the research:

1. To study the maintenance and inspection works of the bridge.
2. To investigate the defects and damages on the bridge structure.
3. To evaluate the level of road user satisfaction on the maintenance of the bridge in Penang Second Bridge.

1.4 Research Scope

Besides achieving the objectives of the research, the scope of the study are as follows:

1. Civil works investigated in the maintenance management.
2. Main factors that cause damages on the bridge.
3. The case study is at Jambatan Kedua Sdn. Bhd since it is the concessionaire running all the maintenance work at Penang Second Bridge.

1.5 Significance of Study

The research conducted to study the view of the road user about the damages and types of damages on the Penang Second Bridge particularly and also to know with more detail about the repairing and maintenance work at Jambatan Kedua Sdn. Bhd. This research were hope to give guidance for the management of JKSB to establish a better and efficient strategy in managing the management works.

This research also will explain about the existing maintenance management and indirectly help to produce a better and effective system. Furthermore, it also can reduce other problems arise during the maintenance work.

1.6 Research Method

Data collection and information processing are consists of two categories: literature review and case studies. The literature review is to use methods such as data acquired through reading and reference materials from the maintenance unit in JKSB. As for the case study method is the use of questionnaires and site visit.

The results of the literature review and case studies, the preparation of the data will be carried out where the data will be generated and displayed in the form of tables and graphs. It aims to simplify and further clarify the data obtained. To see the course of the project implementation process, refer Figure 1.1.

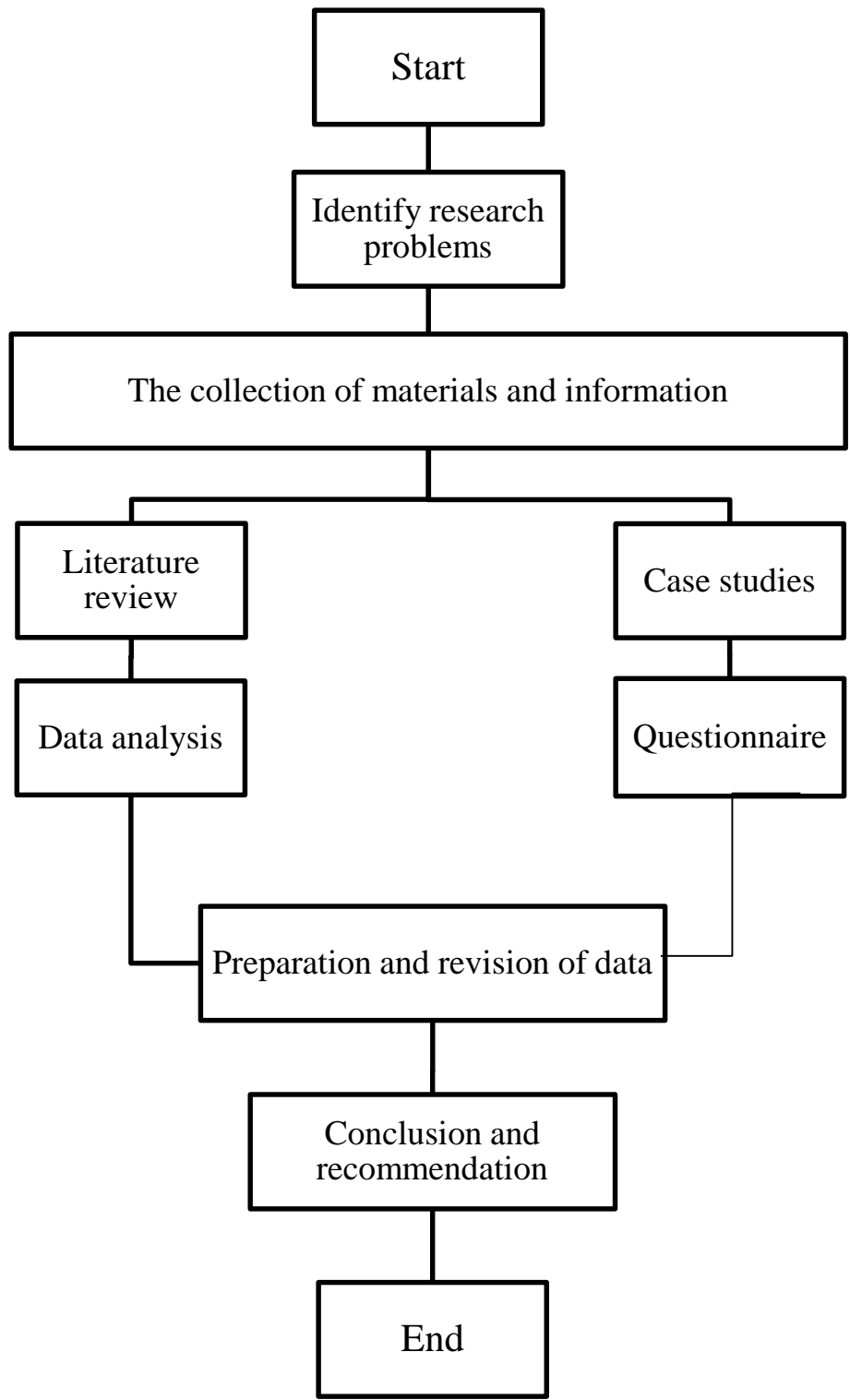


Figure 1-1 Research Methodology Flowchart

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A bridge is a structure built to span physical obstacles without closing the way underneath such as a body of water, valley, or road, for the purpose of providing passage over the obstacle. There are many different designs that each serve a particular purpose and apply to different situations. Designs of bridges vary depending on the function of the bridge, the nature of the terrain where the bridge is constructed and anchored, the material used to make it, and the funds available to build it.

After the construction of a bridge was completed, works such as inspection and maintenance are important to make sure the condition of the bridge constructed is in good condition, and safe to use. Therefore, bridge structure assembled needs more observation and maintenance management should be done regularly so the user feel safer and comfortable when using the bridge.

In our country, bridge or asset management system entrusted to the highway agencies or other involved companies such as PLUS, ELITE, Penang Bridge Sdn. Bhd. and also Jambatan Kedua Sdn. Bhd.

2.2 Maintenance Management Definition

According to “BS 3811: 2000, maintenance management means a well arranged system in an acceptable level. This means that it is a comprehensive system that control maintenance work performed on an acceptable level or standards by the highway maintenance management.

Besides that, the maintenance management system is also intended to give a clearer explanation in deciding the management which will be carried out. Guided by the maintenance management system, adjustment that will be made will always follow modern passage of time and meet the requirement of the operation that was done (Armitage and Avery, 1999).

There are few types of maintenance management as shown in Figure 2.1

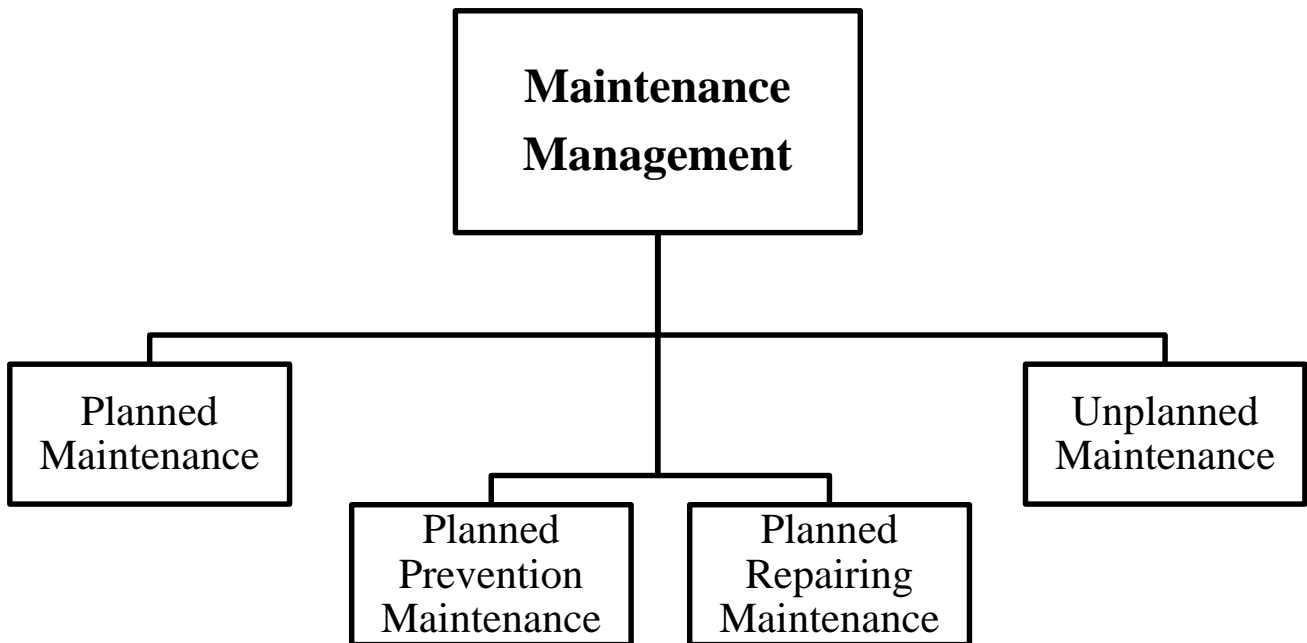


Figure 2-1 Maintenance Management (Abd. Hakim and Wan Min, 1991)

According to Abd. Hakim and Wan Min, 1991, all of the maintenance management can be elaborated as follows:

1. Planned Maintenance

Maintenance works were previously planned and organized at the beginning of the construction process. Plan intended are such as the design, material that affect the maintenance operation. Analysis on any possibility or risk in future was conducted to ensure the problem arise sooner in future are the most minimum.

2. Planned Prevention Maintenance

Maintenance works were done at a specified time or follows the criteria described by the responsible people. The purpose is to reduce the possibility of failure and performance degradation.

3. Planned Repairing Maintenance

This type of maintenance were a work done to repair the defects on an asset until the real function of the asset can be met.

4. Unplanned Maintenance

Cover the work required without following any early planning. This situation happen when there are defects or emergency caused by various thing.

