

## **HIGHWAY ASSET INTEGRITY MANAGEMENT**

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## **ABSTRACT**

Malaysia Highway Authority (MHA) is the government agency that monitors the implementation and management of the privatized tolled highways / expressways in Malaysia. Since the highway / expressway facility consists of many types of assets (pavement, slopes, bridges, drainage systems, tunnels, buildings, lighting and mechanical systems, toll equipment, etc.), application of asset management tools are required for the processing and analyzing of data collected. TEMAN, a maintenance database is used in the management of the North - South Expressway (NSE), where information of asset sub-systems (eg. pavement, culverts, slopes etc) are consolidated for information, discernment, control and decision making. The primary objective of TEMAN is to facilitate the processing and analysis of collected data and information for the monitoring of performance against the prescribed maintenance standards and concession obligations.

This papers shares MHA and PLUS experience in the maintenance regime of the NSE which includes the management of asset inventory and condition data to ensure that the highway related assets would be functioning as intended.

## 1.0 INTRODUCTION

The Malaysian Highway Authority (MHA) is a statutory body incorporated under the Act of Parliament (Act 231, 1980) to establish a network of highways and expressways complete with all the necessary facilities and amenities. Its functions and main roles are:-

- To supervise and execute the design, construction and maintenance of highways as determined by the Government;
- To supervise and execute the design, construction and maintenance of rest and service areas and other facilities that may be deemed necessary along the highways;
- To collect toll from highway users and other dues from facilities along the highways;
- To plan and carry out research to ensure efficient utilization of highways and other facilities along the highways; and
- To undertake all related tasks to ensure maximization of development of highways and facilities along them
- To act as the monitoring and regulatory body for the implementation, operation and maintenance of privatized expressway projects.

A highway / expressway facility consists of several types of assets such as buildings, lighting and mechanical systems, toll equipment, pavement, bridges, slopes, drainage systems etc, to name a few. The proper management of each particular asset in a facility would collectively ensure that the overall business operations and strategic objectives would be met.

### HARD ASSETS

pavement  
slopes  
bridges  
drainage  
tunnels  
footway/cycleway  
street lighting  
pedestrian crossings  
signs  
traffic lights  
verges  
etc

### SOFT ASSETS

Traffic flows  
Safety  
Bus Routes  
Conservation areas. etc



**Figure 1 :** *Hard and Soft Assets*

Asset Integrity Management is the process where the relevant assets involved for the proper operation of the highways / expressways would be

maintained at least to a minimum specified level of service appropriate for the safe, efficient and comfortable operations. Therefore, the condition of the assets needs to be ascertained and checked against the level of standards prescribed and rehabilitation / repair programs need to be undertaken accordingly for the upkeep of the highway / expressway facilities.

In 2010, 27 highways were already in operation with overall length of 1661 kilometers which included over 969 bridges, 7500 slopes, 8000 culverts, 42 Rest Service Areas (RSA), 60 laybys and other structures. The total value of the highways and their assets is estimated to be RM 24 billion. The locations of the highways / expressways are illustrated in Figure 2.



