

## **DEVELOPMENT OF A NEW BRIDGE MANAGEMENT SYSTEM (BMS) IN LAO PDR INCORPORATING THE LESSON LEARNED FROM THE EXISTING BMS AND THE GOOD PRACTICES OF JAPANESE TECHNOLOGY**

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### **1. INTRODUCTION**

Lao People's Democratic Republic (Lao PDR) is a landlocked country having the smallest population (about 7 million) among the countries in the region. Road transportation is the main mode of passenger and cargo transport in Lao PDR. As of 2021, the road network has a total length of 56,000 km with 3,580 bridges of all types. Bridges are an integral and important part of the road network. Thus, proper maintenance and performance assurance of these road and bridge infrastructures are indispensable for realizing the balanced industrial and economic development across the country as stipulated in the five-year National Socio-economic Development Plan (2016-2020). The current approach of bridge maintenance in Lao PDR is "reactive approach", in which repairs are performed only after the heavy damages without "planned repair". In order to ensure safe and smooth traffic, a systematic plan for bridge maintenance and repair is crucial. Japan International Cooperation Agency (JICA) has been providing support in transport sector for the socio-economic development of Lao PDR including technical cooperation project, entitled the Project for Capacity Development on Bridge Maintenance and Management (JICA-BMM) to establish bridge maintenance cycles and contributes to the improvement of bridge maintenance capabilities in Lao PDR. Development of a New Bridge Management System (New BMS) is one of the key activities of JICA-BMM. A New BMS aims to incorporate the lesson learned from the existing BMS and the good practices of Japanese technology in collaboration of Public-Private-Academia participated from both Japan and Lao PDR. Nagasaki University, Japan, and National University of Laos are supporting in development of a New BMS.

### **2. REVIEW OF EXISTING BMS**

Road Management System (RMS) had developed and updated as a planning tool for road maintenance planning in Department of Roads (DOR) in the period 2001 to 2004, 2004 to 2009 and is currently under updating under support from the World Bank. RMS consists of six (6) major modules, and the main analytical modules are Pavement Management System (PMS) and Bridge Management System (BMS). The BMS module (existing BMS) included in RMS is only for bridge routine maintenance management, RAMBOLL et al. (2009). There are some critical issues in the existing BMS as listed below:

- RMS is an offline system developed in MS-Access platform which doesn't allow to integrate with other web-based management systems being developed in DOR, and it is eventually preventing data sharing among systems even within the DOR and Ministry of Public Works and Transport (MPWT).
- The existing BMS is applicable for planning of annual routine maintenance only whereas the share of bridge repair works/costs dominantly falls under major repair works such as rehabilitation (periodic repair) and replacement.
- Bridge major works are included in PMS module without any analytical tool such as deterioration prediction, whereas PMS has a deterioration model for road (pavement) and this difference is making the module inconsistent.
- The bridge major works registered in RMS/PMS include only reactive repair works. Bridge preventative repair works are not included which ultimately leads to inability of adoption of preventive maintenance approach.
- Due to a lack of deterioration prediction, it is impossible to formulate medium and long-term maintenance plans.
- GIS module in RMS consists only GIS software (Arcview 3.2) and the real-world map (base map) is missing, which leads to inability to display bridges in the map properly with the key location information.

### **3. DESIGN POLICY AND DESIGN FRAMEWORK OF A NEW BMS**

#### **3.1 Design Policy**

Design policies of development of a New BMS include customized into user's needs, simple and user friendly, editable for future upgrading, affordability, and sustainability (cost and technology perspective), web-based operation, utilization of MPWT's road asset database, incorporation of GIS base map and involvement of Public-Private-Academia collaboration.