2.3 Maintenance Definition

Maintenance can be define as the combination of all technical and administrative actions including supervision actions, intended to retain an item in, or restore it to, a state in which it can perform a required function (British Standard Glossary of Terms, 1993). Hornby, 2000, define maintenance as a measures to ensure something in a good condition by performing inspection and repair works permanently or continuously. The maintenance of the bridge should always be controlled, repaired and rehabilitated for all

the component structure so that the bridge service management can be enhanced continuously and to ensure the safety of the user.

BS 3811, 2000 define maintenance as the combination of all technical work and administrative to take action for carrying out the real function while AASHTO, 1999 states that ensuring the passage of maintenance should always be done. This shows that the maintenance performed at the beginning of the stage can avoid undesirable situation and can improve the management as well as the design.

2.4 Bridge Maintenance

Maintenance of a bridge structure become an increasingly challenging fields nowadays. This is because the bridge built not only aims to facilitate the passage and look beautiful but becomes more important when maintenance need to be done so the bridge are safe to use and can be used until decades by millions of users.

Highway system on the bridge often more on monitoring on repairing, rehabilitation, and replacement of the damage structures. With a wide variety of bridge design, construction materials used on the bridge, construction method conducted and the guidance provided by the highways agencies can help the bridge maintenance become more organized in accordance with the guidelines.

There are various challenges on carrying out maintenance work on the bridge. Many unlucky incidents that ever happened were due to lack of skills, problem solving on the bridge maintenance cannot be done immediately and had to postpone the maintenance. Some of his actions just plan to do maintenance but no action was taken, some more only deferred without performing any action (Kenneth, 1992).

Maintenance management implementation requires the skill to implement. Therefore, the federal highway administration (FHWA) has introduced a course called “bridge maintenance training” to ease the highway agencies to resolve issues with more efficiently in bridge maintenance system. It is better if the maintenance operations for the bridge involve inspection on the bridge. The section that inspected including a checklist

for structural inspection, wall barrier, upgrading highways and discuss on how to reduce the failure on the bridge (Guidelines for Maintenance Operation, 1971).

Malaysian Highway Authority (MHA) has listed the type of inspection conducted including daily inspection, periodic inspection and specific inspection (MHA, 1991).

Item	Type of inspection	Case	Report to MHA
1	Daily inspection	Conduct regular inspection to find out and control the road traffic situation. Facilities and public facilities (toll plaza).	Every month Once a year
2	Periodic inspection	Maintenance management and facility are conduct in more detail particularly to structure such as bridges and slopes. Road surface conditions (PCA). M&E (toll plaza, emergency telephone, street lights, traffic lights and etc.)	One month after receiving a complaint Once a year Every 6 months
3	Special Inspection	Side inspection and additional daily inspection and periodic for the cases that sometime occur such as heavy rain.	Immediately after receiving complaints.
4	Repairing work	Maintenance repair and repairing works.	Every 3 months

2.5 Bridge Inspection

The purposes of bridge inspection operational is to identify, determine and measure the level of damage and structure ability caused from a variety of causes, effects, environmental effects and etc (JKR, 2001). The main purpose are:

1. To check the safety of the structure.
2. To identify any sources of potential and changes on the failure of the structural nature that contribute to structural damage.
3. Systematically record the condition of the bridge structure.
4. Provide information to make any decisions regarding maintenance, repairing and bridge replacement needs.
5. Provide feedback to the bridge agency concerned and designers in terms of how often do the maintenance done and failure of the structure which is likely due to design errors and construction errors.
6. To determine and give real picture on the impact load acting on the bridge.

2.6 Bridge Inspection Categories

In the United Kingdom at the moment (2000), there are four categories of 'set schedule' inspections listed by Narasimhan and Wallbank (1998), which closely follows the OECD report of 1976:

1. Superficial inspection

Involves a cursory check for obvious deficiencies that might compromise the integrity of the bridge or lead to accidents or result in potentially high maintenance cost. They are often undertaken by highway maintenance staff on an ad hoc basic, usually when a problem has been observed and reported by other staff, the police, or the public. There are no set programmes or reporting requirements.

2. General inspection

A visual examination of representative parts of the bridge to ascertain condition and note items requiring attention. This is normally undertaken every two years. Inspection is from ground level using binoculars if necessary, and information is recorded in the field using a checklist that has been jointly prepared for the particular type of bridge by the engineers responsible for both design and maintenance. In the United Kingdom, for example, on form BE11 (Highways Agency, 1993, 1994), though this allow only one entry for each type of structure element regardless of the number present or the range or the defects.

3. Principal inspection

Involves close examination (within touching distance) of all parts of the bridge against a prepared checklist. There is always an initial principal inspection before handover of new structure, but thereafter it is undertaken generally at intervals of 6 years. Access equipment and traffic management are usually needed to enable all parts of the structure to be inspected. Originally, principal inspection were confined to visual examination.

4. Special inspection

This is a close inspection of a particular area or defect that is causing concern. It is undertaken when needed for a wide variety of reasons, including following up a defect identified in an earlier inspection, unexpected settlement, seismic activity and etc.

2.7 Process for Work Inspection

According to Malaysia Highway Authority guidelines, inspection process are carried out according to the daily inspections, periodic inspections and special inspections. Figure 2.2 shows the process of the inspections.

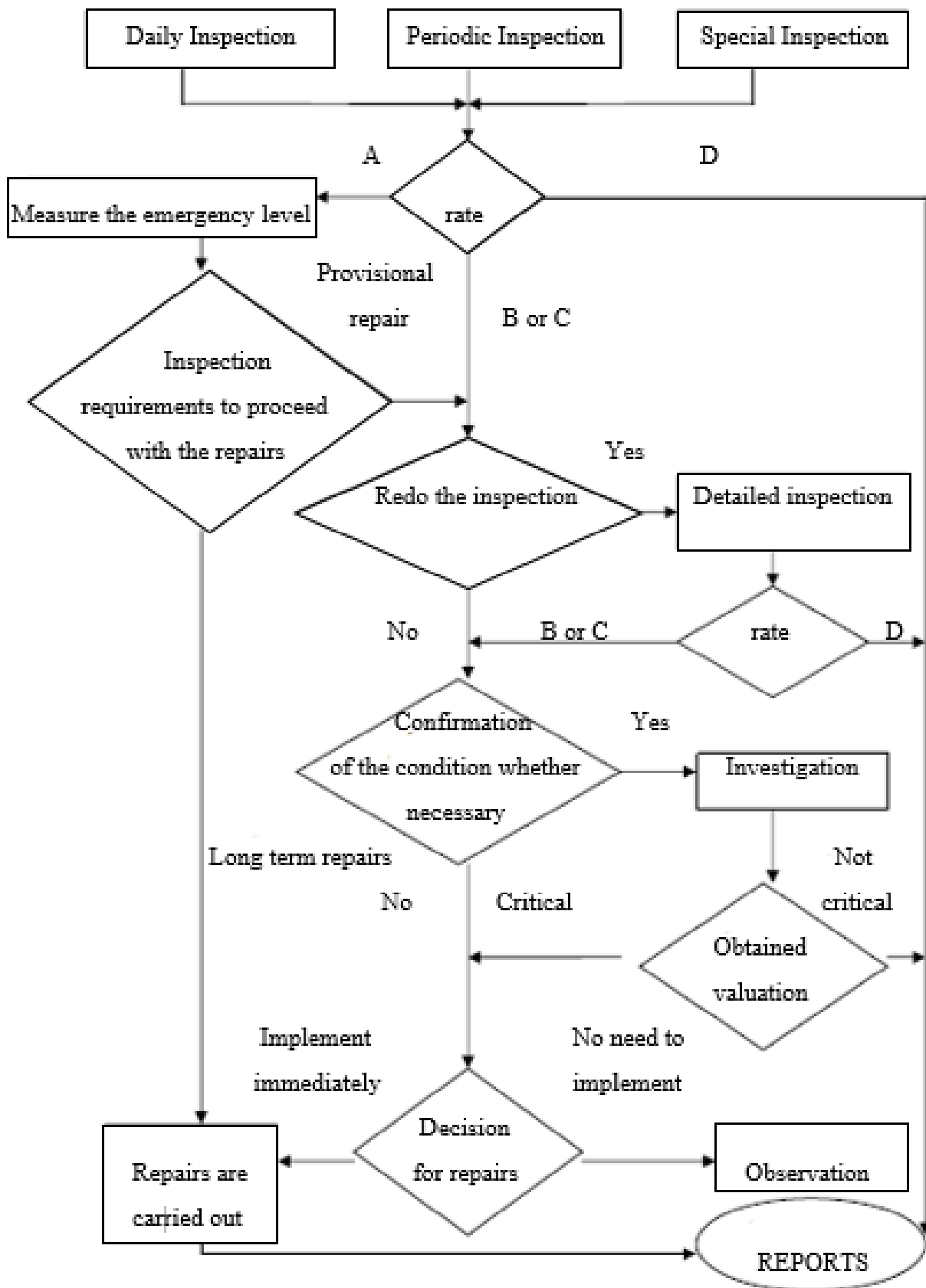


Figure 2-2 Inspection Process (MHA, 1991)

Based on the inspection process in Figure 2.2, monitoring and repair works are carried out according to the categories of damage such as:

1. Severe damage which affect the traffic, emergency repairs carried out.
2. Severe damage only, inspection should be carried out.
3. Damage occurred but not critical, needs repair.
4. Normal harmless damage, not in need of repair.

2.8 The Frequency of Inspection of the Bridge

For bridge, the frequency of inspections depends on factors such as policies that have been set by the authorities other than the age factor of the bridge

The degree of damage and deterioration of load-bearing capacity is different depending on the type of structure, bridge location and etc. To tackle this issue, the effective method are to do few type of inspection which vary by purpose, methods and scale. All aspects of the examination may be obtained entirely and can provide effective maintenance, well scheduled maintenance and repairing work.

