

Pavement Condition Analysis Using GIS: A Case Study Of Prithivi Highway (Pokhara To Kotre)

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Abstract— Reliable and effective data are required in each stage of planning highway, maintenance & various evaluations such as to identify problems, risk factors, priority treatments, formulate strategy, set targets and monitor performance. Current available raw data are not sufficient for the effective evaluation. These data when properly coded and visualized, processed and analyzed in a systematic way could give a better understanding. Pavement condition survey with the pavement evaluation and further predicting pavement performance leads to prioritization needs and develops the works program for highway pavement using GIS (Geographic Information System). This output result can be used to satisfy the requirements of a highway network evaluation and thereby enhance the efficient performance of the pavement of road by effective maintenance.

Keywords— *Pavement condition Rating, GIS mapping, Road maintenance priority Mapping*

I. INTRODUCTION

Highways are the major channel of transportation for carrying goods, passengers and services. It is the most important infrastructure for social and economic development of a country. Huge amount of capital investment along the long period of construction is required for the construction of the road. Pavements deteriorate with time and the rate of deterioration depends upon a number of factors like traffic loading, soil sub grade, climate, drainage, environmental factors and properties of pavement materials. Maintenance work is neither exciting nor as visible as new construction and therefore lacks political prestige and priority. Ultimately, cost of delayed treatment (rehabilitation) rises many times than the cost timely and effective maintenance. The enormity of the cost and the lack of finances mandate the development of systematic approaches and programs for careful and appropriate funds allocation.

The Road User Cost Study (Reddy, 2001) has established that due to improper maintenance and poor surface condition of road pavements, there is a considerable economic loss to the country due to increased vehicle operation costs. Vehicle operating cost increases as surface conditions deteriorate. If timely pavement maintenance is neglected, the surface starts cracking and soon these cracks develop into

potholes. At this stage of deterioration the vehicle operating cost increases by 15%. If pavement is further neglected, it starts deteriorating structurally and then vehicle-operating cost (VOC) increases by 50%. This is approximately twice the cost of construction of the road as it is observed over the life of the road. Pavement will normally deteriorate by 40% during first 75% of its life and during next 12% of its life it will deteriorate further by 40% (Reddy, 2001). The either serious problem or deterioration on these roads will fast affect the transportation system with consequent adverse effects on the socio-economic activities of a nation. Thus responsibility for proper evaluation and management of the road system is required which is one of the challenging problems. This could be only attained with proper timing of the preventive maintenance, light rehabilitation, and reasonably consistent traffic patterns, roadways can be kept in good condition for many years at less cost. Timely preventive maintenance can be achieved by the periodical and effective monitoring and evaluation of the reliable and effective data.

The conventional methods of evaluating of Road Pavement were not suitable for comprehensive computerization of highway information. Road information is geospatial and has recently being managed in Geographic Information System (GIS) environment. GIS offers some special features that can enhance the approach to highway management (Pantha, 2010). The key element that distinguishes GIS from other data systems is the manner in which geographic data are stored and accessed. The addition of this spatial dimension to the database system is, of course, the source of power of GIS. Linked with the spatial dimension, database features enable GIS to capture spatial and topological relationships among geo-referenced entities even when these relationships are not predefined. Visualization helps user to interpret, question, track and visualize data in ways that will establish trends, patterns and relationships, in the form of maps, reports and charts. GIS helps answer questions and solve problems by looking at data in a way that is quickly understood and easily shared to allow for better decision making. Thus, making decision effective. This study analysis with the GIS considering different pavement parameters with the combine interpretation with the International Roughness Index (IRI) and

Surface Distress Index (SDI) for the evaluation of road pavement considering a case study of Prithivi highway segment.

II. RESEARCH METHODOLOGY

A. Study Area

The study area lies in western part of Nepal (Fig. 1). It covers a total roadway length of 18.7 km of Prithivi highway and measures 118.67 km². Prithivi highway is the major highway which is a flexible pavement, that connects the capital city of Kathmandu to Pokhara city and also the other parts of the country. The Annual Average Daily Traffic (AADT) of the part of Prithivi highway is 13841 Passenger Car Units (PCU). The average International Roughness Index (IRI) of the part of Prithivi highway is 13.81 m/km from kotre to bijyapur khola and 7.56 m/km bijyapur khola to Prithivi chowk. This stretch of the highway suffers from frequent deterioration of road pavement. As a result, the road service is lower in aspect of comfort, time of travel, safety and other factors.

