

## A Study on Visual Assessment of Sylhet-Sunamganj Highway Using an Expert System

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**Abstract:** The primary function of pavement is to distribute the concentrated loads so that supporting capacity of the sub-grade soil is not exceeded. Due to continuous application of impact loading, pavement surface often subjected to various types of distresses. The study was conducted on a portion (madina market to tucker bazar) of Sylhet-Sunamganj road that acts as a very important link between two adjacent towns. Pavement Condition Ratings (PCR) of the pavement was obtained on the basis of severity and extent of different types of distresses such as alligator cracks, longitudinal cracks, potholes, rutting, raveling, patching, etc. The PCR values of different segments of madina market to tucker bazar were evaluated in this study most of which fall within the category of very poor to poor conditions. Such condition of PCR immediately recommends proper treatment of the pavement for usage convenience.

**Key words:** Pavement condition rating, distress, severity, extent, deduct values

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### INTRODUCTION

It is crucial in operational and economical terms to evaluate the present performance of the pavement as well suggesting the requisite recommendations for improving its existing conditions. Pavements especially flexible pavements are susceptible to different types of distresses. There are many parameters that need to be acquired to successfully predict the rate of pavement deterioration, among others is Annual Average Daily Traffic (AADT), percent of trucks, drainage, pavement thickness, pavement strength in term of Structural Number (SN) or CBR value and mix design parameters (Isa *et al.*, 2005). Factors enhance such distresses are generally excessive impact loads, poor design, poor soil property, insufficient drainage and environmental factors (Mcghee, 2002). Treatment timing is a more complicated issue. While it may be fairly simple to identify when it is too late to apply a preservation treatment and it may not even be so difficult to identify when it is too soon, finding the best time can be problematic (Zimmerman and Peshkin, 2008).

A visual assessment of the pavement describes its condition to serve the traffic as well identify the defects that exist in present condition and finally make a rating of it. The evaluation of the highway is necessary for determining the existing situation of the highway.

The followings were the main objectives of the study:

- To analyze pavement's present condition of Sylhet-Sunamganj highway
- To obtain Pavement Condition Rating (PCR) through visual assessment
- To recommend the effective solution of the distresses present

All researches and surveys related to this study had a span of time started from April to June, 2012.

### MATERIALS AND METHODS

A pavement condition can be quantified by the Pavement Condition Rating (PCR) which rates the pavements according to the extent and severity of distress types present (cracking, patching rutting, raveling, etc). PCR ranges from 0-100 (worst to best). The PCR major goal to keep down rehabilitation cost is to keep pavement condition in the upper range of 60-90 by limiting surface structural degradation.

**Visual assessment of pavement surface condition:** There were many possible approaches used to define performance and to assess the condition of road facilities. Pavement condition needed to be characterized in measurable terms so that the future performance can be

related to a defined condition. The pavement survey (walk through) was conducted and was oriented towards analyzing the existing roadway conditions so that a reasonable assessment of the special problems and structural needs of the roadway can be made. The experimental portion named (madina market to tucker bazar) of the Sylhet-Sunamganj highway was divided into sections of 100 m length for the consideration of their relevant severity and intensity of distresses.

The 1st step involved was the identification of both type and severity of pavement distresses present in the road sections by establishing the existing pavement condition using the visual walk through survey. This procedure was performed using South Dakota DOT Manual-2001, Miller and Bellinger Manual-2003 (Miller and Bellinger, 2003), WSDOT Manual-2007 (WSDOT, 2007), AASHTO cracking protocol-2003 (Groeger *et al.*, 2003) and Nebraska Pavement Manual (Johanns and Craig, 2004) which contains definitions and information concerning pavement distresses. Graphic plots of various types of pavement surface distress of each pavement section were drawn and were shown in Fig. 1. Various types of distress fed to the system and the distress types identified at site location were shown in Table 1.