Among the categories of bridge inspection are as follows:

1. Inventory Inspection
2. Annual Mandatory Inspection
3. Prevention Inspection
4. Special Inspection
5. Structure Condition Inspection

Inventory inspection is the initial examination carried out on the bridge after completion. The inspection are done visually by conducted observation and daily monitoring according to a report prepared. For mandatory inspection, it is conducted once a year seeks to ensure safe conditions, functioning well and maintained to the satisfaction. The main purpose of the satisfaction are to be aware of any structural damages that occurs and any potential signs contributed to the damage and disability in the future.

Confirmatory inspection intend on verifying the reports receive by the bridge unit. This inspection is to ensure that inspection have been conducted are consistent as well as meet a predetermined procedure. Detailed inspection is the continuation of the mandatory inspection and confirmatory inspection. The purpose of the inspection is to evaluate the overall safety level of the bridge, perform non-destructive testing, structural materials sampling, determine the rate of damage and provide the information necessary to determine repair methods.

While for special inspection it is done when there is an event such as a bridge collapse, flooded bridge or revaluation of the structure due to changes of specification and rules of regulation such as raising the limit vehicle through the bridge and etc. It is a requirement to determine the rate of damage or defects of the bridge member quantitatively during inspection. Structural condition rating needs for comparisons in order to know the damage or defects prior.

2.9 Maintenance Requirement

Bridge maintenance was done to ensure that the bridge always be in a safe condition and comfortable to use by the user. According to JCR-JKR Conditioning Rating (JKR, 2001) there is a predetermined classification for the maintenance of the bridge. For example the range of forging a bridge at level 0 means the inspection on the hard part is done and examination should be performed again. For level 1, no damage and defects identified. While level 2 means the damage and defects is small. Next, level 3 means the damage and disability is less critical. For level 4, sustained damages and defects are severe and critical and lastly level 5, damage worsens and requires emergency repairs.

Table 2.2 shows more clearly the condition of the bridge in accordance with a predetermined classification level by the maintenance of the bridge (JKR, 2001).

Table 2-2 The Classification of Maintenance of Bridges (JKR, 2001)

Rating	General Definition
0	The bridge cannot be fully examined because of a problem that cannot be solved such as the structure is in the water. Re-examination is necessary.
1	No damage or defects detected and maintenance work should not be conducted based on the inspection.
2	Damage or defects detected are small and the damage rate used for the purpose of observation.
3	Damage or defects detected is less critical and repair works conducted through daily inspection.
4	Damage sustained was severe and urgent repairs need to be done, require detailed inspection and rehabilitation works should be carried out
5	Damage is severe or critical cause effects on the safety of the bridge. Should carry out emergency repairs and rehabilitation works immediately.

2.10 Penang Second Bridge Maintenance Management

Bridge maintenance management is important and should not be underestimated to ensure the comfort and safety of users while using bridges as well improving the ability of its services. With a good road network that ease users moving could increase economic activity and the national development. Therefore, the study is to identify the main types of damages or defects and the root cause of the damage that often occurs at Penang Second Bridge.

Penang Second Bridge or also known as Jambatan Sultan Abdul Halim Mu'adzam Shah (JSAHMS) is generally a dual two-lane carriageway expressway of 3.5m -3.65m lane width, with a dedicated 3m motorcycle lane and a 2.4m shoulder. The 24km expressway spans the South Channel of the Malacca Strait, from the mainland at Batu Kawan to Batu Maung on the island side and comprises a 16.9km marine cable stayed bridge, 7km land expressway, bridges and interchanges (JKSB, 2014).

Jambatan Kedua Sdn Bhd or well known as JKSB is the special purpose company (SPV) established by the state association to regulate the bridge. The company also

appointed as concessionaire to monitor the work of construction, management and also the operation of the bridge (Berita Harian, 2010). Operations and maintenance activities on the bridge included are such as collecting toll collection, maintenance of bridge and highways and also responsible for improving the works on the bridge. The official opening of the bridge is on 1st March 2014, whereby asset worth more than RM 4.5 billion need to be well managed.

A total of four million vehicles have crossed the Sultan Abdul Halim Mu'adzam Shah bridge, which is the second link between Penang Island and the mainland between April, 2014, and April this year. Jambatan Kedua Sdn Bhd (JKSB) managing director Datuk Dr Ismail Mohamed Taib said an average of 12,500 vehicles had used the bridge on a daily basis over those past 12 months. He expects the total traffic volume would increase to five million vehicles for the same period up to next year (The Sun Daily, 2015). This shows that bridge maintenance is very important to ensure that the bridge is always in good condition and comfortable to users.

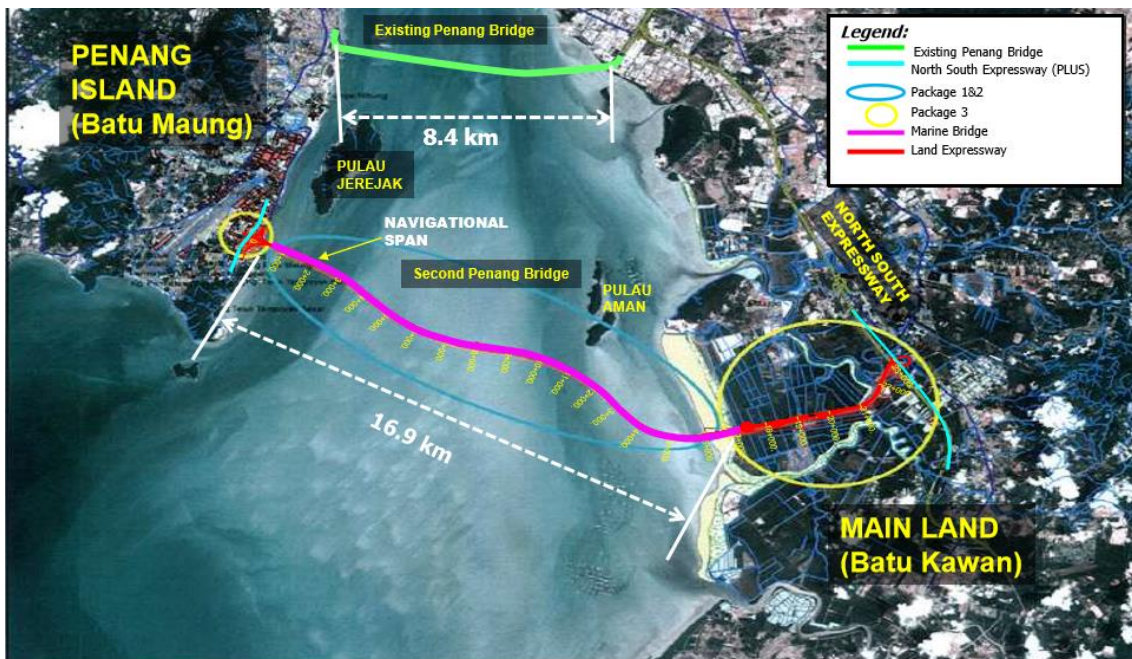


Figure 2-3 Penang Second Bridge Plan

2.10.1 Jambatan Kedua Sdn. Bhd. Maintenance Management Objectives

Bridge maintenance management main objectives are to evaluate the defects and damages occurs on the structure or condition of a structural failure in order to be dealt with promptly and appropriately to ensure the safety of the bridge, the capacity of the bridge service and comfort to the users who use the bridge. The objectives can be clarified more as follows:

1. Ensure that maintenance is always carried out and in accordance with established specifications.
2. Know in detail the information about maintenance management.
3. Identify the damage and plan repairs to the bridge.

Scope involved in the maintenance management of this organization are as follows:

1. Daily maintenance, regular maintenance, special inspection and monitoring.
2. Expansion joint repairs on the bridge.
3. Bridge structure repairing work.
4. Underwater inspection and repairing work.
5. Bridge tower inspection and repairing work.

2.10.2 Maintenance Activities

Maintenance activities in Penang Second Bridge involves all the damage occurred along the bridge and its region. To further facilitate the maintenance management, classification of maintenance activities made in four separate activities namely, regular maintenance, repairing and upgrading work and also bridge inspections.

Among the regular maintenance activities are such as:

1. Cutting the grass
2. Street, signage and bridge cleaning

3. Landscape cleaning
4. Toll plaza building cleaning
5. Management building cleaning
6. Drainage cleaning
7. Other activities

To carry out any management activity, JKSB must obtain approval before carrying out maintenance work according to the established procedures. Maintenance work is then divided into each contractor in accordance with each sector to do the repairing works.

2.10.3 Regular Maintenance

To ensure the flow of traffic is moving smoothly, safely and can add more aesthetic view to the bridge, the regular maintenance work activities need to be done. Activities such as cutting the grass, replacing defective grass and replant the new one. Other activities are including maintenance of the landscape so that it will look more appealing, cleaning of drainage on the bridge, cleaning the buildings on the bridge such as toll plaza, musolla, and also the office. These activities are need to be done every day to ensure the cleanliness of the Penang Second Bridge.

In addition, regular maintenance works also functioning as observing the physical condition of the structure to ensure that the level of structural damage is below the standards of maintenance work needs to be done. Regular maintenance program can be divided into a daily program, followed by a weekly, monthly and so on in a planned.

Apart from these activities, other maintenance activities that are performed as well are maintenance on the structure of the bridge and the road surface. This is to ensure that the bridge conditions are always in a good condition, comfortable for the users who use the bridge and also to avoid any bad incidents such as accidents occurs if the bridge were not properly maintained.

Second Penang Bridge also have installed and use advanced equipment on the bridge such as CCTV, emergency telephones and provide street light along the bridge.

Therefore, inspection of electrical and electronic parts also need to be done from time to time. In case of any damage such as broken street lights, repairing work and replacement needs to be done immediately or soon for the safety of the bridge users.

2.10.4 Repairing Work

Repairing work is necessary to ensure that the damaged structure return to its original condition to guarantee the safety of the bridge all the time. Repairing work is a lot heavier compared to regular maintenance and require high cost. Repair works also require more detailed monitoring and investigating the circumstances and this will take longer time. Therefore, a temporary measure has been proposed to update the appropriate traffic management system to ensure consumer safety.

