NEW APPROACH TO PAVEMENT MANAGEMENT SYSTEM IN THAILAND

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Abstract: Thailand has a total highway network of about 200,000 kilometres, 51,662 of which are main highways under the responsibility of Department of Highways (DOH). In its recent new approach to road asset management, DOH has engaged transportation engineering resources from four leading Thai universities to upgrade existing Thailand Pavement Management System (TPMS) and to introduce Highway Design and Maintenance Model (HDM-4) for use in the Department’s pavement management programme. The new approach involves the utilization of automated data collection of highway conditions for the whole country. Data collected include wheel rutting, pavement roughness and surface distresses with pavement and asset views.

This paper describes the application of the survey vehicle equipped with laser profilers, digital video cameras, distance measuring instrument, GIS database, and GPS in field data collection of highway conditions, asset views, and pavement views. Successful implementation of new approach to the pavement management system (PMS) requires the understanding of the model capabilities with local parameters; quality input parameters; customization of treatment selection process and intervention levels, and consideration of the environment and local maintenance practices in predicting future pavement conditions. Use of HDM-4 is discussed with respect to the strategic assessment of funding needs and optimum resource allocation for the future pavement maintenance and rehabilitation at the project and network levels.

Keywords: Pavement management system, Electronic data collection of highway conditions, GIS database, HDM-4

1. OVERVIEW

Thailand has a total highway network of about 200,000 kilometres, out of which 51,662 kilometres are main highways (National Highways of 51,239 km, Special Highways of 396 km...
and Concession Highways of 27 km) under the responsibility of the Department of Highways (DOH), the Ministry of Transportation. DOH’s highway network comprises 3,045 kilometres of concrete pavement, 43,611 kilometres of asphalt concrete pavement, and 2,967 kilometres of roads still under construction. Asphalt pavement surfacing of many highways have deteriorated and developed extensive damage due to severe climatic conditions and heavy vehicle overloading. The distresses of some of the pavements have been so severe that reconstruction of the whole pavement is necessary.

Within DOH, maintenance of highways is looked after by the Deputy Director General (Maintenance), the Director of Maintenance Bureau in Bangkok, with the assistance of 15 Highway Division Bureaus, which are mostly located in provinces, 105 highway district offices, and 499 highway depots. While the work of administration, monitoring and budgeting is handled by the Headquarters in Bangkok, the field operations are carried out in district offices and highway depots. The works of periodic and special maintenance which constitute some 60 per cent of all works are assigned to contractors.

Responsibility for another 42,465 kilometres of rural roads is under the jurisdiction of the Department of Rural Roads (DOR), Ministry of Transport and the remainder of over 100,000 kilometres are looked after by the Provincial Administration Organizations within the Ministry of Interior. The DOR has one full directorate for maintenance and rehabilitation at the Headquarters bureau for policy, technology and budget allocation with the assistance of 12 division bureaus in provinces and 75 district maintenance offices.

In addition, urban tolled expressways of 150 kilometres in Bangkok and some 200 kilometres of inter-city tolled expressway and motorway are under the responsibility of the Expressway and Rapid Transit Authority of Thailand (ETA) and DOH respectively.

2. THE DEVELOPMENT OF PMS IN THAILAND

The objectives of highway maintenance management systems are to compile an inventory of all highways; assess their importance in terms of the service they provide; examine their surface and structural conditions; diagnose existing deficiencies and failures and their future development; conceive remedial measures; establish work standards and intervention levels; to rate priority works; implement maintenance work; monitor and report cost and performance and evaluate efficiency. Besides these technical means, maintenance management systems provide a systematic and sound framework for maintenance requirements which will convince decision makers by facts and figures to allocate funds in rational manner.

Highway maintenance policy of Thai DOH is to categorize treatment types and assign them to various implementing programmes. Reconstruction and rehabilitation are included in highway development or investment plan while overlay, seal coat and routine maintenance are financed under maintenance budget, also called recurrent expenditure.

Since 1983 the Department has been developing a highway database on a mainframe computer in the early days and currently on the computer network system as shown in Figure 1. However,
for the highway maintenance priority/ranking system, the British BSM system has been introduced for the country. Meanwhile, distress thresholds for intervention on maintenance work are temporarily employed during the development of the BSM system. For the purpose of identifying highways for reconstruction/rehabilitation under the highway development/investment plan (5-year), the Department of Highways has developed its own system to verify treatment needs. The criteria is technically based on PSI rating, pavement deflection and economic internal rate of return.

