# SYNOPSIS

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Thesis Title: **Road Condition Evaluation, Prioritization, and Optimal Resource Allocation for Highway maintenance at Network Level**

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The purpose of highway maintenance at the network level is to maximise the improvements in the highway conditions (for a given highway network system) through diverse maintenance activities, while remaining within the limits of available resources. In order to maintain any existing highway network, large resources are required not only in terms of money but also in terms of other resources such as equipment, manpower and materials. Typically, and this is especially true for developing nations like India, the resources allocated for maintenance are inadequate for carrying out all the maintenance needed in the highway network. This creates the need to not only determine which sections will be chosen for maintenance but also to determine which maintenance actions are to be used.

It is felt that a successful comprehensive highway network maintenance system must

include (i) a quick and reliable evaluation process for the constituent sections, (ii) a procedure to identify sections with greater needs, and (iii) a procedure to select maintenance activities at sections by optimally allocating the available resources to the competing maintenance requirements at sections. Thus, this thesis proposes a three module system for the optimal network level highway maintenance system. These three modules are (i) evaluation module, (ii) maintenance urgency determination module, and (iii) maintenance activities' selection module. In the following these three modules are briefly described.

The first task is to evaluate the present distress conditions of highway sections in order to determine its health. The distress conditions that should be evaluated for each of the sections in order to characterize the health of the section are: (i) structural conditions, (ii) traffic safety conditions, (iii) traffic operations condition and (iv) riding quality conditions. Evaluation of structural condition quickly and effectively without the use of costly equipment (many highway agencies do not posses costly equipment for determination of structural health) is important. This has motivated the development of a structural evaluation model which is simple, cost effective and reasonably accurate for applications at the network level. This thesis proposes a statistical model to evaluate the structural condition of existing pavements from two distress parameters, namely, fatigue cracking and rutting. The proposed statistical model has been developed using the pavement performance data available from the Long Term Pavement Performance (LTPP) database of the US Department of Transportation. Traffic safety conditions are evaluated on the basis of traffic accidents rate, which can be easily obtained from the accident records. Traffic operation conditions are evaluated on

the basis of traffic volume and capacity of the highway facility; volume data can be collected and capacity can be estimated using standard procedures. The conditions of a pavement surface affect the riding quality. Therefore, riding quality of the highway pavements are assessed considering the pavement surface conditions. Pavement surface may be fractured (cracking, etc.), distorted (rutting, corrugation, etc.) or disintegrated (raveling, pothole, etc.). Therefore, simple models are proposed to evaluate fractured surface conditions, distorted surface conditions and disintegrated surface conditions of highway pavements on the basis of fractured surface area, distorted surface area, and the disintegrated surface area respectively. Analysis on the accuracy and efficacy of the evaluation models are also presented.

The next task is to determine the urgency of maintenance requirements at sections. It is felt that resources should be allocated based on the urgency associated with maintenance requirements at various sections. This urgency for maintenance, should be determined considering present and future distress conditions (assuming nothing is done now) as well as social and political importance of the highway sections. A rational approach is proposed in this thesis to determine the urgency of maintenance at highway sections considering the present and future conditions, highway class, importance of the highway to the community and the political importance. The various factors and sub-factors affecting the urgency are arranged in a hierarchical structure culminating in "urgency of maintenance." The impact of each factor is determined from a countrywide survey of experienced transportation professionals using the analytic hierarchy process (AHP). The hierarchical structure developed to determine the maintenance urgency of sections is also used to determine an index which can be utilized to prioritize sections

for maintenance. It may be mentioned here that this thesis also proposes a series of statistical models which attempts to predict the future of the present distress conditions if nothing is done now, following the principles of developing simple models which are reasonably accurate, these models too do not require the use of any costly equipment and rely on data which are easily determinable. Analysis on the accuracy of these models are also presented.

The final task is to develop a method which will determine which maintenance activities are to be carried out at which section so that the health of the network is maximally improved within the available resources. The method should take into account the urgency of maintenance at various sections while determining the activities. In this thesis the above problem is viewed as an efficient resource allocation problem and is formulated as a 0-1 integer programming problem. This model requires the following as input (i) extent of improvement in distress condition due to implementation of a given task at a given section, (ii) estimation of resource requirements for each activity for a given section, (iii) the availability of various resources, and (iv) the urgency of maintenance of each section. The output of the model is the various activities which should be undertaken at the different sections.

This thesis also presents a study of a highway network located in northern part of India to illustrate how the proposed methodology can be utilized by the highway agencies in evaluating the highway conditions, determining the maintenance urgency of the sections, and selecting the most effective maintenance activities.