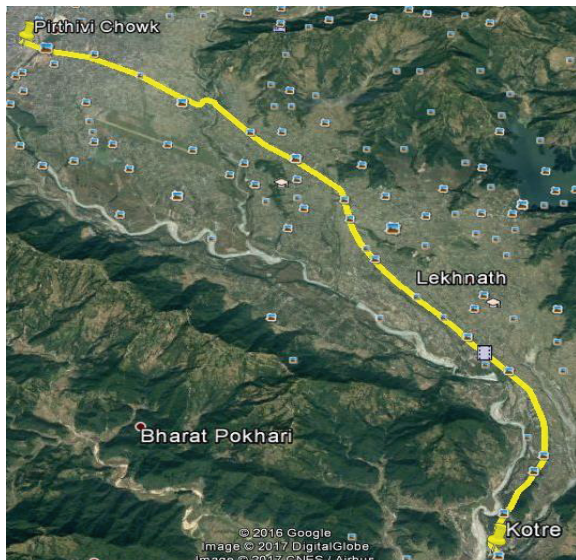


Figure 1: Study Area

B. Site Selection

The site and stretch to be considered for the implementation of this project effectively need to have different variation of pavement condition. Pavement inspection is conducted by considering small inspection units. An inspection unit is a small segment of a pavement section or management unit selected of convenient size which is then inspected in details such that the inspection units represents the average pavement condition surrounding.

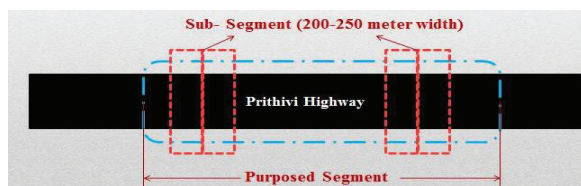


Figure 2: Pavement Segment Sample

When a small area of pavement is found to be worse than the majority of the pavement, it can be inspected and identified as a "special" inspection unit. This is used to identify areas of localized deterioration such as an area damaged by utility cuts, crossing of construction traffic, or other localized problems.

C. Methodology for Data Collection

The major data to be collected for this project is done through the field investigation. Different pavement condition is considered such that the combine data gives the effective measures of the pavement condition of the road segment considered. The pavement survey was conducted by using a GPS and the visual inspection along the segment considered. This measured value represents the various pavement phenomena including pavement distress, rut depth, patch and potholes and cracks. The pavement surface roughness was collected by IRI values (International Roughness Index) for further analysis from the DOR site as a secondary data.

The IRI was developed by the World Bank in the 1980s and is still in use as pavement condition index. The IRI is used to define characteristics of longitudinal profile of a traveled wheel-track and constitutes a standardized roughness measurement. It is based on the average rectified slope (ARS), which is a filtered ratio of a standard vehicle's accumulated suspension motion (in mm, inches, etc.) divided by the distance traveled by the vehicle during the measurement (km, mi, etc.). The stretch of road under study was divided into a number of equal sections.

D. Methodology for Data Extraction

A weighted average is used to calculate the pavement condition when special inspection units are inspected. The inspection or Data that has been collected are also geospatially referenced and further the data are now analyzed by using GIS. Before the analysis and mapping of the pavement condition, this study finds the pavement condition rating of the segment of the highway individually for the different indexes and which are:

- AI= Alligator Cracking Index
- TI= Transverse Cracking Index
- LI= Longitudinal Cracking Index
- EI= Edge Cracking Index
- BI= Bleeding Index
- PAI= Patching Index
- PHI= Pothole Index
- RI= Rutting Index
- DEI= Depression Index
- DRI= Drainage Index

Here the different index is calculated by the assigning the severity level rating for the condition. In this project three severity conditions have been considered, i.e. Low, Medium, High. And one

additional severity condition is added i.e. for the negligible condition i.e.