![Diagram of DOH computer network system](image)

**Figure 1** Diagram of DOH computer network system

In the past, highway condition surveys were carried out by visual inspection by a study panel/district office panel and mechanical means (roughometer and Benkelman beam) from which the deficiencies were recorded and evaluated. DOH’s maintenance work programmes are standardized and average figures for equipment, material, personnel requirements as well as average performance and guidance for cost estimates do exist.

Present activities for improving highway maintenance management are to fully develop the PMS, implement staff training in the operation of the system and assess the various highway maintenance scenarios.
3. ON-GOING PROJECT ASSIGNMENTS

Presently, the DOH has engaged transportation engineering resources from four leading Thai universities to upgrade existing Thailand Pavement Management System (TPMS) and to implement the Highway Design and Maintenance Model (HDM-4). The data collection for the project utilizes automated (electronic) data capture of highways inventory, asset views and pavement views for all highway sections in the country, the pavement distresses captured via digital video, and laser profilers are: wheel track rutting at 25 meter-interval with 1 mm accuracy, pavement roughness (IRI) at 25 meter-interval, asset views and pavement views for analyzing surface distresses (cracking, deformation and disintegration) at 3 meter-interval. Computer application programmes are used for analyses and optimization of investment plans.

The scope of assignments to the four universities responsible for each region is summarized as follows:

1) Surveying the highway conditions, recording asset views and pavement views of the whole highway network by using automated (electronic) equipment.
2) Creating the map of highway network in such a way that rutting, roughness and distresses of pavements can be displayed in GIS with the video views of assets and pavements shown by section.
3) Creating the database of pavement distresses in order to enable the analyses of the extent and severity of distresses and propose the maintenance measures for short term (1 year) and medium term (3-5 year) plans to achieve better performance with optimum capital expenditure. The computer programs used will be on Microsoft Windows platform.
4) Creating the planning details in GIS highway network for managing maintenance and repair for a period up to 5 years and also prioritize the planned works, given the surveyed network condition, and optimizing resource allocation to achieve a safe and serviceable highway network.

Scope of Work for the Northern Region of 148,785 square kilometres, consisting of Highway Division Bureau 1 (Chiang Mai), Highway Division Bureau 2 (Phrae), Highway Division Bureau 4 (Phitsanulok) and Highway Division Bureau 6 (Phetchabun) totalling 16,888 kilometres of highway in length of 2 lanes equivalent (asphaltic surface 16,194 km and concrete surface of 694 km) is assigned to Chulalongkorn University as the responsible team (surveying and analyzing not less than 15,850 km of asphalt and 541 km of concrete pavements).

Scope of Work for the Central Region of 105,886 square kilometres, consisting of Highway Division Bureau 9 (Lopburi), Highway Division Bureau 10 (Suphanburi), Highway Division Bureau 11 (Bangkok) and Highway Division Bureau 12 (Chonburi) totalling 15,016 kilometres of highway in length of 2 lanes equivalent (asphaltic surface 11,431 km and concrete surface of 3,585 km). Kasetsart University is the responsible team (surveying and analyzing not less than 10,252 km of asphalt and 2,424 km of concrete pavements).

Scope of Work for the North-eastern Region of 169,924 square kilometres, consisting of Highway Division Bureau 3 (Sakonnakhon), Highway Division Bureau 5 (Khonkaen), Highway Division Bureau 7 (Ubonratchathani) and Highway Division Bureau 8 (Nakhonratrasima) totalling 17,385 kilometres of highway in length of 2 lanes equivalent (asphaltic surface 16,420
km and concrete surface of 965 km). *Thammasart University* is the responsible team (surveying and analyzing not less than 16,230 km of asphalt and 785 km of concrete pavements).

**Scope of Work for the Southern Region** of 88,520 square kilometres, consisting of Highway Division Bureau 13 (Prachuapkhirikhan), Highway Division Bureau 14 (Nakhonsithammarat), Highway Division Bureau 15 (Songkhla, Hat Yai) totalling 12,178 kilometres of highway in length of 2 lanes equivalent (asphaltic surface of 11,798 km and concrete of 380 km). *Prince of Songkla University* is put in charge (surveying and analyzing not less than 11,664 km of asphalt and 322 km of concrete pavements).

**Resources – Equipment** (as shown in Figures 2 and 3): The study uses the following equipment:

1) **Multilaser Profilometers** with seven lasers of 16 kHz for analyzing rutting and roughness. The vehicle is externally fitted with multiple flashing hazard lights and reflective panels on the sides, rear and front. The Profilometer is operated by a technician seated in the front passenger seat with the on board computer and electronic devices housed at the rear of the vehicle.