**Figure 2** : Highways / Expressways in Peninsular Malaysia

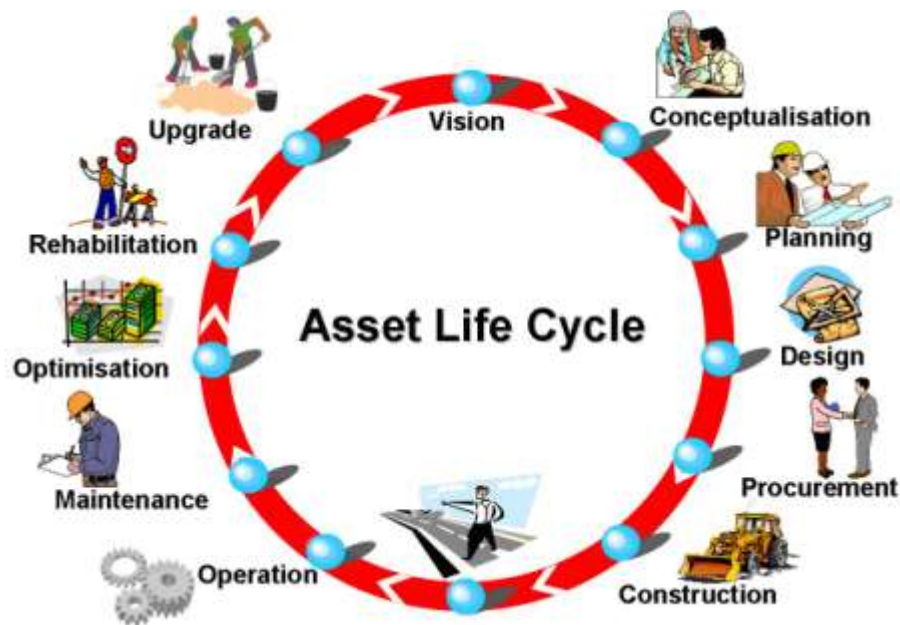
## 1.1 Asset Management Overview

Asset Management is a process by which an organization ensures that all systems and services provide effective support to the core business operations and contribute to achieving the organizations strategic objectives. Consideration of the process should also include the means to manage the “whole of life” of a facility to ensure optimal asset performance for continuous reliable service delivery at the least cost to the service provider within the life cycle of the asset.

An ideal asset management approach should encompass the whole development period of a facility from conception to planning,

acquisition/construction, operation and maintenance right up to disposal/renewal. However, at present, the role of facility management usually commences during the operational stage of a facility.

As described by Halim et al (2005) and illustrated in Figure 3, operation and maintenance are among the main tasks in asset integrity management where both processes are to ensure that the facility's assets are optimised for reliable service delivery.



**Figure 3:** *Total Lifecycle Management of Assets – Ideal Model*

Source : Halim, S. et al, *Asset Management : Cornerstone of Highway Concessions*, 2005

The role of an Asset Manager in both tasks is defined as follows:-

i. Operation

- to have good knowledge of the assets and its functioning condition during the asset's lifecycle; and
- to have knowledge on how best to operate a facility to get the best service delivery results within its capacity.

