# DEVELOPMENT OF MAINTENANCE RECORD DATABASE USING GIS TECHNIQUE: A CASE STUDY BRIDGE KUANTAN

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## ABSTRACT

Conventional database management systems bridge maintenance have many limitations in recording the bridge components, maintenance of historical data, geographical information about the bridge, and storage of information related images. Geographical Information System (GIS) has capability to record geographical data objects and associated characteristic. The system is also capable of managing, analyzing, and displaying all forms of geographic data objects and their properties. The main objective of this study is to develop a prototype system using the bridge maintenance database using Geographical Information System techniques. Data on components, bridge maintenance records obtained from the Department of Public Works District of Kuantan. Location and photos related bridges determined and recorded. Bridge maintenance records database was developed using GIS techniques. This prototype gives ideas to the relevant authorities and makes it as a starting point in developing its bridge maintenance database more effectively.

# ABSTRAK

Sistem konvensional pengurusan pangkalan data penyelenggaraan jambatan mempunyai banyak batasan dalam merekodkan komponen-komponen jambatan, data sejarah penyelengaraan, maklumat geografi sekitar jambatan, dan penyimpanan maklumat imej berkaitan. Sistem Maklumat Geografi (GIS) mempunyai keupayaan merekodkan data geografi objek dan ciri-ciri berkaitan. Sistem ini juga mampu mengurus, menganalisis, dan memaparkan semua bentuk data geografi objek serta ciri-cirinya. Objektif utama kajian ini adalah untuk merangka semua prototaip pangkalan data penyelenggaraan jambatan diperolehi dari Jabatan Kerja Raya Derah Kuatan. Kedudukan dan foto jambatan-jambatan yang berkaitan ditentukan dan direkodkan. Database rekod penyelenggaraan jambatn telah dibangunkan mengunakan teknik GIS. Prototaip ini memberi idea kepada pihak berkuasa yang berkaitan dan menjadikannya sebagai titik mula dalam membangunkan pangkalan data penyelenggaraan jambatan yang lebih berkesan.

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| | |
|---|---|
| ABIS | Automated Bridge Inspection System |
| ACD | Acoustic crack detector |
| ADT | Average daily traffic |
| ADTT | Average daily truck traffic |
| ASR | Alkali-silica reaction |
| AASHTO | American Association of State Highway and Transportation Officials |
| BRIDGIT | Project management system |
| CAD | Computer-aided design |
| $CO_2$ | Carbon dioxide |
| $Ca(OH)_2$ | Calcium Hydroxide |
| CGM | Computer Graphics Metafile |
| EPA | Environmental Protection Agency |
| GIS | Geographical Information System |
| GPS | Global Position System |
| ID | Identification |
| MCD | Magnetic crack detector |
| NBI | National Bridge Inventory |
| OSHA | Occupational Safety and Health Administration |
| PWD | Public Work Department |
| SCDOT | South Carolina Department of Transportation |
| WGS | World Geodetic System |

# CHAPTER 1

# INTRODUCTION

## 1.1 INTRODUCTION

At present, the construction industry is one of the important sectors around the world and Malaysia is no exception. To enhance accessibility, construction of roads and bridges grow in line with Malaysia's development. However, infrastructure maintenance efforts are not done well.

In case of the bridges, the main role of maintenance is to reduce small risk, the next to avoid to increased risk. Lack of maintenance will cause traffic delays. Maintenance work to be done periodically to maintain the bridge in an acceptable level of service.

In order to manage more effective bridge maintenance, database maintenance information must be provided with a good method. All information is recorded and can be easily reached. Based on this requirement, GIS techniques have the ability to help.

## 1.2 PROBLEM STATEMENT

Spectacular developments in the construction sector expended in Malaysia indirectly helping the country's economy. However, if the history of the maintenance work was not recorded with a good method, it cannot help maintenance work in the future effectively.