2) **Visual Data Collection**, the vehicle, also fitted with five digital video cameras, collects and manipulates streaming video images of the pavement surface and adjacent assets. The system allows the engineer to rate and review the condition of the network from within the comfort and safety of the office. The resultant information is easily plotted into the GIS system via DGPS signals collected in the field. The asset views are for visually identifying and locating roadside features accurately. The pavement views are for visually identifying and locating pavement deterioration and cracking accurately at highway speeds with resolutions of 1280x960 pixels.

3) **DGPS Packages** enable the referencing of data against GPS coordinates and delivering real-time sub-meter accuracy.

4) **GIPSI-Trac Geometry Package**, using dead reckoning sensors and GPS data, collects road geometry information and continuous highway 3D maps.

5) **Rotorpulser** is the high resolution distance measurement instrument for accurate chainage.
4. EVALUATING PAVEMENT PERFORMANCE, STRUCTURAL CAPACITY AND DISTRESSES

Data on traffic, pavement performance and structural capacity, along with carrying out condition surveys that would be directly used in the PMS were collected and stored. The data described the present functional condition of the pavement, i.e., how well the pavements serve the users at the present time with respect to costs and safety, and present structural condition, which is used to predict the future functional condition. However, the latter is not in our scope of study, the DOH uses the Falling Weight Deflectometer to assess the structural capacity of its pavement in another assignment.

**Functional Condition:** The data used to describe the present functional condition (or the present serviceability) are mostly the pavement roughness (IRI) and surface distresses (cracks, deformation, disintegration), which are directly related to the user costs, but also the skid resistance which is related to user safety. The equipment used here to measure the pavement longitudinal roughness is the Multilaser Profiler with real time data processing to present the assessment at every 100 meters whereas to measure the distresses is the high resolution digital cameras “Hawkeye 2000 series” with an office-based data reviewing and analysis software.

**Structural Condition:** The analysis applied the analytical-empirical method by the use of elastic layer analysis to determine the critical stresses or strains in each pavement material caused by traffic loading. The future pavement performance, including structural distress, was then related to these critical stresses or strains. The thickness and stiffness (elastic modulus or “E” – value of each structural layer in the pavement were obtained by newly developed non-destructive method of determining layer thicknesses.
5. THE APPLICATION OF HDM-4

The application of HDM-4 covers Strategy analysis, Programme analysis and Project analysis. A benefit/cost analysis is first carried out at the project level for each uniform subsection. For each of these the benefits and costs of each feasible maintenance and rehabilitation measure are evaluated. The benefits are the reductions in user costs resulting from the intervention, and the costs are the initial construction costs plus the future maintenance costs. Future benefits and costs are both discounted back to the programme year.

The ideal solution is to calculate the savings in highway user costs resulting from each possible rehabilitation measure for each subsection. Decreasing longitudinal roughness will lead to decreasing user costs, first in terms of decreasing vehicle maintenance costs, decreased fuel consumption, etc, and later also in terms of decreasing travel time. In the Thai PMS, only the roughness relations are considered directly. Reductions in highway user costs arising from improvements to the highway geometry may also be indirectly included as a benefit of this special additional work.

Pavement conditions in terms of roughness, rutting, etc, are compared to the minimum condition requirements, as specified in the Thai DOH standards for highway pavements. Priority is also assigned based on the economy of repair works compared to the yearly interest charge on and the depreciation of, the investment needed for a new wearing course.

6. CONCLUDING REMARKS

The development of new approach for PMS in Thailand has drawn on the resources of the Highway Directorate, the local highway authorities, universities and private companies and incorporating the results of state-of-the-art international research and development. The system is based on in situ measured physical properties of the highway pavements and makes use of analytical-empirical models for predicting pavement performance. Highway user costs of local parameters are considered (using the World Bank relationships) and 0-1 integer programming is used to determine the optimum combination of maintenance and rehabilitation measures within the available budget. Through an iterative process, the system makes full use of the knowledge and experience of local engineers responsible for implementing the maintenance and rehabilitation. The foundation of the system is, therefore, objective measurements and analytical tools, complemented by sound engineering judgement.

The new approach of PMS in Thailand and GIS database provide the decision makers at different levels with a very useful tool for planning the future pavement maintenance and rehabilitation, at the project level as well as the network level. For the engineer responsible for the maintenance of a part of the highway network, the system will provide a site specific listing of the maintenance and rehabilitation alternatives to be carried out to obtain the maximum benefit possible with the available budget. Top management may use the system to study which consequences of different budget levels will have on the future functional and structural conditions of the highway network, and for determining the budget level that will result in the highest rate of return to society of the investments made in maintaining the highway network.
The outcome of the study is a certain reduction in cost of maintenance through timely intervention, best use of resources, controlled planning and expenditure, and significant improvements in highway safety, serviceability and structural adequacy for the same expenditure.

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