Among the repairing works are, road surface repair, making road marking, expansion joint repair, earthwork repair, slope and retaining walls, structural repair of bridges, drainage systems, and etc. Repair works will be carried out based on the inspection report, when the structure exceeds the limits of standard specifications or fail. According to Civil Executive (CE), repair work can also be divided into several sections to monitor the situation more closely, such as:

1. Earthworks
 - Monitoring and repair the cracks, ground movement, soil erosion and sedimentation.
2. Drainage
 - Repair works on the damage to the overall related to the drainage system
3. Road surface/pavement
 - Repair works on the damage to the overall related to the road surface.
4. Structure
 - Repair works on damages such as cracks, corrosion on the reinforcement bar, bridge bearings and bridge joint.

5. M & E

- Repair works performed on transformers, switchgears, street lights and etc.

2.10.5 Emergency Maintenance Works

Emergency maintenance work is unpredictable damage or a sudden accident happened for example, severe damage to the bridge structure due to bad weather, continuous heavy rain, and etc. Repairing maintenance action should be taken as soon as possible tackle all the emergency.

When a damage occurred, the officer in charge of the operation will go to the place to investigate and identify the type of repair work, cause of the damage, the cause of the breakdown and the damage bridge has suffered. For example, in the event of an accident on the bridge, the officer in charge will try to control traffic and ensure no lasting congestion.

If the situation becomes very uncontrollable, the temporary closure of roads to traffic which will take place within 24 hours and will reopen immediately after the situation under control. Often as a result of an accident damage on the bridge will occur. Therefore after the situation have stabilized the repair works will be taken as soon as possible.

2.10.6 Inspection Work

The purpose of inspection work is to collect data information concerning the traffic situation, assess the effectiveness of the service and maintenance work carried out and early detection of structures damaged that can bring harm to users. Inspection is usually done by using a slow moving vehicles or go down to the area to be examined. The inspection will be made up of those who are experienced on the job and getting enough training.

Bridge inspection work shall be done for the following parameters (Part B2-Technical Requirement, 2013)

1. Visual inspection.
2. Data collection for destructive coring/boring/lab tests.
3. Data collection on non-destructive test.
4. Surface distress: type of distress, severity, extent.
5. Routine and periodic inspection of bridges.
6. Special inspection, e.g. after a major event.
7. Planning for detailed inspections of bridges and structural evaluation.

Table 2-3 Type of Inspection Work and the Frequency

Type of Inspection	Frequency of Inspection
Routine Inspection	Every 6 month.
Periodic Inspection	Every 2 years.
Principal Inspection	Every 5 years (on all bridge elements, including those that are difficult to access-may require special bridge equipment).
Underwater inspection	Every 5 years (to inspect and monitor any environmental problems or impact).
Special inspection	After a major event, expiration of anticipated service life of warranty period.

2.10.7 Daily Inspection

Normally, the JKSB will send inspectors to carry out checks on a particular day. It usually performed in the morning to facilitate inspection work. To ensure that maintenance work was carried out, the inspection will be conducted on the following day and will be re-examined after 7 days to ensure that the maintenance works are in good condition and perfect.

Daily inspection on the toll plaza, grass cutting, drainage and so on will be monitored by JKSB. It aims to ensure the quality and conditions in the area are always clean and safe.

2.10.8 Fixed-Term Inspection

Fixed-term inspection is different from the daily inspection. This is because fixed-term inspection is a more detailed examination performed on all bridge structures such as roads, bridges, slopes and drainage systems. Duration of inspection is made up of three months, six months or two years as determined by HMA. Inspection can also be done when required and pictures are needed during the inspection.

2.11 Integrated Asset Management System

Penang Second Bridge management has developed a systematic computer software system namely as Integrated Asset Management System (IAMS) to manage the bridge.

The system ease the work such as in managing the data obtained from the inspection, condition rating, predict the rate of deterioration and the life span of the bridge structure. It will also allow the management in Jambatan Kedua Sdn Bhd to make plans, organizing and obtain information related to the bridge, maintenance and restoration required and also be able to plan an effective budget on maintaining the asset.

Generally, IAMS is a system that contains pertinent data collection details for the respective assets which will be later used by Client to identify their physical locations and track their conditions from time to time. All the assets are commonly grouped into main asset system that serve similar overall functionality. Asset system then can be broken down into it sub-system whereby it describe more detail the functionality of the asset.

Mainly, assets can be classified into two categories which are physical assets and non-physical assets. The focus of this Integrated Asset Management System is more towards managing the Client's physical asset which can be further broken down to:

- | | | |
|---------------------|---|--|
| 1. Movable | - | Equipment and machineries, furniture. |
| 2. Immovable assets | - | Roads, sewerage, water supply, drainage. |
| 3. Living assets | - | Plants (greens and flowers), decorative. |

In view that the maintenance of the Penang Second Bridge (PSB) is for a period of forty five years, the Client intends for a professional, systematic and proven sustainable Integrated Asset Management System (IAMS) to be established and developed to allow an effective operation and maintenance of the PSB.

The IAMS shall be used as a preventive maintenance tool which in turn will improve the safety and reliability of the bridge and meet the following objectives:

1. Facilitate the processing and analysis of collected data and information for the monitoring of performance against the prescribed maintenance standards.
2. Provide the basis for an understanding of possible consequences of alternative decisions related to the preservation of highway assets.
3. Provide a structured program that minimizes the life cycle cost of asset ownership while maintaining the required service level and sustaining the infrastructure.
4. Fulfil the concept of "cradle to the grave" idea for maximum performance and usage of a built asset.

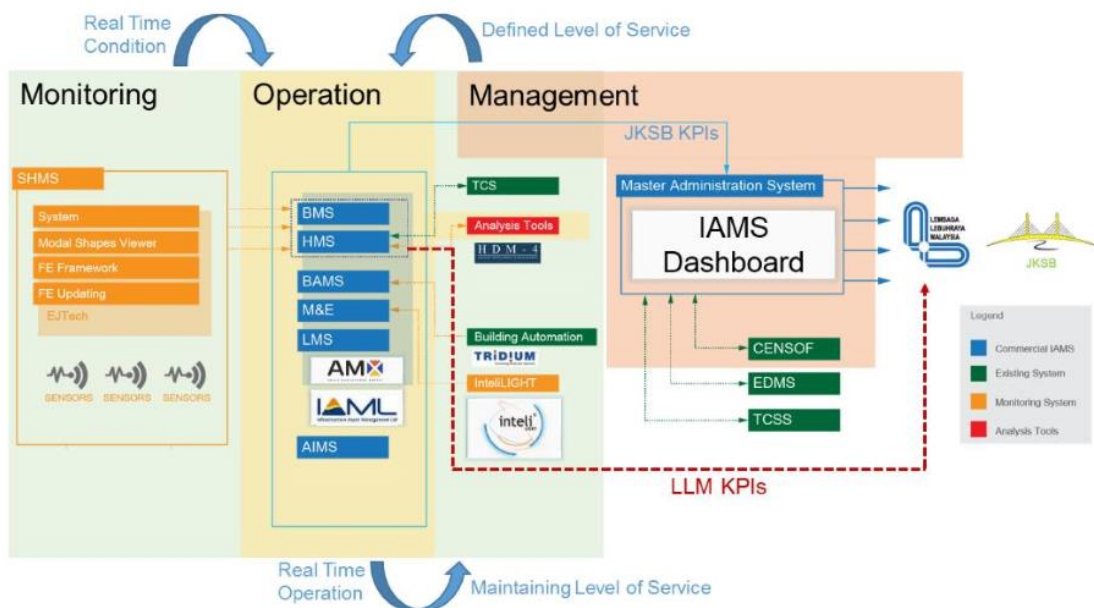


Figure 2-4 Overview of Integrated Asset Management System (IAMS)

2.12 Bridge Inspection Findings

After the completion of the bridge inspections, the data then were gathered to provide a full report before the data analysis is carried out. Its main purpose is to determine the category of the most critical damage to the less critical. The following is the discovery of defects that often appear on the Penang Second Bridge.

1. Drainage
2. Pothole (Pavement)
3. Settlement (Pavement)
4. Settlement on the abutment
5. Expansion Joint
6. Bridge Parapet
7. Water Ponding

2.13 Factors Affecting Bridge Damage

Drainage system at the bridge such as drain that does not functioning well will affect the disability of the bridge. Most of the systems are not closely monitored and mostly filled with garbage and dirt. This will cause a clogged and the drainage system cannot function properly.

Replacement of pavement was done in the life expectancy of five years to ten years. Pavement maintenance on the bridge is more focus on the overlaying works. This works will increase the dead load and lower down the live load of the bridge. Defects such as pothole also often occurs on the pavement. Maintenance work will be carried out immediately so that a serious damage will not occur. Replacement of pavement is usually standardized with expansion joint replacement so that the traffic would not be disrupted.

Settlement on the abutment often occurs when water flowing into the abutment wall will stagnate and then seep into the soil on the abutment. This will affect the ground thus undermine the strength characteristic of the soil. Expansion joint is a component that needs to be maintain from time to time. Often, the expansion joint will be changed when

it exceed its life span which is five or ten years. Each conversion of the joint must consider the type of connection whether it is structure type or not to ensure that no damage occurs.

Damage to the parapets was often occurs as a result from an accident or erosion. Accident often occur on the abutment therefore, this area requires strong built parapet and guard rail at all times. Erosion often occur especially on the coast of the bridge. The problem can be solved by performing composed scheduled maintenance.

The main problem which always affect the performance of the bridge is the water problem. Water ponding on the bridge when it rains make the road slippery and may cause the vehicle passing through the bridge prone to accidents. When the drainage system is not functioning properly, water ponding will occurs and seep into the roadway. This will lead to side effects such as decreasing the durability of the concrete and steel.

Settlement of soil is also facing a similar issue with the settlement on the abutment. This situation is more threatened because the settlement of the soil will cause the bridge structure suffered severe effects such as the occurrence of cracks in the structure. Extra observation and maintenance need to be given to this part to ensure the bridge is always safe to use.