In the 2nd step, each of the various types of pavement distresses was identified and measured (units

of linear meter or square meters). In addition for each distress, a level of severity was determined (Low (L), Medium (M) and High (H)).

Once the visual assessment of the road sections was complete, calculations were performed by the expert system using the data collected in the field. Through these calculations, Pavement Condition Rating (PCR) for the road network was determined.

**Assessment of severity of distress:** The most common form used for the representation of the system was IF-THEN rule (Sarsam, 2010).

**Assessment of extent of distress:** The assessment of extent was obtained using the system of IF-THEN rule. The values for the densities (extent) were recorded. Next, using the calculated densities and the severity (L, M or H), a deduct value for each distress type was determined. The deduct values were determined through the use of deduct value curves for each of the various distress type identified. The curves are the part of the US Army Corporations of Engineers Technical Report TR97/104 (US Army Corporations of Engineers, 1997) (Fig. 2). The mathematical models for each distress type curve were fed to the system. The deduct values for all the distresses were then summed up to produce a deduct total using the mathematical equation given as:

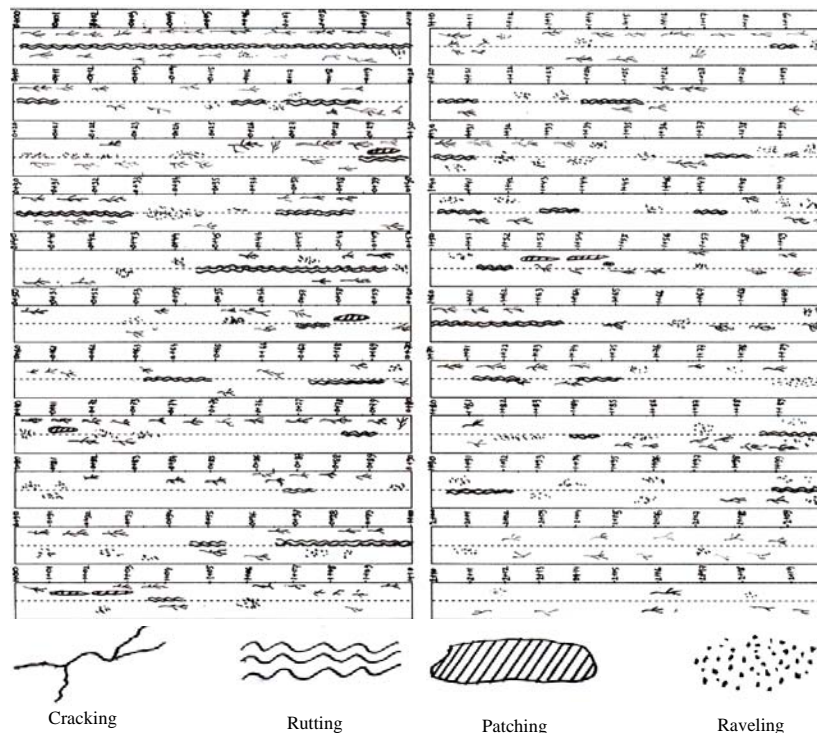


Fig. 1: Plotting of various types of distresses along road sections

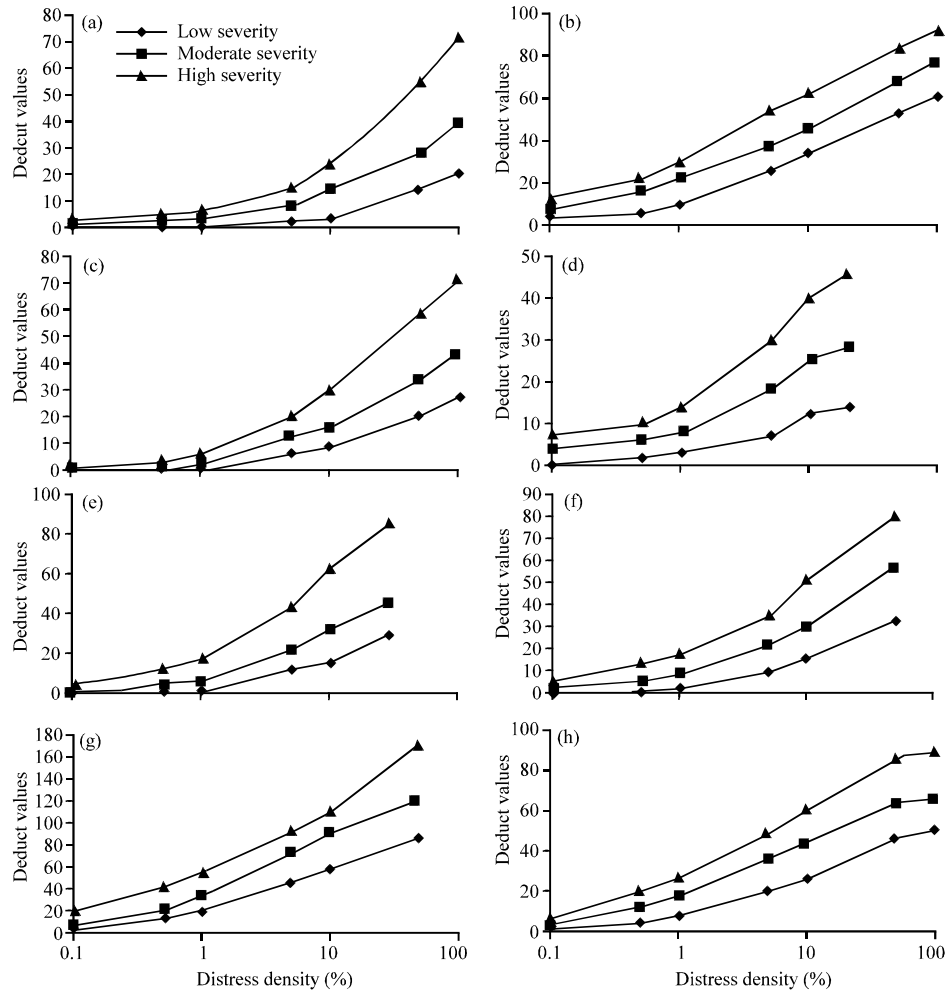


Fig. 2: Deduct values for various distress types, severity and extent: a) Bleeding; b) Alligator cracking; c) Block cracking; d) Edge cracking; e) Longitudinal and transverse cracking; f) Patching; g) Potholes; h) Rutting