## 1.3 OBJECTIVE

The objectives of this study are as follows;

1. To study the process in maintenance management of bridge,
2. To develop information database of bridges at Kuantan District using Geographical Information System (GIS) technique.

## 1.4 SCOPE OF STUDY

The scopes of the research are as followings;

i. Study limited to the main bridge in the district of Kuantan.

ii. Bridge maintenance information obtained from the Public Works Department, Kuantan Distric.

iii. GIS software used is Arc GIS 9.3.

## 1.5 THESIS STRUCTURE

The thesis is divided into six (6) chapters. Chapter One describes background and objectives of the study are to be achieved. While chapter two and three, highlight of previous studies related to the research carried out. In chapter four studies carried out about the data, explained the process on how to design database. Further, the map can be visualize, retrieve and analysis to create a report on chapter five is result in the Arc Map and lastly, chapter six about the conclusions and recommendations.

# CHAPTER 2

# GENERAL VIEW ON MAINTENANCE

## 2.1 INTRODUCTION

In order to ensure satisfactory long term safety and performance of bridges, maintenance, rehabilitation, or replacement must be carried out in a timely and adequate manner. To provide safety and comfort to road users, a comprehensive road maintenance schedule must be formulated and adopted to ensure those roads are in the good condition at all times. Preventive maintenance works, such as road rehabilitation will help to reduce the major road repairs and expenditure. Prior to this, a good database, gathered though GIS will be necessary in order to ensure maintenance is done effectively. Geographic Information System (GIS) is said to be one of useful tools that can be utilized to manage database in road maintenance engineering. This system is capable of storing, managing, analyzing, computing and displaying all forms of geographical data for road maintenance works. (Yunus, 2010; Hasan, 2010).

## 2.2 GEOGRAPHICAL INFORMATION SYSTEM (GIS)

A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts. A GIS helps you answer questions and solve problems by looking at your data in a way that is quickly understood and easily shared. GIS technology can be integrated into any enterprise information system framework. (Esri,2013)

A GIS is a collection of computer hardware, software, data, procedure, and personnel that functions as an automated system for the capture, storage, update, retrieval, manipulation, analysis, management, and display of all forms of geographically referenced information. GIS is an appropriate technology for integrating and managing information because it is designed as a mapping and spatial data management tools, in contrast with other technologies which are, for example, design primarily for "electronic drafting". There are many distinctions about GIS technology which make appropriate tool for integrating the maintenance bridge spatial data, including the following key points:

a) Data about map features is stored in a database, along with the associated map graphics: This characteristic allows the creation of intelligent maps, more efficient storage and retrieval of data, spatial analysis, and other benefits.

b) GIS Data Model: The data model used in GIS software allows for specialized functions and analyses, such as the ability maps features to "know where they are" in relation to each other. This characteristic is essential for spatial analyses such s proximity analysis, buffering, spatial queries, etc.

c) Data is referenced to an established coordinate system: This allows relations to be established between different maps and databases.

d) GIS software may be used as a data integrator: This provides the ability to tie together a number of different software tools into one Spatial Data Management System.

### 2.2.1 History Geographic Information System (GIS)

When introduced in the 1960s, the use of Geographic Information System (GIS) was limited to a small number of research and applications users. Today, GIS is one of the fastest growing technologies; it has applications in public safety, natural resources management, environmental analysis, utilities, and government, and is moving quickly into many other areas.(Coppock,1988: Rhind, 1976).

Geographic Information System is a software program combined with a database that allows the manipulation, analysis and printing/plotting of data with geospatial location. It grew out the efforts to use computers in map-making, but has grown beyond that application.

A Geographic Information System (GIS) also a computer system capable of capturing, storing, manipulating, and displaying spatially referenced information. GIS is a tool planning and decision making processes. GIS is used in wide range of applications including urban and regional planning, agriculture, emergency response systems, and natural management.

GIS enables users to produce high quality maps at any scale, to store and maintain a large quantity of geographically related information, to visualize and simplify complex data, and to create new data from existing data. The most powerful aspect of a GIS is that it allows users to perform complex analyses by linking data layers and overlaying different data sets to get a spatial perspective.