Very Low = 0 ; Low = 0.25; Medium =0.5 ; High =0.9 and above (i.e. 0.9).

III. RESULT AND DISCUSSION

A. Analysis based on Pavement condition rating

GIS map indicating important areas that contribute trip generation will consider different facility such as: Pavement condition rating is calculated by adding the weighted value rating of the various pavement conditions index. The GIS map is plotted by overlaying the weighted value of the considered various index which is given by:

"Pavement Condition Rating " ("PCR")= AI + TI + LI + EI + BI + PAI + PHI + RI + DEI + DRI"

a) Alligator Cracking (AI)

In the field observation it has been found that alligator crack was more dominant at segment towards kotre than towards pirthivichowk Refer Fig 3.

b) Transverse Cracking Mapping

In field observation it has been found very less and minor traverse cracks along the segments so the map below shows very low transverse cracking along all segments Refer Fig 4.

c) Longitudinal Cracking

In field observation it has been found very less and minor Longitudinal cracks along the segments so the map below shows very low transverse cracking along all segments Refer Fig 5.

d) Edge Cracking

In field observation it has been found high edge cracking along the segments taken such the map below shows mostly high edge cracking almost all segments Refer Fig 6.

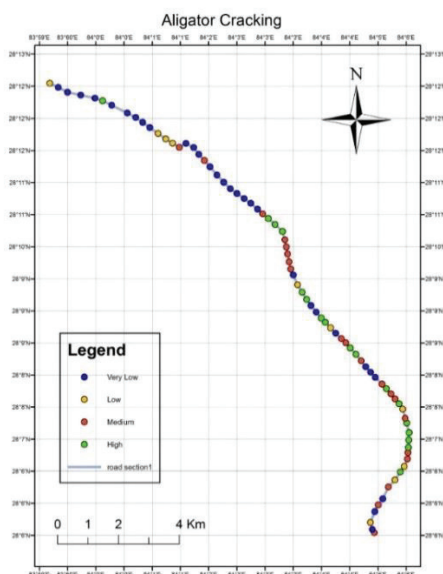


Figure 3: Alligator Cracking

e) Bleeding

In field observation it has been found very less and minor bleeding along the segments only few place were seen to have minor bleeding such map below shows the field conditions of bleeding Refer Fig 7.

f) Patching

In field observation it has been seen patching in high density all over the segments and minor patching is observed near to segment to pirthivichowk as recently the highway pavement was reconstructed which is clearly seen in the map below Refer Fig 8.

g) Pothole

In field observation it has been found very less potholes as all potholes has recently been patched along the segments so the map below shows very low potholes along all segments Refer Fig 9.

h) Rutting

In field observation it has been found very less and minor rutting along the segments so the map below shows very low rutting along all segments.

i) Depression

In field observation it has been found less and minor deformation towards the pirthivichowk while high deformation at sections near to the kotre which is shown by the map below Refer Fig 10.

j) Drainage

In field observation it has been found different drainage condition along the segments which is shown in the map below and it shows very power drainage arrangement along all segments Refer Fig 11.

k) Pavement Condition Rating Mapping

After all the mapping for the different condition is done the layering of each condition is done in order to get the combine effect which is the pavement condition rating of all segments Refer Fig 12.