$$\text{Deduct total} = \sum_{D=1}^{16} \text{Deduct}(\text{patching}) + \text{Deduct}(\text{cracking})$$

Given the deduct total and a value for the number of deducts >5 points. Figure 3 will be used by the system to determine Corrected Deduct Value (CDV). Finally, the Pavement Condition Rating (PCR) was calculated using the following equation:

$$\text{PCR} = 100 - \text{CDV}$$

**Pavement condition rating:** Given the PCR value for the road section, a pavement condition classification was determined using the most common form used for the knowledge representation of the system IF-THEN rule (Table 2).

Table 1: Distresses fed into the system of visual assessment

| Distress types included      | Distress types observed at madina market to tukur bazar of Sylhet-Sunamganj highway |
|------------------------------|---|
| <b>Cracking</b>              | <b>Cracking that present in sections</b>  |
| Edge                         | Edge  |
| Transverse                   | Longitudinal wheel path   |
| Longitudinal wheel path      | Longitudinal non-wheel path   |
| Longitudinal non-wheel path  | Alligator   |
| Fatigue                      |   |
| Block                        |   |
| Fatigue                      |   |
| Reflection                   |   |
| <b>Surface deformation</b>   |   |
| Rutting                      | Rutting   |
| Shoving                      |   |
| <b>Patching and potholes</b> |   |
| Patch                        | Patch   |
| Potholes                     | Potholes  |
| <b>Surface defects</b>       |   |
| Bleeding                     |   |
| Lane to shoulder drop off    | Polished aggregate  |
| Polished aggregate           | Raveling  |
| Raveling                     |   |