### 2.2.2 Function of Geographic Information System

a) Display Information

- display information which resides locally or over a distributed network

- read spatial and tabular information from variety of data formats

-access external database

b) Thematic Mapping

-use colors and symbols to represent features based on their attributes

c) Spatial Query

Connect spatial information to database attribute

-select data spatial and retrieve database information

-select data from database and see the spatial representation of the selected features

d) Simple GIS functionality

e) Customization with Avenue

### 2.2.3 Advantages of Geographic Information System

Overall, the use of modern GIS offers many advantages over paper maps:

- The superior graphic image obtained which is much easier to interpret than tabular data, and greatly enhances the speed of decision making.

- Can cope with larger amounts of data.
- Can cover large study areas (the whole world if necessary).
- Can conveniently select any sub-study area.
- Can cope with unlimited and frequent edits and changes.
- More robust and resistant to damage.
- Faster and more efficient.
- Requires less person time and money.
- To combine a wide variety of information gleaned from variety of sources.

### 2.2.4 Disadvantages of Geographic Information System

- The costs of retraining of personnel and restructuring of responsibilities across the organization.

- Generally amongst many land surveyors, is that the traditionally lower positional-accuracy of imagery, tax- assessor parcels, and other GIS layers, may lead to costly mistakes when property agents interpret a GIS map, or engineer's design around GIS utility lines.

- In conclusion, although it is easy to compare maps to a GIS and source information about the advantages and disadvantages, GIS is certainly the fastest growing form with the most applications, without which many of the daily functions that granted would not be possible.

## 2.3 MAINTENANCE

Bridges are the most critical yet vulnerable elements in highway transportation networks. The bridge infrastructure throughout the country, especially in the dense

urban regions, has been exposed to aggressive environments and facing ever- increasing traffic volumes and heavier truck- load. In order to ensure satisfactory long-term safety and performance of bridges, maintenance, rehabilitation, or replacement must be carried out in a timely and adequate manner for mitigating progressive deterioration and for correcting major structural defects.

The primary role of maintenance is to minimize the risk of events escalating into major incidents. The reason of the maintenance process seemed as another part of construction phase. Maintenance services which carried out are to ensure normal and safe utilization of the structures. However, it is fact that maintenance is the most important and only activity to be carried out to prolog or at least maintain serviceability of the structure until end of its service age.

There are varieties if maintenance management methodologies have been develop to cost- effectively allocate limited budgets to deteriorating structures for performance enhancement and life span extension. Maintenance management will help preserve the physical asset. Management systems detect when something is going to fail or not in good condition. Good management initiates remedial action before deterioration happened. Breakdowns are always the most expensive and the most disruptive type of repair.(Levitt, 1997) Against the effective management, it charged the lower cost for the maintenance.

### 2.3.1 Definition of Maintenance

There are some definitions of maintenance from different sources:

a) Definition from Oxford Advanced Genie defined maintenance as act of keeping something in good condition by checking or repairing it regularly.

b) The recurring day to day, periodic/scheduled work required pressure or restore facilities, systems and equipment to continually meet or perform according to their designed functions. (Johnson,2001)

c) All actions appropriate for retaining an item/part/equipment in, or restoring it to, a given condition. (Dhillon,2002)

d) Maintenance can be defined as orderly control of activities required to keep a facility in as built condition, while continuing to maintain its original productive capacity. (Korka et al,1997)

As result, the objective of maintenance as an extension of the production strategy, link, and the task of the maintenance is directly to that strategy. The primary objective of maintenance is the repair and upkeep of production equipment to ensure that it is kept in a safe, effective, as designed, operating , condition so that production target can be met on the time and at least cost. A secondary objective of maintenance is to perform approved, properly engineered and correctly funded non-maintenance work(such as construction and equipment installation) only to the extent that such work does not reduce the capability for carrying out the maintenance program.(Tomlingsom, 1992)

### 2.3.2 Maintenance Classifications

Work classifications provide a type of control that channels and prescribes the handling and management of each type of work from inspection to completion, as well as its review and appraisal. In accordance with navy's manual (Naval, 1985), maintenance work is categorized as emergency work, service work, minor work and

specific jobs, and standing jobs. The relationship between these works classifications are illustrate in Figure 2.1.