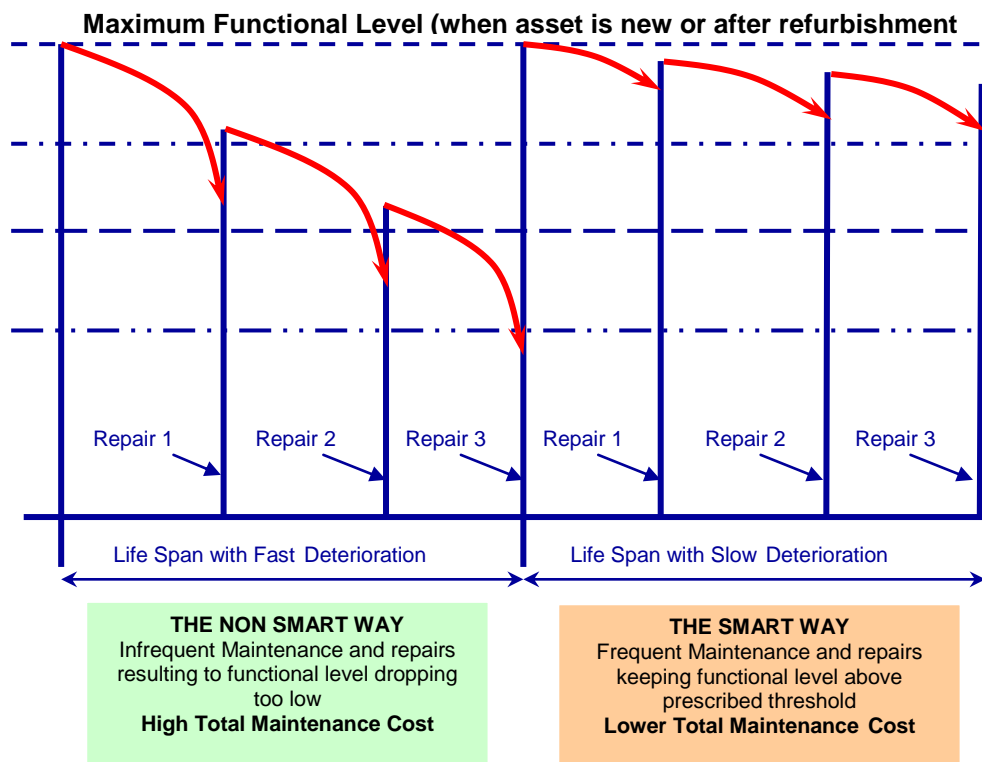
ii. Maintenance

- to have knowledge of assets with regard to condition and service delivery performance;
- to have records of what, how and when maintenance works have been carried out; and to know which components of the asset are due to be replaced.

## 1.2 Maintenance

In life cycle costing of an asset, in order to keep the overall maintenance costs with respect to the required level of services to a minimum, it is imperative that maintenance activities are carried out based on timely scheduling where plans, budgets and strategies could be carried out for maintenance executions in a systematic manner with minimal disruptions to the customer. Delaying required maintenance would result to more extensive repairs needed, resulting to higher costs and longer 'downtime'. This is illustrated in Figure 4 where the costs involved and the 'downtime' in terms of disruptions to the customers could be minimised.

It is also important to recognise that when maintenance schedules are not strictly adhered to, residual damage would set in even after emergency repair has been carried out.



**Figure 4:** *Effects of Timely Maintenance and Repair*

Source : Leong K.C., *The essence of good facility management*, Bulletin Ingenieur, December 2004.

The usage of computer programs is essential in order to manage the amount of data that will be collected, stored and processed. Essentially, data management is defined as the total process of data handling such as:

- Field data collection;
- Data base input; and
- Data handling, verification, storage, processing and retrieval

To select a computerised system, the following criteria should be considered (Draft TRH 22, 1994):

- The system should be able to handle the volumes of data calculated within the acceptable time periods;
- Staff should be available who can support it and its application;
- The system should be able to operate across a computer network;
- It should provide some kind of control whereby users can share data without introducing inconsistencies;
- Data retrieval procedures should be simple and effective;
- The system should operate efficiently; and
- It should be appropriate to the needs of the road authority

## **2.0 ASSET INTEGRITY MANAGEMENT BY MHA**

The main principle involved in expressway / highway maintenance is to preserve the assets' functional and structural characteristics for the provision of safe, comfortable and reliable passage for all traffic.

As the governing authority, MHA monitors the expressways both from its Head Office and its Regional Offices (North, South, Central and East). In general, MHA's Head Office monitors the policy and strategic aspects of the expressway concessions while MHA's Regional Offices will be monitoring the site and operational aspects of them.

All expressway maintenance related works have to be in line with MHA's maintenance manuals which provide some basic guidelines and requirements for material, labour and equipment, working procedures and expected performance for effective maintenance and operations. Routine inspections for the carriageways, drainage systems and roadside furniture are done on a daily, weekly or monthly basis while a periodic detailed inspection, as a follow up on the routine inspections, are undertaken between three (3) to six (6) months (ie. critical slopes).

The Government may elect to carry out the necessary maintenance obligations and recoup the costs from the Maintenance Bond of the Concessionaires (upon issuance of notices and rejected justifications) if the Concessionaires were not performing their maintenance or structural overlay obligations in accordance with the Concession Agreement.

Further actions undertaken by MHA to ensure that the Concession Obligations would be met by the Concessionaires include:-

- Publishing relevant Guidelines and Standards for Construction and Maintenance;
- Undertake audits of asset conditions (Joint Site Visits);
- Undertake Performance Evaluation of Concessionaires (Analisa Prestasi Penyelenggaraan Lebuhraya);
- Setting up of Key Performance Indicators (KPI).