- IF PCR >0 and  $\leq 40$ , THEN PCR = Very poor; IF PCR >40 and  $\leq 55$ , THEN PCR = Poor
- IF PCR >55 and  $\leq 65$ , THEN PCR = Fair to poor; IF PCR >65 and  $\leq 75$ , THEN PCR = Fair

Table 2: Pavement Condition Rating (PCR) sheet

| Section starting (m) | Section ending (m) | Total deduct value | Corrected deduct value | Pavement Condition Rating (PCR, %) | Pavement condition |
|----------------------|--------------------|--------------------|------------------------|------------------------------------|--------------------|
| 0+0                  | 0+50               | 80                 | 80                     | 20                                 | Very poor          |
| 0+50                 | 0+100              | 80                 | 80                     | 20                                 | Very poor          |
| 0+100                | 0+150              | 44                 | 40                     | 60                                 | Fair to poor       |
| 0+150                | 0+200              | 80                 | 65                     | 35                                 | Very poor          |
| 0+200                | 0+250              | 44                 | 35                     | 65                                 | Fair to poor       |
| 0+250                | 0+300              | 80                 | 80                     | 20                                 | Very poor          |
| 0+300                | 0+350              | 75                 | 55                     | 45                                 | Poor               |
| 0+350                | 0+400              | 50                 | 50                     | 50                                 | Poor               |
| 0+400                | 0+450              | 44                 | 46                     | 54                                 | Poor               |
| 0+450                | 0+500              | 75                 | 75                     | 25                                 | Very poor          |
| 0+500                | 0+550              | 50                 | 50                     | 50                                 | Poor               |
| 0+550                | 0+600              | 44                 | 46                     | 54                                 | Poor               |
| 0+600                | 0+650              | 55                 | 54                     | 46                                 | Very poor          |
| 0+650                | 0+700              | 95                 | 68                     | 32                                 | Very poor          |
| 0+700                | 0+750              | 88                 | 64                     | 36                                 | Very poor          |
| 0+750                | 0+800              | 60                 | 60                     | 40                                 | Very poor          |
| 0+800                | 0+850              | 44                 | 46                     | 54                                 | Poor               |
| 0+850                | 0+900              | 46                 | 47                     | 53                                 | Poor               |
| 0+900                | 0+950              | 34                 | 34                     | 66                                 | Fair               |
| 0+950                | 1+0                | 97                 | 68                     | 32                                 | Very poor          |
| 1+0                  | 1+50               | 66                 | 34                     | 66                                 | Fair               |
| 1+50                 | 1+100              | 51                 | 40                     | 60                                 | Fair to poor       |
| 1+100                | 1+150              | 62                 | 60                     | 40                                 | Very poor          |
| 1+150                | 1+200              | 22                 | 24                     | 76                                 | Good               |
| 1+200                | 1+250              | 62                 | 52                     | 48                                 | Poor               |
| 1+250                | 1+300              | 38                 | 38                     | 62                                 | Fair to poor       |
| 1+300                | 1+350              | 55                 | 54                     | 46                                 | Poor               |
| 1+350                | 1+400              | 70                 | 60                     | 40                                 | Very poor          |
| 1+400                | 1+450              | 70                 | 60                     | 40                                 | Very poor          |
| 1+450                | 1+500              | 63                 | 45                     | 55                                 | Poor               |
| 1+500                | 1+550              | 73                 | 72                     | 28                                 | Very poor          |
| 1+550                | 1+600              | 62                 | 60                     | 40                                 | Very poor          |
| 1+600                | 1+650              | 82                 | 60                     | 40                                 | Very poor          |
| 1+650                | 1+700              | 70                 | 70                     | 30                                 | Very poor          |
| 1+700                | 1+750              | 70                 | 58                     | 42                                 | Poor               |
| 1+750                | 1+800              | 48                 | 47                     | 53                                 | Poor               |
| 1+800                | 1+850              | 51                 | 50                     | 50                                 | Poor               |
| 1+850                | 1+900              | 62                 | 62                     | 38                                 | Very poor          |
| 1+900                | 1+950              | 51                 | 50                     | 50                                 | Poor               |
| 1+950                | 2+000              | 66                 | 48                     | 52                                 | Poor               |