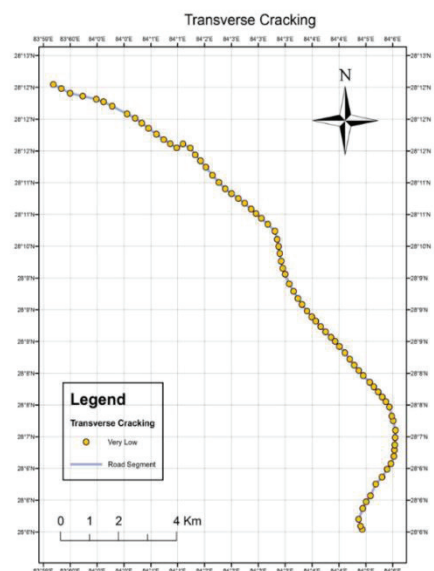


Figure 4: Transverse Cracking

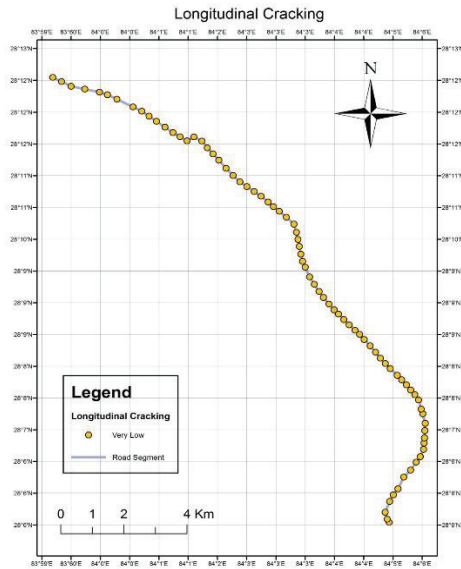


Figure 5: Longitudinal Cracking

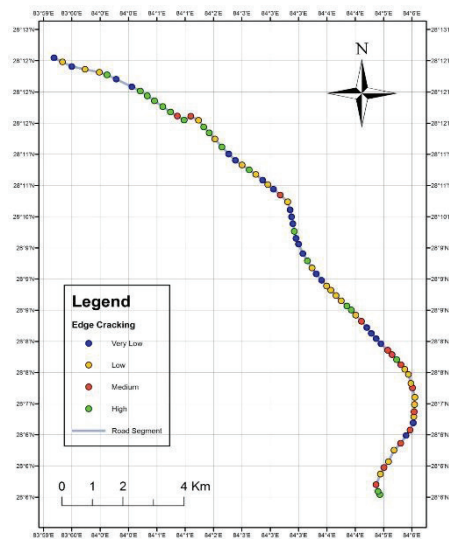


Figure 6: Edge Cracking

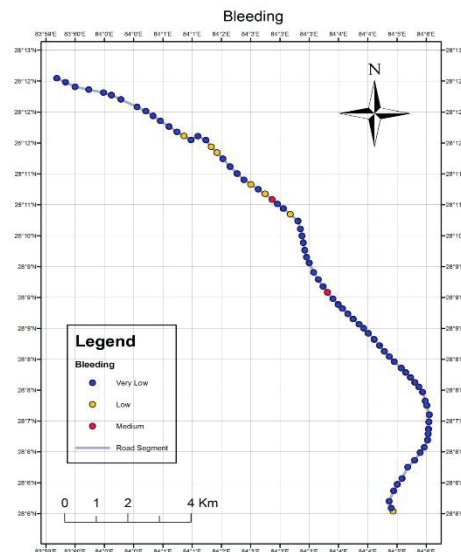


Figure 7: Bleeding

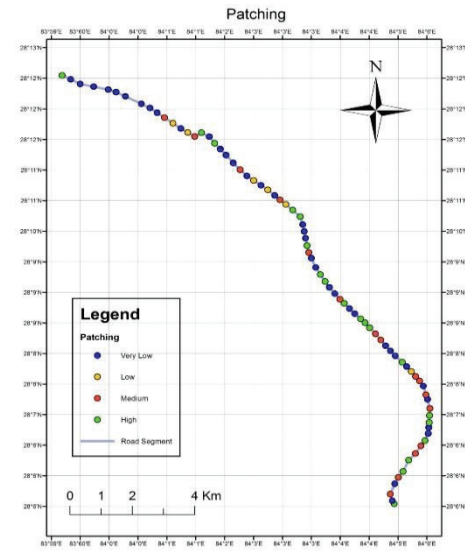


Figure 8: Patching

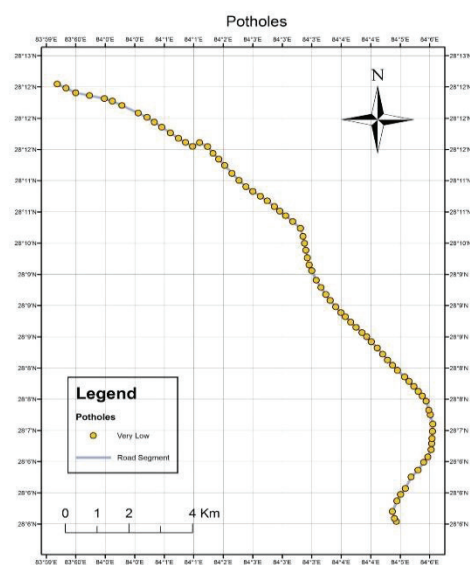


Figure 9: Potholes