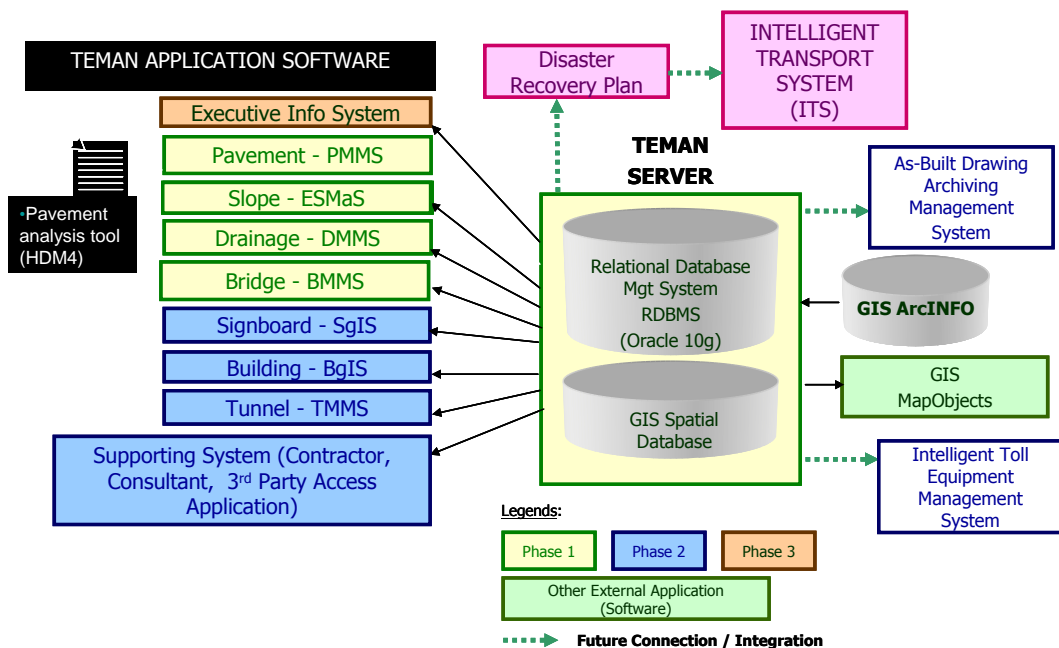
### 3.0 MONITORING OF OPERATIONS & MAINTENANCE OF NSE

#### 3.1 TEMAN

In 1998, PLUS had begun the study and commissioning of TEMAN, acronym for Total Expressway Maintenance Management System, a maintenance database where information of maintenance sub- systems (e.g., pavement, drainage, earthworks etc) are consolidated into reports suitable for information, discernment, control and decision making. The primary objective of TEMAN is to provide a tool to assist PLUS to facilitate the processing and analysis of information for the managing of the expressway elements to meet the maintenance standards and its concession obligations.

The processes and requirements incorporated into TEMAN are:-

- i. maintenance goals;
- ii. expressway element inventory;
- iii. intervention levels by either performance criteria, trigger point value or maintenance standards;
- iv. identification of monitoring and maintenance activities;
- v. calculation of maintenance costs
- vi. the creation and evaluation of alternative maintenance strategies using cost benefit analysis; and review strategies with funding levels and priorities.