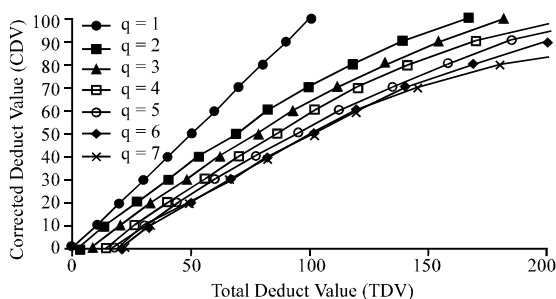


Fig. 3: Relationship between corrected vs. total deduct values

- IF PCR >75 and  $\leq 90$ , THEN PCR = Good; IF PCR >90 and  $\leq 100$ , THEN PCR = Very good

## RESULTS AND DISCUSSION

**Inspection sheet preparation:** Table 3 illustrates a typical inspection sheet for visual assessment of the distresses.

**Pavement condition determination:** A typical representation of the road network's present situation is given by Fig. 4.

**Pavement maintenance treatment decision:** There were six major treatments which should be taken into consideration as follows:

- Do nothing
- Crack filling and sealing
- Patching
- Milling
- Thin hot mix overlay
- Shoulder maintenance

Each type of pavement distresses will lead the system to consider more than one treatment (alternatives) for extension in pavement life depending on distress severity and extent as follows:

- IF alligator cracking exists, THEN select a, c, e
- IF edge cracking exists, THEN select a, b, f
- IF longitudinal cracking exists, THEN select a-c
- IF transverse cracking exists, THEN select a-d
- IF raveling (or weathering) exists, THEN select a, e
- IF distortion exists, THEN select a, b, c, e
- IF rutting exists, THEN select a, d, e

It must be emphasized that the above treatments could be applied and may be effective in treating the distress and increasing the expected life of pavement. The do nothing strategy may be the most appropriate under certain circumstances. A typical output of the expert system is given in Appendix.

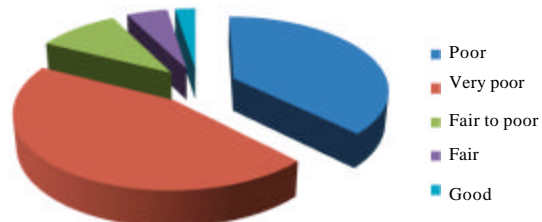


Fig. 4: Pavement condition rating of road network madina market to tuker bazar section of Sylhet-Sunamganj highway

Table 3: Inspection sheet fed to the system Sylhet-Sunamganj highway (madina market to tuker bazar section)