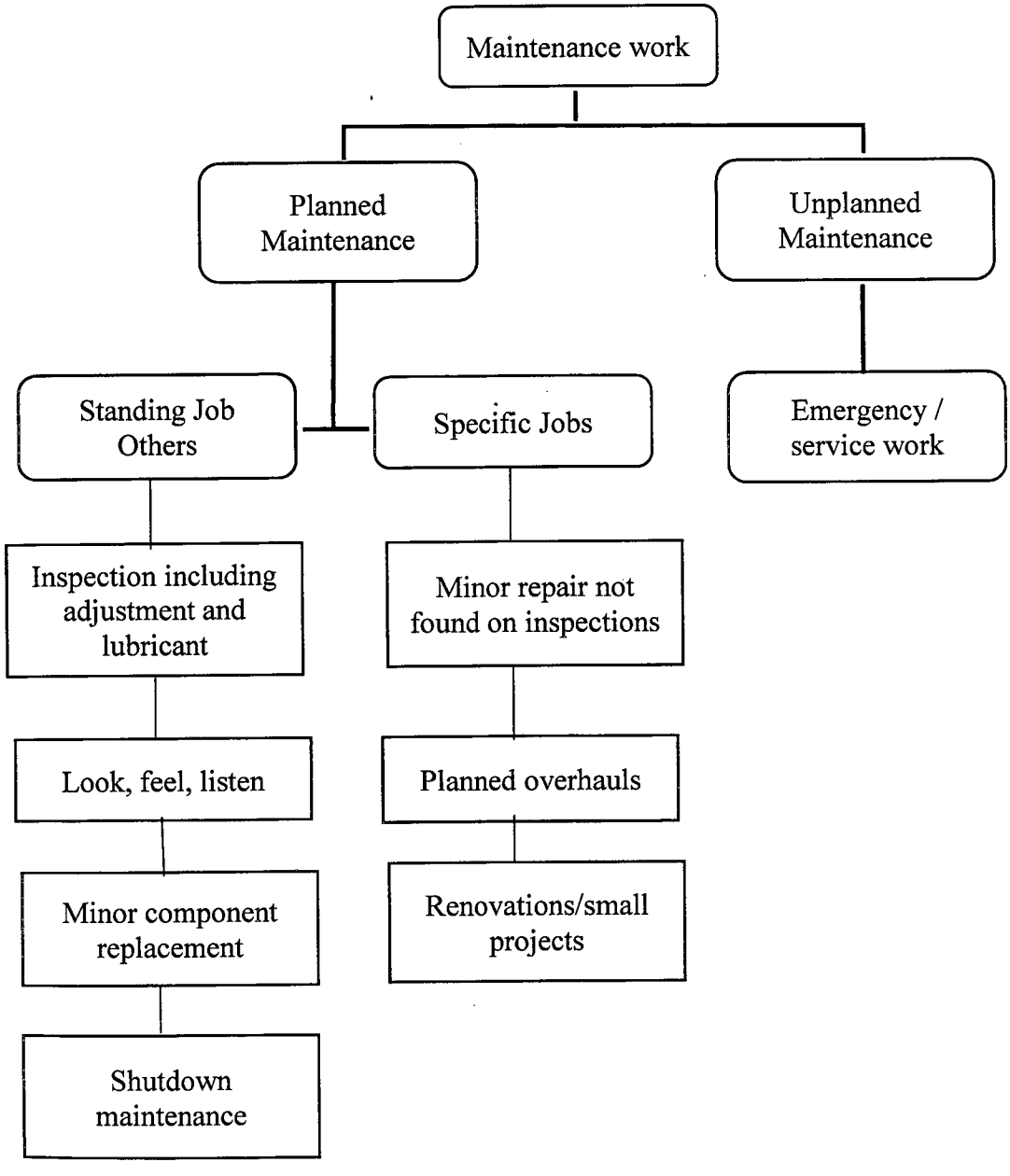


**Figure 2.1:** Various maintenance work classifications

Source: Korka et al. (1997)