Therefore, the main objective of the inspection and maintenance work is necessary to ensure the safety of the bridges and highways are safe and secure. Sensitivity of inspectors in carrying out good work, diligence and punctuality are the key in achieving these objectives.

To clarify further the above statement, Table 2.4 shows the type of damage and factors that affect the damage on the bridge.

Table 2-4 The Type of Damage and Factors Affecting the Defects

Defects	Factors Affecting the Defects
Drainage system (Drain)	Most of the drainage system are filled with dirt and debris causing the system is clogged and cannot work properly.
Pothole (Pavement)	Pavement maintenance on the bridge is more focus on the overlaying works. Defects that always occurs is pothole.
Settlement on the abutment	Water flowing into the abutment wall will stagnate and then seep into the soil on the abutment. This will affect the ground thus undermine the strength of soil.
Expansion joint	Needs to be maintain from time to time. Often, the expansion joint will be changed when it exceed its life span which is five or ten years.
Bridge parapets	Often occurs as a result from an accident or erosion. Accident often occur on the abutment.
Water ponding	Rainy days make the road slippery and may cause the vehicle passing through the bridge prone to accidents. When the drainage system is not functioning properly, water ponding will occurs and seep into the roadway.

Settlement (Highway)

Cause the bridge structure suffered severe effects such as the occurrence of cracks in the structure.

CHAPTER 3

METHODOLOGY

3.1 Introduction

For this study several methods and approaches were used to obtain data and information. Implementation of every research methods can assist in analysing, evaluating, and give conclusions on the information obtained. Information should be obtained by collecting data, then sorted and selected thus making analysis. This aims to ensure the objectives of the research were achieved.

3.2 Research Planning

Planning for the research methodology began with a set of issues and matters that will be discussed in the study. Next, the objective, scope and definitions of the study of the research was geared to the bridge maintenance management system for Penang Second Bridge as a case study thus set out the research objectives that would serve as guidelines in the selection of research methods.

3.3 Process of Gathering Material and Information

The process of collecting data or the case study is the stage where the information needed for the study were obtained. Generally, the data collected through two main categories which is case study and literature review.

3.3.1 Literature Review

Literature review is a data acquisition through reading and reference material consist of material such as books, magazine, journal, newspaper and undergraduate project reports. These materials are needed to further strengthen the basic method conducted in the study.

3.3.2 Case Studies

Data obtained directly were called as primary data. In this study several methods were empirically identified which then will be used to obtain information. The method use are Questionnaire. The questionnaire aims to obtain practical data of the actual situation prevailing in the study area.

Questionnaires were prepared and will be distributed to the maintenance unit in JKSB. In addition, the questionnaires will also be distributed to users and the public using the Penang Second Bridge. With feedback obtained then it will be the basis for identifying the level of maintenance of existing and proposed the need to enhance the effectiveness of existing systems.

3.4 Data Analysis

This study is made available to ensure that questions in the questionnaire is in line with and meet the objectives of the study. In this study, a five-point scale of 'likert' has been used for nearly all questions provided.

Likert scale was divided into five ranges: 1) Very unsatisfactory, 2) Not satisfactory, 3) Less satisfactory, 4) Satisfactory and 5) Very satisfactory. It is very suitable for the pattern and the range of responses from all respondents on issues occur, a factor that led to the failure occurred and methods necessary to reduce problems in the maintenance of the bridge.

Respondents then were asked to give an answer based on a five point scale provided based on the Likert scale that provides a score between 1 and 5 with regard to the factors contributing to any given question. Five classification range to answer will be given by each respondent as follows:

Table 3-1 Classification Range				
1	2	3	4	5
Very unsatisfactory	Not satisfactory	Less Satisfactory	Satisfactory	Very satisfactory

Feedback obtained from respondents will be analysed using the average index. For purposes of analysis, the questionnaire was divided into 2 categories, respondents from the Penang Second Bridge and workers in JKSB. Questions have been designed to be made of its own classification as follows:

a) Respondents from the Penang Second Bridge

1. General information consists of four questions that require respondents to answer questions about their gender, their age, the vehicle used and location of residence.
2. Contains questions aimed at identifying the role responded, how complaints and problems on the bridge damage were reported containing three key questions.
3. Identification of customer satisfaction in the organization of the Second Penang Bridge consists of six key questions where one question is proposed for the purpose of improving the maintenance of the bridge.

b) Respondent of the maintenance unit in JKSB

1. General information contains three questions that require respondents to answer questions about the position held, gender, and duration of their employment.
2. Contains questions aimed at identifying the role of the respondents, issues and problems related to the maintenance of the bridge which consists of six questions about the nature and cause of the damage to the bridge.

3.4.1 Statistical Package for Social Science (SPSS)

For the purposes of analysis of data collected through the questionnaire, the Statistical Package for Social Science (SPSS) was selected.

SPSS for Windows software contains various data analysis methods that can be applied by the user easily. Among the applications available in the SPSS for Windows is a descriptive statistical analysis methods, general linear model analysis, the average analysis, correlation analysis, regression analysis, data classification, and etc. However, for analytical purposes of this study, only the method of statistical analysis frequencies (Frequencies) was used. Generally, statistical analysis shows the percentage frequency and frequency for each variable.

In the preparation of the preliminary analysis, frequency analysis method (Frequencies) used to determine the feedback from each group of respondents with the following distribution of the number of questionnaires received back from the respondent. The analytical methods will also be used in the next part of the analysis of data from the questionnaire in detail.

3.4.2 Average Index

The following statistical methods have been used for data analysis. The average index is calculated as follow (Al-Hammad et al., 1996):

$$\text{Average Index} = \frac{\sum a_i x_i}{\sum x_i}$$

Where, a_i = constant expressing the weight given to i , x = variable expressing the frequency of response for $i = 1,2,3,4,5$.

In order to determine the level of satisfaction on the maintenance of Penang Second Bridge the classification of the rating scales proposed by Abd. Majid (1997) have been used. The classifications of the rating scales are as follows:

1	=	Very unsatisfactory	$1.00 \leq \text{Average Index} \leq 1.50$
2	=	Unsatisfactory	$1.50 < \text{Average Index} \leq 2.50$
3	=	Less satisfactory	$2.50 < \text{Average Index} \leq 3.50$
4	=	Satisfactory	$3.50 < \text{Average Index} \leq 4.50$
5	=	Very satisfactory	$4.50 < \text{Average Index} \leq 5.0$

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

Data analysis and the results explain the research conducted. The analysis carried out is based on responses from the public and the maintenance unit of Jambatan Kedua Sdn. Bhd.

Analysis of the data is the explanation of raw data obtained by making a conclusion and a summary from it. In this study all the information and the data obtained is more subjective and which need to be formulated in a more concise. Next, a description and explanation of these can then be deduced and thus will get an answer in a more detailed form.

Therefore the final decision can be understood by other users who want to learn and get information from studies that have been carried out. Generally, the analysis is very important in any matter involving decisions especially in the field of research that requires data to be re-used and can be presented in a final answer that is easily understood by all users.

4.2 Analysis Process

The questionnaires distributed have two categories, the form provided to users of the bridge and to the employees in the Jambatan Kedua Sdn Bhd maintenance unit. Division of categories of this questionnaire is based on the questions contained in a questionnaire which there are technical questions for employees in the maintenance unit. 67 questionnaires were returned back.

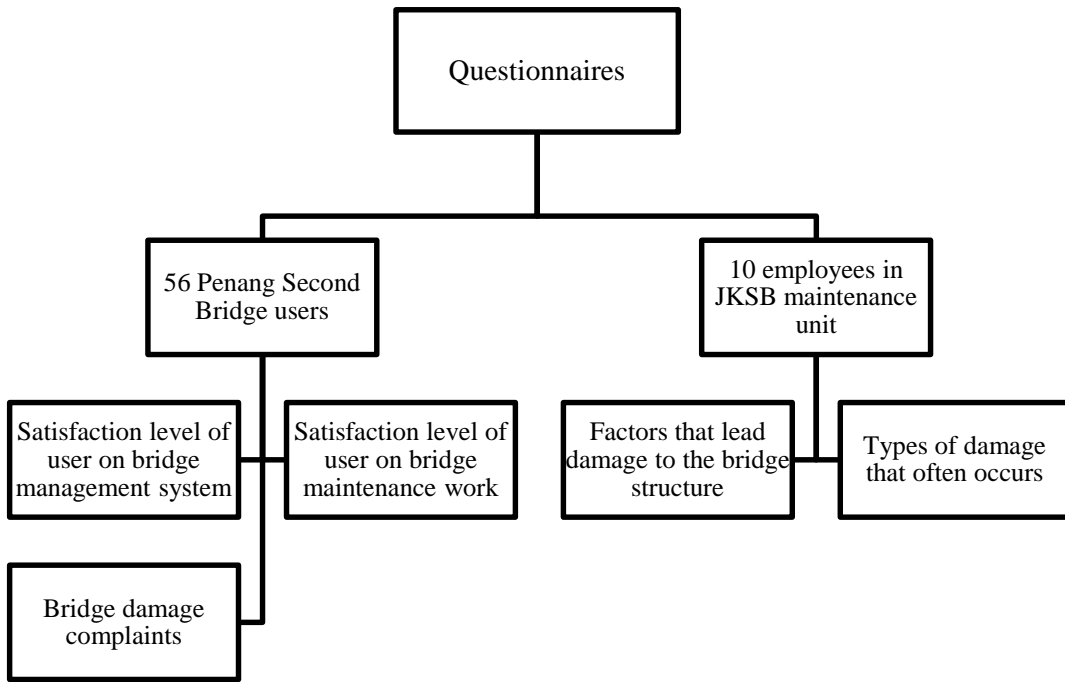


Figure 4-1 Questionnaire categories

4.3 Users Complaints

Normally, the maintenance unit will be performing maintenance on the complaints reported. Complaints regarding damage are often from the Penang Second Bridge users. Figure 4.2 shows users complaints on the bridge damage.