**Figure 5 :** TEMAN General Configuration

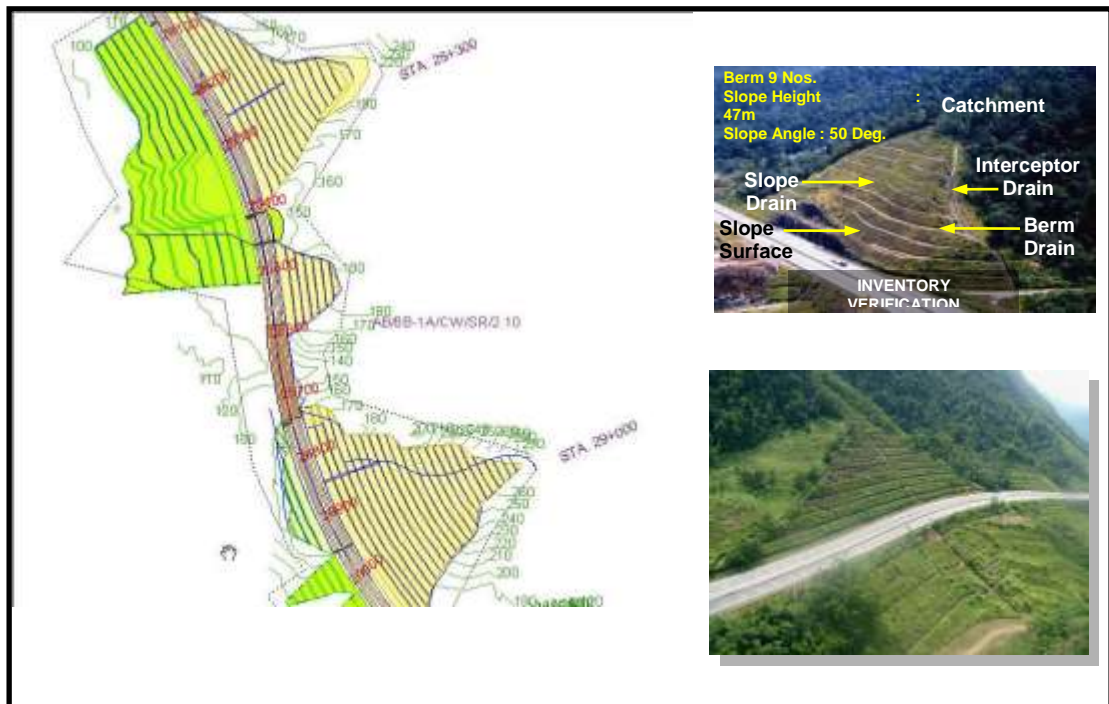
From the inception of TEMAN in year 2000, several subsystems were added as shown in Figure 5.



TEMAN is the defining Asset Management Tool used in the operations and maintenance of the North South Expressway where the inventory, maintenance history, condition data are kept for further processing into reports and information.

### 3.2 Inventory

It is imperative that a complete inventory of assets is maintained in order to ascertain the type, numbers and condition of the assets for maintenance purposes. The inventory list, with the necessary referencing system (unique ID), would enable the owner to ascertain the inspection activities that need to be carried out, their condition and performance of the assets with respect to their intended function and also the resulting type of repairs and replacement activities that needed to be carried out. The typical asset element inventory collected is depicted in Figure 6.



**Figure 6:** Asset Inventory and Asset Elements (Typical Example)

### 3.3 Data Collection & Asset Inspection

Typical data collected are asset condition data via both manual and automated means. As per the concession obligations, inspection and maintenance manuals and guidelines were prepared and the respective assets are monitored based on the criteria and performance stipulated. Examples are pavement ride quality (International Roughness Index) via

surface profilers, pavement deflection using Falling Weight Deflectometers, skid resistance using Griptesters etc.

Manual visual inspections were also carried out to ascertain the condition of slopes, culverts and bridges. The frequency of asset condition inspection adopted for the NSE is as follows:-

- |                    |   |
|--------------------|---|
| Bridges            | - Periodical Inspection every 2 years<br>- Principal Inspection every 5 years |
| Culverts & Tunnels | - Periodical Inspection every year  |
| Pavement           | - Periodical Inspection undertaken annually                                   |
| Slopes             | - Based on Hazard Ranking (4 months, 6 months, 12 months and 18 months)       |