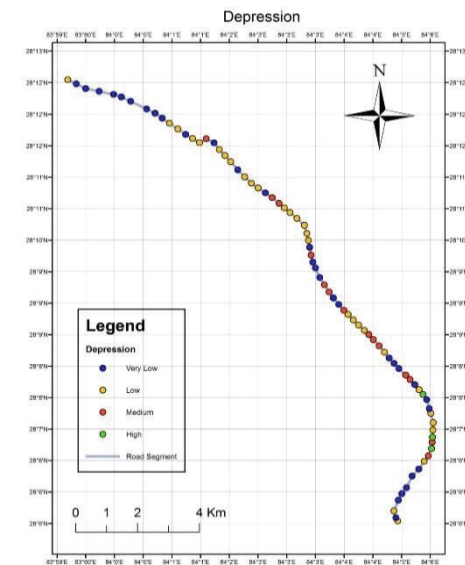


Figure 11: Drainage

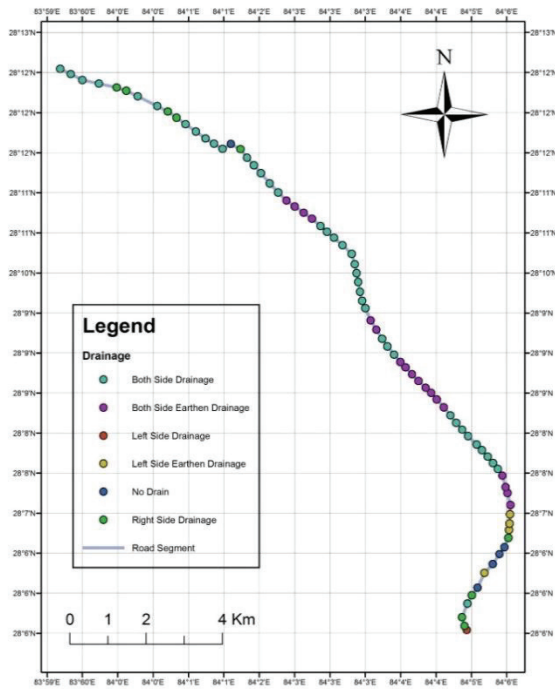


Figure 11: Drainage

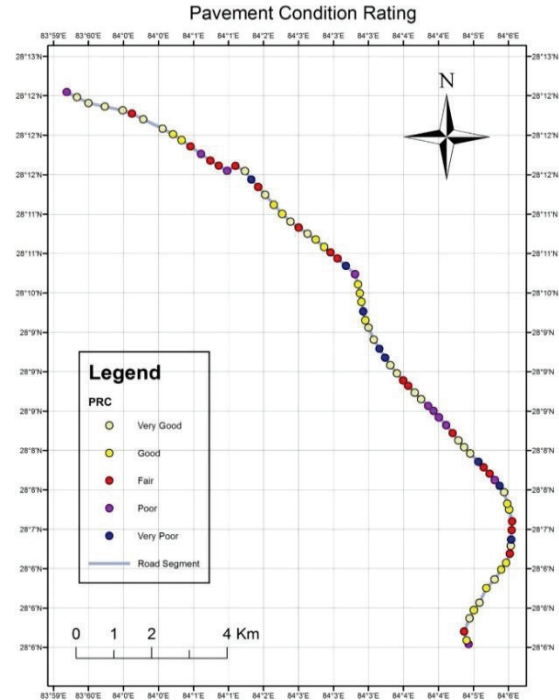


Figure 12: Pavement Condition Rating

B. Analysis based on IRI, SDI and PCR comparison

Here the International Roughness Index (IRI) & Surface Distress Index (SDI) are got from the DOR and the value starts from Kotre to Prithivichowk. (ssrn.aviyaan.com, 2015).