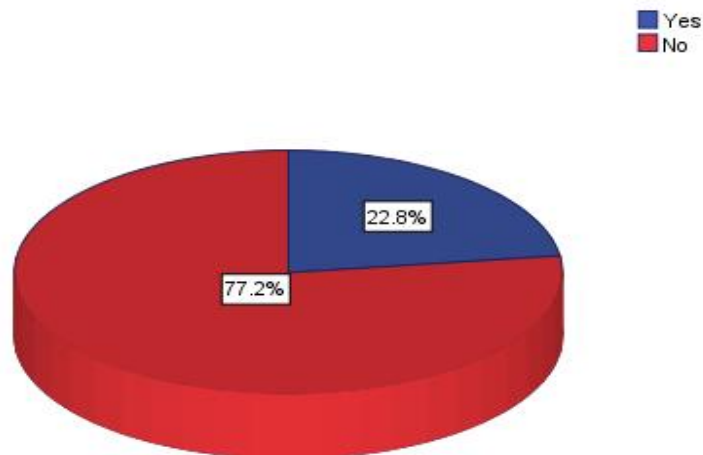


Figure 4-2 Users Complaints on the Bridge Damage

From the feedback received, 16% of respondents stated that they had made a complaint, while 84% of respondents said they never made a complaint. Most of the complaints are from people who often use the bridge each day.

4.4 Methods of Reporting a Complaint

There are various methods a complaint can be reported such as using telephone, forms, letters, emails, direct meetings, complaints from the authorities and others.

Figure 4.3 shows the percentage based on the frequency of the complaint made by the user. Telephone is the most popular and frequently used to complain having the highest frequency percentage of 54%. This method were chosen by the consumer because it is more convenient and saves a lot of time. While 23% of respondents prefer to use email to make complaints and 15% of respondents chose the way of direct meetings with complaints of service users in JKSB. Only 8% of users use the complaint form provided by JKSB.

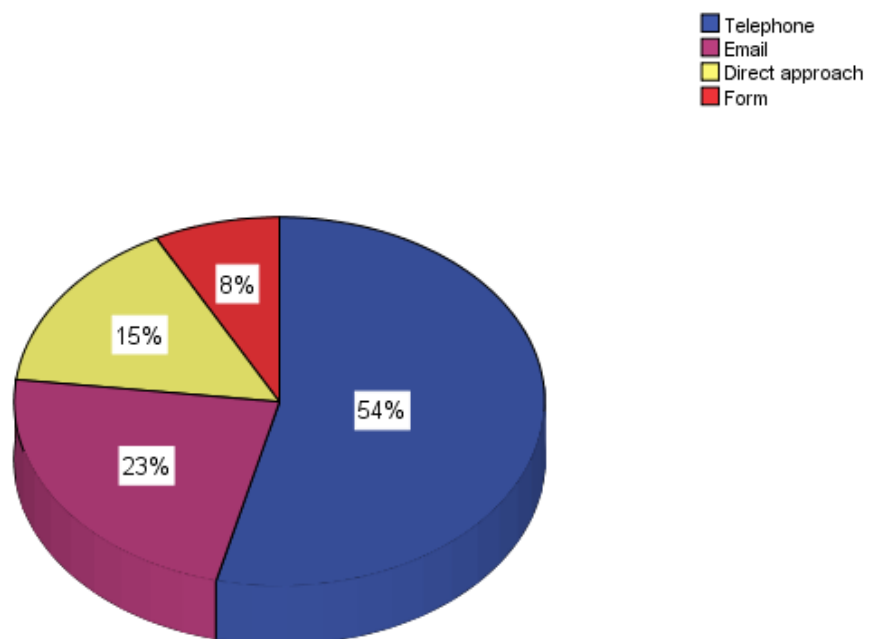


Figure 4-3 Methods of Reporting a Complaint

4.5 Type of Damages Reported

There are various types of damage that occur on highways and the bridge. However the JKSB have listed some type of damage that is often reported by the Penang Second Bridge users. Among them are, pothole, water ponding, settlement on the abutment, settlement of the soil, drainage, expansion joint and bridge parapet.

Based on the type of damage, respondents were also asked to identify the type of damage that occurred on the bridge. The respondents are from the publics and workers from JKSB. Figure 4.4 shows that the damage has been reported by users of the Penang Second Bridge.

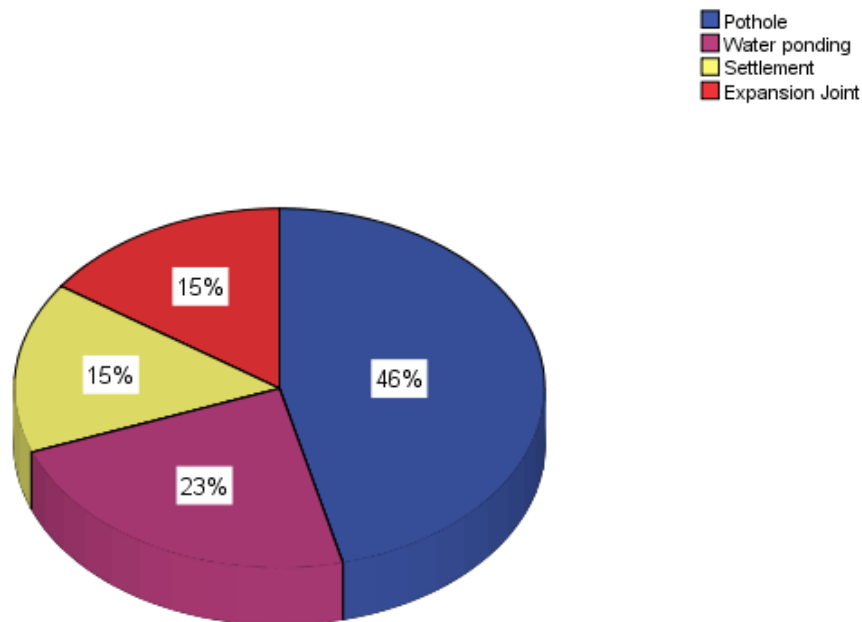


Figure 4-4 Types of Damage Reported

Based on the Figure 4.4 above, was found that pothole is the most frequently reported damage having six reports and having the highest frequency percentage which is 46%. This is followed by water ponding having three complaints while settlement and expansion joint defects both reported by two person each. The other damage were not reported mostly because of the 84% other respondents who never made a complaint.

4.6 Defects that Often Occurs on the Bridge Structure

There are seven main defects that often on the bridge structure. The arrangement of the defects on Penang Second Bridge are according to the average respectively. Ten questionnaires were handed out and filled by employees in the maintenance unit. The main defects that often occurs on the bridge structure is pothole, which having an average index of 3.2 followed by water ponding on the pavement. Defects on the bridge parapet is not a major defect that often occurs in Penang bridge structure. Table 4.1 shows the defects that often occurs in the following order of frequency of the bridge structure damage.

Table 4-1 Defects that Often Occurs on the Bridge Structure

Defects	Rating of frequency										Average Index	Ranking		
	1		2		3		4		5				Total	
	N	%	N	%	N	%	N	%	N	%				
a) Pothole	0	0.0	0	0.0	8	80	0	0.0	2	20	10	100	3.2	1
b) Water ponding	0	0.0	0	0.0	3	25	9	75	0	0.0	10	100	3.0	2
c) Settlement on the abutment	0	0.0	7	70	3	30	0	0.0	0	0.0	10	100	2.3	3
d) Settlement of the soil	0	0.0	10	100	0	0.0	0	0.0	0	0.0	10	100	2.0	4
e) Drainage	2	20	7	70	1	10	0	0.0	0	0.0	10	100	1.9	5
f) Expansion joint	4	40	6	60	0	0.0	0	0.0	0	0.0	10	100	1.6	6
g) Bridge parapet	10	100	0	0.0	0	0.0	0	0.0	0	0.0	10	100	1.0	7

4.7 Types of Damages that Often Occurs on the Bridge Structure

In the categories of damage to the bridge, there are eight types of damage that has been listed by JKSB. A total of 10 questionnaires were distributed to employees in the maintenance unit. Based on the Table 4.2, spalling is the type of damage that often occurs having an average index of 3.4. Cracking is at the second place having an average index of 3.2. Staining is the least chosen as the type of damage often occurs on the bridge structure. Table 4.2 shows the type of damage that occurs in the following order of frequency.

Table 4-2 Types of Damage that Often Occurs on the Bridge Structure

Types of damage	Rating of frequency										Average Index	Ranking		
	1		2		3		4		5				Total	
	N	%	N	%	N	%	N	%	N	%				
a) Spalling	0	0.0	0	0.0	6	60	0	0.0	4	40	10	100	3.4	1
b) Cracking	0	0.0	0	0.0	8	80	0	0.0	2	20	10	100	3.2	2
c) Honey combing	0	0.0	4	40	6	60	0	0.0	0	0.0	10	100	2.6	3
d) Corroded	0	0.0	5	50	5	50	0	0.0	0	0.0	10	100	2.5	4
e) Leaching	2	20	7	70	1	10	0	0.0	0	0.0	10	100	1.9	5
f) Void	3	30	7	70	0	0.0	0	0.0	0	0.0	10	100	1.7	6
g) Mold growth	4	40	6	60	0	0.0	0	0.0	0	0.0	10	100	1.6	7
h) Staining	5	50	5	50	0	0.0	0	0.0	0	0.0	10	100	1.5	8

4.8 Factors that Lead the Damages on the Bridge Structure

There are many factors that can cause an object, equipment or the like cannot be used anymore and damaged. Similarly, the bridge which many people pass through every day. There are eight factors identified as major factors. The ranking in the table is done according to the average obtained in which the high average value indicates the number of high ranking.

A total of 10 questionnaires were distributed to unit maintenance found that respondents chose aging bridges as the most important factor that lead to damage of the bridge having the highest average index. In addition, the second highest was caused by accident and environmental factors is the third on the rank having an average index of 3.7. Improper maintenance is not the main factor that causes damage to the bridge with an average index of 1.0. Table 4.3 shows the factors that cause damage to the bridge.

