Preliminary Studies for using HDM-4 effectively in Strategy Analysis of Road Network

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1. Introduction: The World Bank’s Highway Development and Management Tool (HDM-4) has widely been used to combine technical and economic appraisals of road projects, to prepare road investment programmes and to analyze road network strategies corresponding to project analysis, programme analysis, and strategy analysis, respectively. Strategy analysis is used to analyze a chosen road network as a whole, to prepare medium to long range planning estimates of expenditure needed for road development and maintenance under different budget scenarios. In analyzing strategies HDM-4 applies the concept of a road network matrix comprising analysis sections defined according to the key attributes that most influence pavement performance and road user costs. Creating proper analysis sections is fundamental to the establishment of correct maintenance treatments or improvements. Thus, it is necessary to investigate how analysis sections influence outputs and what is the appropriate sectioning method before using HDM-4.

HDM-4 is a computer model that simulates physical and economic conditions over the period of analysis, usually a life cycle, for a series of alternatives and scenarios specified by the user. For the Road Network Improvement Project in Vietnam (RNIP), the analysis period defined by user is the same as plan period (10 years) given by road administration. Therefore, from HDM-4’s outputs the road administrator cannot know what would happen after the plan period, and thus, cannot give appropriate decisions for long-term road management.

HDM-4 was developed from studies in five countries i.e. Kenya, the Caribbean, India, and Brazil. In order to apply the model correctly, it must be calibrated according to the specific conditions of a country or region where they are to be used. Calibration of the HDM-4 model focuses on the two primary components that determine the physical quantities, costs and benefits predicted for the analysis, namely: (1) Road user effects (RUE) - comprised of vehicle operating costs (VOC), travel time, safety and emissions, and (2) Road deterioration and works effects (RDWE) - comprised of the deterioration of the pavement and the impact of maintenance activities on pavement condition and the future rate of pavement deterioration. The paper introduces recent studies on important issues mentioned above using HDM-4 in the strategy analysis that were carried out by the Design and Planning Laboratory of Saitama University, and presents comments for further studies to use HDM-4 in strategy analysis of road network effectively.

2. Results of Preliminary Studies

2.1. Analysis period: Using database derived from the Vietnamese conditions, Watanabe K. and Tsunokawa (2004) investigated the effects of analysis period on pavement management strategies and suggested that while using HDM-4 for strategy analysis the analysis period should be longer than plan period decided by the road administration. By extending the period of analysis over plan period, HDM-4 outputs predict road condition and expenditures after plan period. Thus, road administrator can use the additional information and can select better pavement management strategies.

2.2. Sectioning: HDM-4 works on analysis sections with homogeneous characteristics that were called homogeneous sections. The importance of creating proper analysis sections is that it establishes the correct maintenance treatments or improvements. In HDM-4 database, the attributes that are considered to be uniform along a section include: road class,
speed-flow type, climate zone, traffic flow pattern, carriageway width, pavement construction, and traffic volume. To create analysis sections, sectioning is based on road condition. Using data of road condition (cracking, rutting, and roughness) derived from Akita prefecture for HDM-4 analysis, Watanabe M. and Tsunokawa (2004) shows that sectioning of road network affects annual road agency cost. Therefore, it is important to find a suitable sectioning method for road network in order to use HDM-4 effectively.

2.3. Road User Effects Calibration: RUE model contains a large number of parameters that can be adjusted to appropriate local condition (Bennett, C.R. and Paterson, W.D.O., 2002). Ul-Islam et all. (2003) carried out a preliminary calibration of the RUE relationships for five typical vehicles in Japan i.e., small passenger cars, medium passenger cars, medium trucks, heavy trucks, and heavy buses. The calibration uses the basic input data obtained from reports published by the Japanese trucks and buses operating companies, car dealers, etc., and earlier studies on VOC and exhaust emissions undertaken by the Japanese government agencies. Calibration factors were estimated for the parts consumption and labour hours for the VOC relationships and for the nitrous oxide, carbon monoxide, hydrocarbon, particulates, carbon dioxide and sulphur dioxide exhaust for emissions relationships. However, the data employed for calibration are limited. Therefore if the detailed data are available, future study will consider the calibration of speed and capacity relationships, fuel consumption, and tyre and lubricating oil relationships.

2.4. Road Deterioration and Works Effects Calibration: In HDM-4 the flexible pavement deterioration and works effects models have six deterioration adjustment factors i.e., roughness-age-environment, cracking initiation, cracking progression, rut depth progression, potholing progression, and roughness progression general. The roughness-environment factor is the most important due to a high potential net impact, followed by the cracking initiation, cracking progression, and rut depth progression factors. By using the available data observed from 1993 to 2002 in Akita prefecture, Nishio and Tsunokawa (2004) calibrated these factors and compared with the prediction models recommended by Infrastructure and Transportation Ministry in Japan (ITMJ). The results show that the calibrated HDM-4 models were more accurate than the ITMJ models. However, this result will be examined when the detailed data are available.

3. Conclusion: HDM-4 is a powerful system for the analysis of road management and investment alternatives with broad-based applicability in diverse climates and conditions. To apply the model, the input data must be qualified and interpreted correctly, and model parameters must be adjusted to enhance the accuracy of its representation of local conditions. There are some initial studies carried out by the Design and Planning Laboratory of Saitama University for using HDM-4 in strategy analysis that have been discussed above. However, if the required data are available, all sensitive model parameters should be considered in order to use HDM-4 in the road management effectively.

References