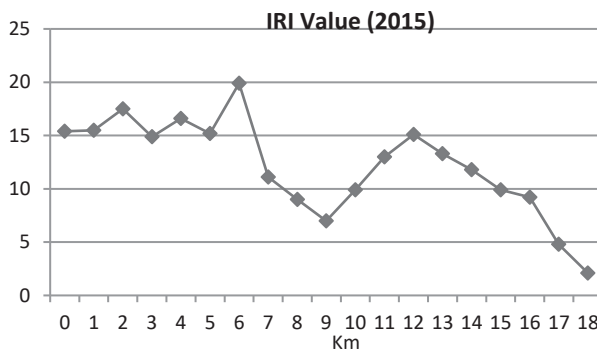


Figure 13: IRI (International Roughness Index)

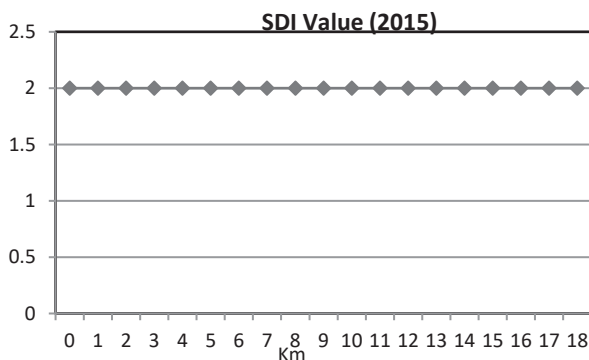


Figure 14: SDI (Surface Distress Index)

PCR Index

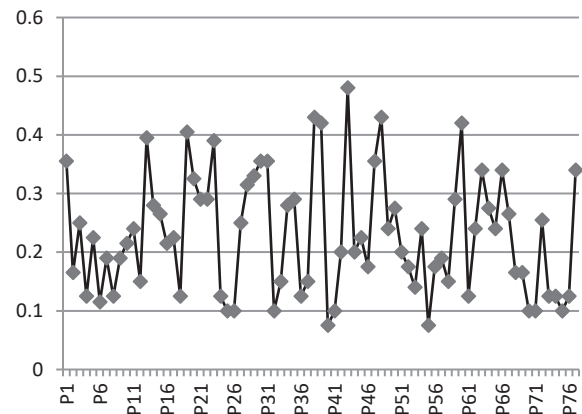


Figure 15: Pavement Condition Rating

Here, this study shows that the IRI and SDI value from DOR are not as reliable as the data does not seem similar to the current pavement condition rating.

IV. RESULT AND DISCUSSION

Field investigation of the Prithvi Highway (Prithvi Chowk to Kotre) has been done taking the small segments (200 mtr. to 250 mtr.) such representation the average information of the considered length of highway. During field investigation the data has been taken on basis of ranking of the pavement condition. And the data that is obtained is also geo-referenced by the use of GPS which together gives the complete information of the pavement condition. The data is presented on this report. While SDI Index and IRI Index got from the road department is taken as secondary data and is compared with the data acquired

from the field investigation .As the latest data acquired is of 2015 AD which shows that the condition of the road has gone worse.

This approach has important benefit. Currently, Road maintenance planning under the constraints of budget, time and other resources is very challenging. Characteristics and spatial distribution of different road components makes the decision making process on priorities very complicated. The process can be made easier by applying a powerful tool which can store, analyze and manipulate spatially distributed data. In this project, GIS-based integrated model has been developed for road repair and maintenance considering road pavement component and roadside drainage. This study has drawn attention to effective inspection and monitoring, which plays important role in road maintenance and prolongs the life of road.

The section of highway that has been considered in this project is a major link to the Pokhara to other parts of the country, but it is frequently observed that the deteriorates of pavement and government road maintenance work is less effective than it could be. The study hopes that this project will be useful in maintenance planning to ensure operation of the highway throughout the year not only in Nepal, but also in other similar geographical and topographical regions.

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