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### 3.2 Design Framework

The design framework of a new BMS comprises of various modules and fully integrated with MPWT central database and

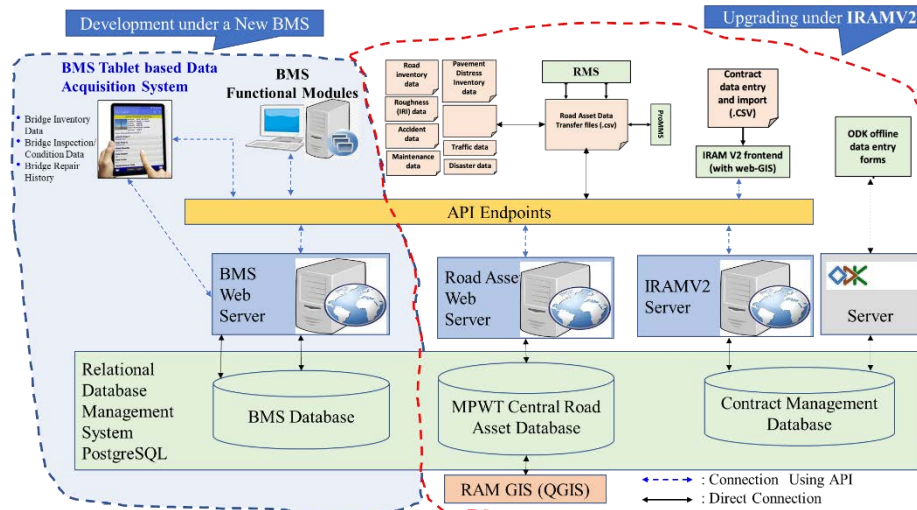


Fig. 1 System Structure of a New BMS

to be updated RMS. A new BMS will run on its webserver, whereas data are integrated with central database as shown in Fig. 1. The smart phone application is customized to collect data and can send data automatically to the BMS database server. A new BMS mainly includes eight (8) Modules, namely Data Acquisition/Collection System, Data Management, Deterioration Prediction, Life Cycle Cost (LCC) Analysis, Maintenance Planning, Reporting, Documentation and GIS Map Module. Application Programming Interface (API) Endpoints are to be used for integration with other systems.

## 4. KEY DEVELOPMENT FEATURES OF A NEW BMS

### 4.1 Development of Bridge Data Acquisition System

In order to avoid these possible errors in data collection, manipulation and inputting, a smartphone-based data acquisition application that has been gradually applied in Japan as well, is customized into Lao PDR context. The data acquisition system can record inventory, condition (damage types and levels), location information (GPS), photo, etc., at site and send data to the database server via internet. Data input control and the data validation process are embedded in the application.

### 4.2 Development of Deterioration Prediction Model

Considering this shortcoming, a statistical deterioration prediction model developed/studied in Nagasaki University, Japan, is introduced in a New BMS. Damage level is categorized into five grading scales from A to E. Damage Level "A" indicates no damage, whereas damage level "E" indicates the heaviest damage. Percentage of each damage level of each bridge element is recorded at site and then Health Index (HI) is calculated using a statistic model using Eq. (1)

$$HI = aT^2 \quad (1)$$

The gradient factor (a) is to be calculated based on regression analysis of the past inspection results of bridges. Similarly, Time (T) is the year(s) elapsed from the bridge inspection year. The deterioration curve is to draw for each bridge element.

### 4.3 Development of Life Cycle Cost Analysis Model

LCC calculation is done for the bridge life under six (6) scenarios incorporating various combinations of proactive to reactive maintenance works and repair frequency depends on repair work type. Therefore, in LCC analysis, LCC for the analysis period is estimated for different scenarios and the optimal life cycle cost is determined.

### 4.4 Budget Planning for With/Without Budget Constraint Scenario

Budget planning module will support in formulation of annual, medium-term and long-term bridge maintenance planning for with and without budget constraint scenario. The minimum level service in the form of HI can set in the interface either based on optimal scenario as per LCC analysis or user's selection. As for budget constraint scenario, the constrained budget amount can also input manually. The annual allocation budget for constrained analysis can be equal or variable by year.

## 5. CONCLUSIONS

MPWT has been making all its efforts for effective and efficient maintenance and management of bridges in Lao PDR for a long time. It is anticipated that upon completion of development of a New BMS, it will support MPWT engineers in maintenance and management of bridges in Lao PDR significantly. Since a New BMS is under development, this paper only presents the design policy and framework of a New BMS development. The actual output of a New BMS will be presented in the next paper in the near future.

## REFERENCES

RAMBOLL, Grontmij Carlbro and Hifab, RMS Software User Guide, Road Management System, Ministry of Public Works and Transport, Public Works and Transport Institute, 2009, pp 1-136.