***Plate 1 : Asset Condition Assessment for Pavement***

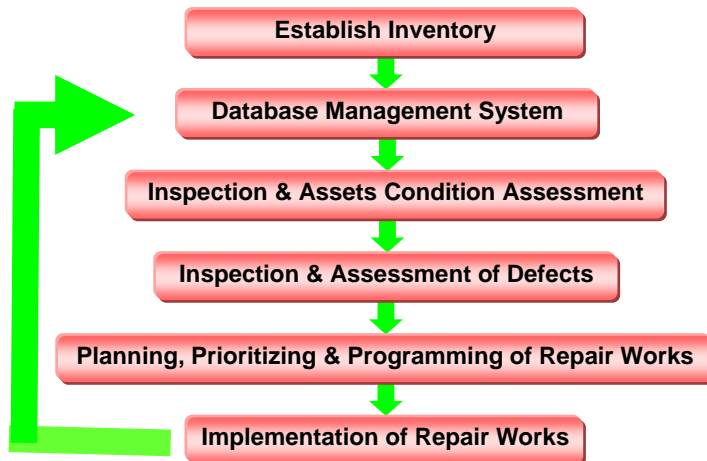


**Plate 2 : Asset Condition Assessment of Slopes**



**Plate 3 : Asset Condition Assessment of Bridges & Culverts**

The data collected were updated into TEMAN or via bridging software such as HDMIV where it will be analysed accordingly. The processes involved are as follows:-



**Figure 7 :** Asset Management Process for the North-South Expressway

### 3.4 Performance Based Measures

The overall management of the North South Expressway can be broadly categorized into three (3) performance based measures namely

- i. Management Performance Measures (MPM)  
- Measures the asset manager's performance in the delivery of services
- ii. Durability Performance Measures (DPM)  
- Measures the long term sustainability of assets in delivering the specified level of service
- iii. Operations Performance Measures (OPM)  
- Measures the performance of contractor in the delivery of service

Typical output for these measures is summarized as follows:-

- MPM - Reporting, Traffic management, Announcements, Data Management
- DPM - Cracking, Roughness, Residual Life, Defects, etc
- OPM - Working hours, Joint Inspections, Construction Audits, etc

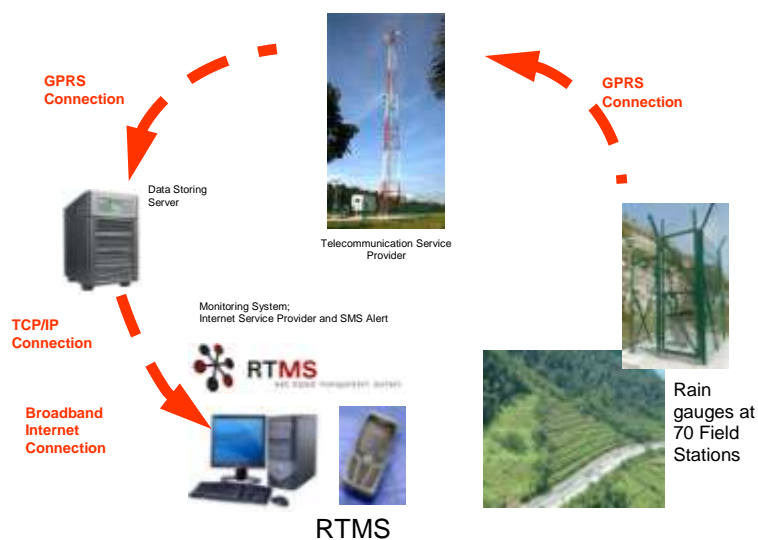
An example of DPMs for the North South Expressway is illustrated as follows:-

Overall Condition	Roughness (IRI), m/km	Mean Texture Depth (MTD) – mm	Rutting (RUT) - mm	Pavement Condition Index (PCI)
Good	< 2	> 0.5	< 5	< 2
Fair	2 – 3	0.3 – 0.5	5 – 10	2 – 3
Poor	3 – 3.8	< 0.3	10 – 20	>= 4
Bad	>= 3.8	-	> 20	-