Table 4-3 Factors that Lead to Damage of the Bridge Structure

Factors of damage	Rating of frequency										Average Index	Ranking		
	1		2		3		4		5				Total	
	N	%	N	%	N	%	N	%	N	%				
a) Aging bridges	0	0.0	0	0.0	0	0.0	6	60	4	40	10	100	4.4	1
b) Accidents	0	0.0	0	0.0	2	20	7	70	1	10	10	100	3.9	2
c) Environmental factor	0	0.0	0	0.0	3	30	7	70	0	0.0	10	100	3.7	3
d) Driver irresponsible	0	0.0	0	0.0	4	40	5	50	1	10	10	100	3.7	4
e) Design problem	0	0.0	10	100	0	0.0	0	0.0	0	0.0	10	100	2.0	5
f) Low quality of materials	2	20	8	80	0	0.0	0	0.0	0	0.0	10	100	1.8	6
g) Less effective work monitoring	8	80	2	20	0	0.0	0	0.0	0	0.0	10	100	1.2	7
h) Maintenance not handled properly	10	100	0	0.0	0	0.0	0	0.0	0	0.0	10	100	1.0	8

4.9 Satisfaction Level of User on the Maintenance of the Bridge

In this study, the average index method is used to determine the satisfaction level of maintenance of the Penang Second Bridge. The table shows the satisfaction level of user on maintenance management system, safety measures taken, the time taken to carry out the maintenance and quality of maintenance work carried out.

Based on table 4.4, all the average value is in the range of 3.5 to 4.0. This shows that all maintenance work carried out by the appointed contractor is at a satisfactory level.

Table 4-4 Satisfaction Level of User on Bridge Maintenance Work

Satisfaction level of user on bridge maintenance work	Rating of frequency												Average Index	Satisfaction Level
	1		2		3		4		5		Total			
	N	%	N	%	N	%	N	%	N	%	N	%		
Existing maintenance management system	2	3.5	5	8.8	6	10.5	38	66.7	6	10.5	57	100	3.72	Satisfactory
Safety measure taken during maintenance work	1	1.8	4	7.0	6	10.5	39	68.4	7	12.3	57	100	3.82	Satisfactory
Time taken to perform a maintenance work	3	5.3	3	5.3	8	14	39	68.4	4	7	57	100	3.67	Satisfactory
Quality of maintenance work	1	1.8	2	3.5	5	8.8	42	73.7	7	12.3	57	100	3.91	Satisfactory

To classify more the level of user satisfaction on the maintenance of the bridge, Figure 4.5 shows the result of satisfaction level on existing maintenance management system. 38 of the 57 respondents said the existing maintenance management system is at a satisfactory level at 67%. 6 people said maintenance management is at less satisfactory level while 6 respondents were at satisfactory at the level of 11%. 5 respondents indicated an unsatisfactory level and only 2 respondents at very unsatisfactory level of implementation of the existing maintenance management. Well organized and systematic maintenance management are very important and highly needed in order to guarantee perfect quality during repairing works.

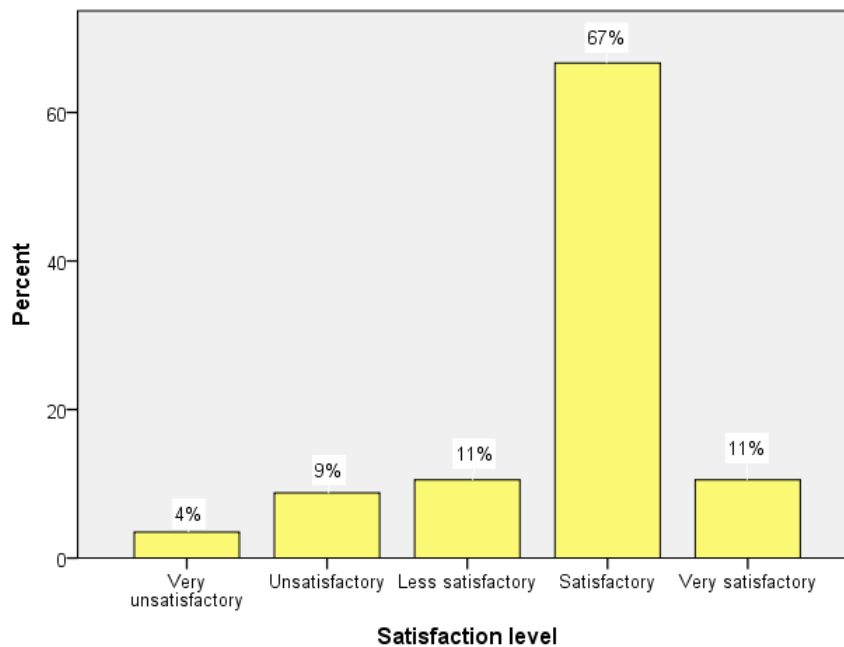


Figure 4-5 Satisfaction Level on Existing Maintenance Management System

Safety is very important during maintenance work. This can increase user confidence when using the bridge. Referring to Figure 4.6, 68% of the respondents are at satisfactory level with the safety measures taken during the maintenance work that is a total of 39 respondents. A total of 6 respondents were at less satisfactory level while 7 other respondents were at very satisfactory level on the safety measures taken during maintenance work. The remaining 7% of the respondents and 2% of respondent was unsatisfied and very unsatisfied with the safety measure taken.

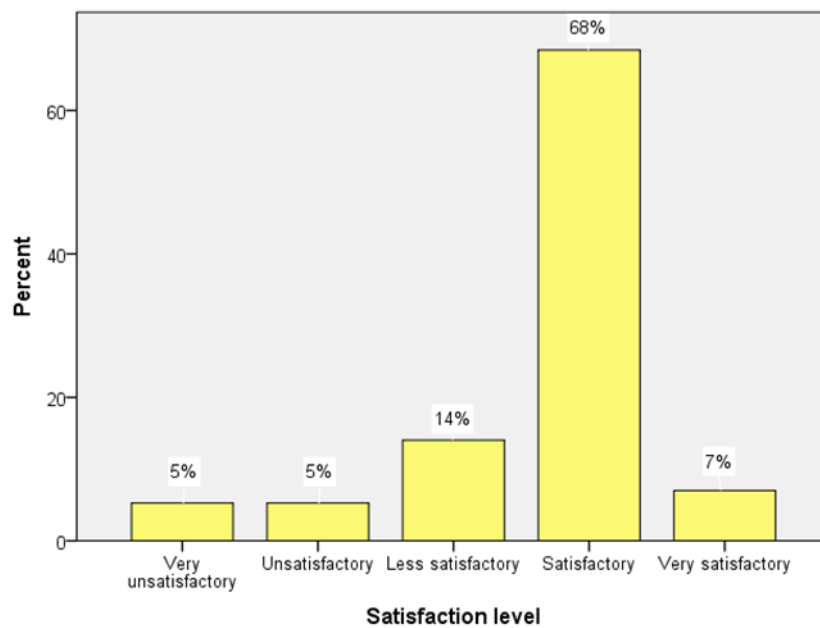


Figure 4-6 Satisfaction Level on Safety Measure Taken

From figure 4.7, 39 of the respondents or 68% said they were at a satisfactory level while 14% of respondents, or 8 respondents were at less satisfactory level. 3 respondents indicated an unsatisfactory level and there are 4 respondents expressed that they were very satisfied. There are only 3 or 5% of respondents was very unsatisfied with the time taken to perform a maintenance work.

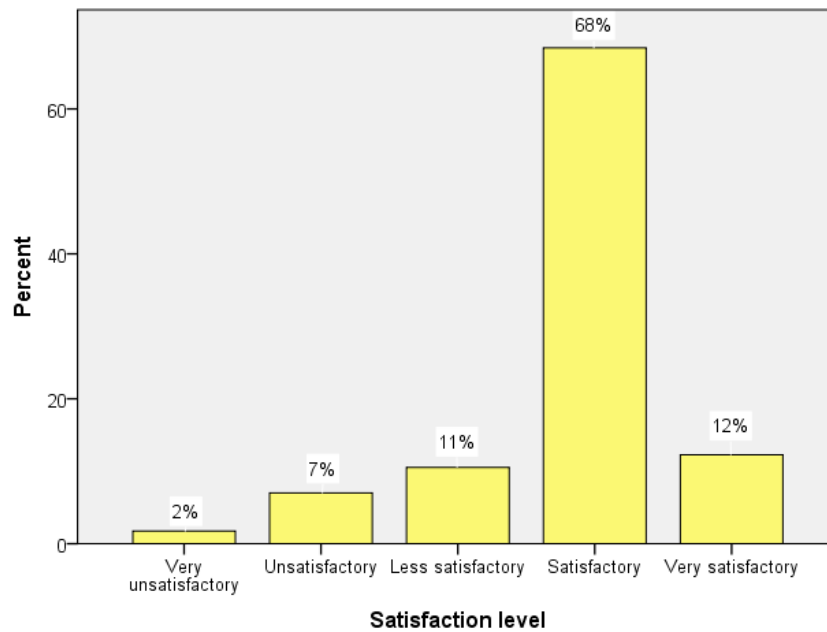


Figure 4-7 Satisfaction Level on Time Taken to Perform a Maintenance Work

In Figure 4.8, respondent stated they are very satisfied with the quality of maintenance work carried out by the management of the bridge which is 12%. This is followed by 74% of other respondents that were on satisfactory level. 2 respondents indicated an unsatisfactory level and another 5 respondents expressed that they were less satisfied. While the remaining is not very satisfied. High quality work during maintenance work is needed to ensure the comfort of the user in addition to showing a good image to the bridge users.