(Terry, 2005) classified maintenance into five parts, reactive maintenance, corrective maintenance, preventive maintenance and maintenance prevention. The different between this types of maintenance as follow.

(i) Reactive maintenance, it is react by technicians, working only on equipment that is malfunctioning. This approach is most expensive way to coordinate maintenance.

(ii) Corrective maintenance, it carries out routine operational requests, and routine service requirement. It makes up the maintenance backlog and should be planned and scheduled in advance. This approach is the most cost-effective way to perform maintenance.

(iii) Preventive maintenance includes the lubrication program, routine inspection, and adjustment. At this level of maintenance, equipment service in acceptable range for most operations.

(iv) Predictive maintenance allows equipment to be repaired at times that does not interfere with production schedules. The equipment service level will be very high under predictive maintenance.

(v) Maintenance prevention focus on changing the design on equipment component so they require less maintenance. The data gathered from the previous techniques been used to design the maintenance requirement.

Another maintenance classification was made by (Narayan, 2003) with the following descriptions:

(i) Breakdown maintenance, it defined as repair is done after functional failure of equipment and without the schedule of repair. It is also termed on failure maintenance.

(ii) Corrective maintenance, the repair is done after initiation of failure or leading to degraded performance. Usually condition monitoring or inspections will reveal such degradation.

(iii) Scheduled overhaul or replacement or hard- time maintenance, repair is done based on age. This strategy is applicable when the age at failure is predictable.

(iv) On-condition maintenance, repair is based on the result of inspections or condition-monitoring activities which are themselves scheduled on calendar time to discover if failure has already commenced. All on-condition maintenance is corrective in nature.

(v) Predictive maintenance, repair is based on predict time of functional failure, generally by extrapolating from the result of on-condition activities or continuously monitored condition readings.

(vi) Preventive maintenance, repair or inspection task is carried out before functional failure. It is carried out on the basis of age- in-service and the anticipated time of failure. Thus, if the estimate is pessimistic, it may be done even when the equipment is in perfect operating condition.

According to (Dhillon, 2002) the background of the preventive maintenance is an important component of a maintenance activity. Within a maintenance organization it usually accounts for major proportion of the total maintenance effort. Some of the main objectives of preventive maintenance are to enhance capital equipment productive life, reduce critical equipment breakdowns, allow better planning and scheduling of needed maintenance work, minimize production losses due to equipment failures and promote health and safety of maintenance personnel. Besides that, the corrective maintenance may be defined as the remedial action carried out due to failure discovered during preventive maintenance, to repair an equipment/item to its operational state. Corrective maintenance is an unscheduled maintenance action, usually composed of unpredictable maintenance needs that cannot be preplanned or programmed on the basis of occurrence at particular time.

## 2.4 VALUE OF MAINTENANCE

Normally, the poor maintenance may result in the need for reparation, renovation or reconstruction, which may be cost more at the end. The value of maintenance show as following:

i) Time

When compared to time for reparation or renovation on structure, maintenance consumes less time needed. However, it produces better quality works.

ii) Cost

The cost of maintenance is defined as costs that include lost opportunities in uptime, rate, and due to non-operating or unsatisfactorily operating equipment in addition to cost involved with equipment-related degradation of the safety of people, property and the environment. (Dhillon, 2002)

iii) Structure value and performance

Generally, the structure will have the high value and good performance during its service life if maintenance works are done according to schedule and planned. Without proper maintenance, a structure will unable to provide the service at its maximum performance all the time.