\*All pavement shall conform to either “Good” or “Fair” category at least 95% of the total lane km of the expressway

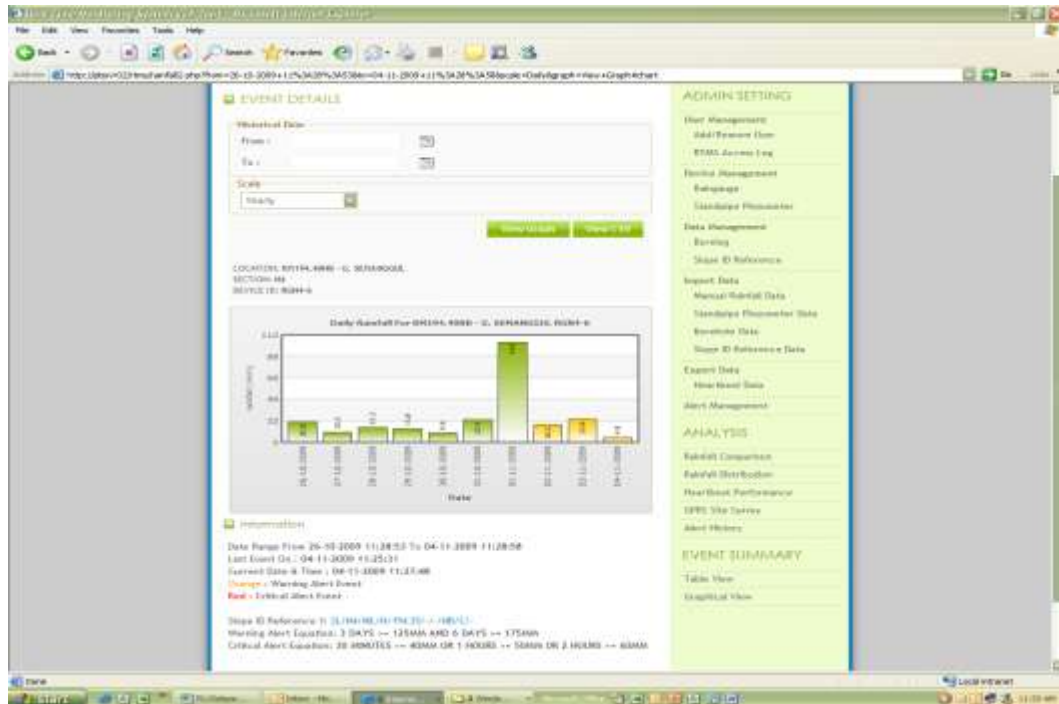
#### 4.0 Real Time Monitoring Systems

Implementation of an early warning system could be used to monitor and advise the concession owner so that appropriate steps could be undertaken to ensure the safety of the road users.



**Figure 8** : Real Time Monitoring System

In the North South expressway, a Real Time Monitoring System was implemented in 2008. Rainfall data was collected from site instrument and updated in real time and monitored against a set threshold value. The data was updated using GPRS and alerts were given to the relevant maintenance personnel at site.



**Figure 9 :** Graphical User Interface of RTMS

## 5.0 CONCLUSION

As mentioned previously, asset management principles were adopted for the maintenance of the highways / expressways to achieve the minimum cost of maintenance and upkeep of the expressway to the specified levels of service by the Malaysian Government. It is important that the asset management criteria adopted consist of ensuring all assets to perform as per intended during the operations and maintenance phase.

From MHA point of view, the knowledge of the asset condition and the time for intervention are of utmost importance to ensure that the expressways' assets condition would be maintained accordingly.

Asset Integrity Management is a sub-process in the overall Asset Management discipline, where the condition of the existing assets need to be adequately maintained to ensure that the mission of establishing a network of expressways that is safe, efficient, comfortable and complete with the necessary facilities and amenities would be able to be realized.

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