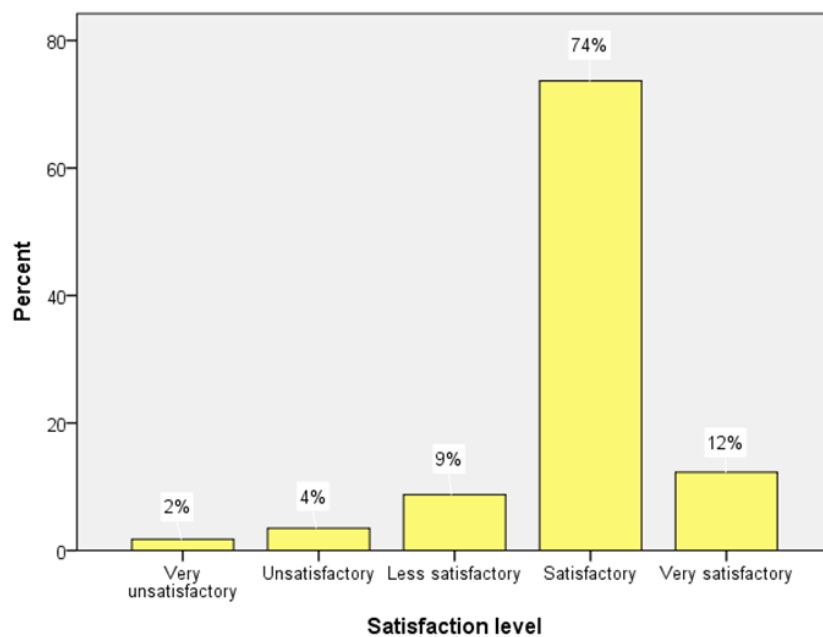


Figure 4-8 Satisfaction Level on Maintenance Work Quality

4.10 Satisfaction Level of User on the Management of the Bridge

Table 4.5 shows the satisfaction level of user on the management of the bridge by using average index. Referring to Table 4.5, notice that the cleanliness of the bridge is at a less satisfactory level with the average index of 3.46. This may be due to lack of maintenance performed on this section. For the other matters the user satisfaction levels are at a satisfactory level.

Table 4-5 Satisfaction Level of User on Management of the Bridge

Matter	Rating of frequency												Average Index	Satisfaction Level
	1		2		3		4		5		Total			
	N	%	N	%	N	%	N	%	N	%	N	%		
Signs places suitably and clear	3	5.3	4	7.0	17	29.8	22	38.6	11	19.3	57	100	3.60	Satisfactory
Adequate facilities	1	1.8	5	8.8	18	31.6	18	31.6	15	26.3	57	100	3.72	Satisfactory
Ride comfort on the bridge	2	3.5	4	7.0	19	33.3	16	28.1	16	28.1	57	100	3.70	Satisfactory
Cleanliness of the bridge	4	7.0	6	10.5	17	29.8	20	35.1	10	17.5	57	100	3.46	Less satisfactory
Level of safety on the bridge	1	1.8	3	5.3	15	26.3	24	42.1	14	24.6	57	100	3.82	Satisfactory

CHAPTER 5

CONCLUSION

5.1 Introduction

An efficient management system will enhance the maintenance system of a bridge. Furthermore, systematic management and maintenance of the bridge can effectively ensure the quality of the bridge structure maintained by the JKSB's maintenance unit. Based on standards that have been set, maintenance work steps involving repairs and damage prevention measures can be implemented effectively in the field of management and the maintenance among the parties involved will be able to facilitate programs and projects conducted.

5.2 Conclusion

Here it can be concluded that the overall objective of the research that has been framed as guidelines to this project which has been successfully achieved through the studies that have been done on the management of maintenance in the maintenance unit of the Second Bridge Sdn Bhd.

This study has been able to achieve all three objectives as set out at the beginning of the chapter, namely through a questionnaire survey and data analysis methods with the use of frequency and other general statistical calculations. The results of the research, study and analysis of the data found that the objectives have been achieved.

Evaluations and conclusions are based on studies and data analysis in chapter 4. It can be described that the conclusion is as follows:

a) Objective 1

To study the maintenance and inspection works of the bridge.

The results of the study found that there are four main categories of implementation of the bridge maintenance which is regular maintenance, repairing work, upgrading work and bridge inspections. Besides that, Integrated Asset Management System (IAMS) was developed using systematically computerized software. This will simplify the work such as obtaining inspection data, condition rating, predicting the rate of decline and the level of bridge structure.

b) Objective 2

To investigate the defects and damages on the bridge structure.

From research and data analysis conducted found that the main damage involved on the bridge according to priorities such as drainage, pothole, settlement, expansion joint, bridge parapet and water ponding, it can be concluded that majority of road users choose expansion joint as the main damage that often occurs on the bridge structure. The types of damage to the bridge structure are cracking, spalling, leaching, void, honey combing, mold growth, staining and corroded. Majority of the road user has identified that spalling and cracking are the type of damage that often occurs on the bridge. Factors that can cause damage to the bridge are design problem, environmental factors, accidents, low quality of materials, less effective monitoring work and control, aging bridges, irresponsible drive and maintenance is not handled properly. Employees in the maintenance unit has recognized that the aging bridges and accidents are the main factors that cause damage to the bridge.

c) Objective 3

To evaluate the level of road user satisfaction on the maintenance of the bridge in Penang Second Bridge.

From research and analysis, it can be concluded that the level of user satisfaction highway bridge maintenance management in Penang Second Bridge is satisfactory.

5.3 Suggestion and Improvement

Based on research studies conducted, the following proposals have been put forward to ensure that the bridge maintenance management in JKSB always run in a more systematic and effective way to ensure the safety and satisfaction of Penang Second Bridge users.

Table 5-1 Issues and Actions to be Performed

Issues	Actions
Receiving complaints process	JKSB parties can make a difference by using the latest technology in the process of receiving the complaint to encourage public to report more frequently. For example, JKSB can open a social media account to get closer with their user on sharing information such as repairing, maintenance work, and etc. Users also can directly send message to them if they want to make a report on defects or complaints. This is important because the survey found that most consumers have never made any complaint.
Spreading awareness	To raise awareness of the responsibility of the user of the bridge, the more enterprising campaign should be conducted on a complaint that can be made 24 hours and value the bridge. The campaign can be run as a road accident campaign generated on a large scale throughout Malaysia.

Spalling problems

Any problems or causes of problems frequently encountered causes of damage at this time should be studied and taken the necessary steps. In view of the problems that often occur, spalling damage the maintenance unit should provide more frequent inspections to identify problems that cause damage to the part to overcome them in the future.

5.4 Recommendation

Among the recommendation listed out in order to make the research better for future research are:

1. The scope of the title that is more focused on bridge maintenance management system. This is to make sure you can identify the damage and how repairing work performed in more detail.
2. The survey conducted is more accurate if get the user to scale the frequencies that have been introduced by Krejcie and Morgan. This will get more accurate results in the investigation.
3. Submission of questionnaire were done directly, namely to make the delivery to the user. This will reduce the risk of difficulty in the form returned. The usage of internet also can help ease distributing the questionnaire by using google docs.

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APPENDIX A
SAMPLE APPENDIX 1

a) Questionnaire 1 (Public/Road Users)

Section A – Personal Information

INSTRUCTION : Tick (/) on the given space

- | | | | |
|----------------------------|---|----------------|-----|
| 1. Gender | : | Man | () |
| | | Woman | () |
| 2. Age | : | < 19 | () |
| | | 20 – 39 | () |
| | | 40 – 59 | () |
| | | > 60 | () |
| 3. Type off transportation | : | Motorcycle | () |
| | | Lorry | () |
| | | Van | () |
| | | Car | () |
| | | 4x4 | () |
| | | Others : | |
| 4. Residential location | : | Seberang Perai | () |
| | | Mainland | () |

**Section B – The following statement is attributable to the maintenance of the
Penang 2nd Bridge**

INSTRUCTION : Tick (/) on the given space

1. Have you made any complaints about defects/damage on Penang 2nd Bridge?

Yes ()

No ()

*Ignore question 2 and 3 if your answer is **No**

2. How complaints are reported?

Telephone ()

Form ()

Letter ()

Email ()

Social media ()

Direct approach ()

3. Specify the type of damage reported

Drainage ()

Pothole ()

Settlement ()

Expansion joint ()

Bridge parapet ()

Water ponding ()

Section C – The following statement is attributable to user satisfaction on the bridge

INSTRUCTION : Circle the given answer

*The number below represent the level of satisfaction of user

1	Very unsatisfactory
2	Unsatisfactory
3	Less satisfactory
4	Satisfactory
5	Very satisfactory

1. Your satisfaction level on the bridge maintenance work

No	Matters	1	2	3	4	5
1	Are you satisfied with the maintenance management system that has been provided?					
2	Are you satisfied with the security measure taken during maintenance work carried out?					
3	Are you satisfied with the time taken to perform a maintenance work?					
4	Are you satisfied with the quality of maintenance work carried out by the management of the bridge?					

2. Your satisfaction level for the management of the bridge

No	Matter	1	2	3	4	5
1	Signs places suitably and clear					
2	Adequate facilities					
3	Ride comfort on the bridge					
4	Level of safety on the bridge					
5	Cleanliness of the bridge					

b) Questionnaire 2 (Maintenance unit department)

Section A – Personal Information

INSTRUCTION: Tick (/) on the given space

1. Position :
2. Gender : Man ()
Woman ()
3. Employment Period : > 5 years ()
3 – 5 years ()
1 – 3 years ()
< 1 year ()

Section B

INSTRUCTION: Tick (/) on the space provided

*The number below represent the level of satisfaction of user

1	Very unsatisfactory
2	Unsatisfactory
3	Less satisfactory
4	Satisfactory
5	Very satisfactory

1. How users make a report/damage complaints

No	Ways complaints are made	1	2	3	4	5
1	Phone					
2	Form					
3	Letter					
4	Email					
5	Direct encounter					
6	Complaints from the authorities					
7	Others (Specify:.....)					

2. Based on your observation, what are the damages that often occurs on the bridge structure

No	Damages that often occurs on the bridge	1	2	3	4	5
1	Drainage					
2	Pothole					
3	Settlement on the abutment					
4	Expansion joint					
5	Bridge parapet					
6	Water ponding					
7	Settlement of the soil					
7	Others (Specify:.....)					

3. Based on Question 2, what are the types of defects that occurs on the bridge structure?

No	Defects that often occurs on the bridge	1	2	3	4	5
1	Crack					
2	Spalling					
3	Leaching					
4	Void					
5	Honey combing					
6	Mould growth					
7	Staining					
8	Corroded					
9	Others (Specify:.....)					