| Starting station (m) | Ending station (m) | Cracking (%) | Patching (%) | Rutting (%) | Raveling (%) | Severity |          |         | Extent |       |
|----------------------|--------------------|--------------|--------------|-------------|--------------|----------|----------|---------|--------|-------|
|                      |                    |              |              |             |              | Cracking | Patching | Rutting | Crack  | Patch |
| 0+0                  | 0+50               | 70           | -            | 20          | 10           | H        | -        | M       | H      | -     |
| 0+50                 | 0+100              | 65           | -            | 30          | 20           | H        | -        | M       | H      | -     |
| 0+100                | 0+150              | 40           | -            | 10          | 25           | M        | -        | L       | H      | -     |
| 0+150                | 0+200              | 50           | -            | 30          | 10           | H        | -        | M       | H      | -     |
| 0+200                | 0+250              | 40           | -            | 10          | 30           | M        | -        | L       | M      | -     |
| 0+250                | 0+300              | 60           | 5            | 5           | 30           | H        | L        | L       | H      | L     |
| 0+300                | 0+350              | 70           | -            | 30          | 10           | H        | -        | M       | H      | -     |
| 0+350                | 0+400              | 60           | -            | 20          | 20           | M        | -        | L       | H      | -     |
| 0+400                | 0+450              | 90           | -            | 10          | 3            | M        | -        | L       | M      | -     |
| 0+450                | 0+500              | 80           | -            | 40          | 5            | H        | -        | M       | H      | -     |
| 0+500                | 0+550              | 50           | -            | -           | 10           | M        | -        | -       | M      | -     |
| 0+550                | 0+600              | 90           | 5            | 10          | 30           | M        | L        | L       | M      | L     |
| 0+600                | 0+650              | 100          | -            | 20          | 20           | L        | -        | L       | M      | -     |
| 0+650                | 0+700              | 70           | -            | -           | 20           | H        | -        | -       | H      | -     |
| 0+700                | 0+750              | 80           | 4            | -           | 10           | H        | L        | -       | M      | L     |
| 0+750                | 0+800              | 75           | -            | 5           | 30           | M        | -        | L       | M      | -     |
| 0+800                | 0+850              | 30           | -            | -           | -            | M        | -        | -       | M      | -     |
| 0+850                | 0+900              | 60           | -            | 2           | 30           | L        | -        | L       | L      | -     |
| 0+900                | 0+950              | 90           | -            | 5           | 40           | M        | -        | L       | M      | -     |
| 0+950                | 1+000              | 40           | -            | 10          | 20           | H        | -        | M       | H      | -     |
| 1+000                | 1+50               | 30           | 6            | 2           | 5            | M        | L        | M       | M      | L     |
| 1+50                 | 1+100              | 40           | -            | -           | -            | H        | -        | -       | M      | -     |
| 1+100                | 1+150              | 40           | -            | -           | 20           | H        | -        | -       | M      | -     |
| 1+150                | 1+200              | 50           | -            | 5           | 20           | H        | -        | L       | L      | -     |
| 1+200                | 1+250              | 10           | 2            | 20          | -            | H        | M        | M       | M      | L     |
| 1+250                | 1+300              | 60           | -            | -           | 40           | L        | -        | -       | H      | -     |
| 1+300                | 1+350              | 40           | -            | 5           | 30           | H        | -        | L       | M      | -     |
| 1+350                | 1+400              | 40           | -            | 10          | 30           | M        | -        | L       | H      | -     |
| 1+400                | 1+450              | 80           | -            | 10          | 50           | M        | -        | L       | L      | -     |
| 1+450                | 1+500              | 10           | -            | 5           | 10           | H        | -        | L       | L      | -     |
| 1+500                | 1+550              | 20           | 8            | 2           | -            | M        | M        | L       | H      | L     |
| 1+550                | 1+600              | 40           | -            | -           | 10           | L        | -        | -       | H      | -     |
| 1+600                | 1+650              | 30           | -            | 20          | -            | M        | -        | M       | M      | -     |
| 1+650                | 1+700              | 50           | -            | -           | -            | M        | -        | -       | H      | -     |
| 1+700                | 1+750              | 30           | -            | 5           | 5            | M        | -        | L       | L      | -     |
| 1+750                | 1+800              | 50           | -            | -           | 20           | L        | -        | -       | H      | -     |
| 1+800                | 1+850              | 80           | -            | 2           | 20           | L        | -        | L       | H      | -     |
| 1+850                | 1+900              | 60           | -            | 10          | 10           | H        | -        | M       | M      | -     |
| 1+900                | 1+950              | 70           | -            | 2           | 10           | L        | -        | L       | H      | -     |
| 1+950                | 2+000              | 70           | -            | 10          | 30           | L        | -        | L       | L      | -     |

## CONCLUSION

This study has produced a methodology that can use the visual data obtained in the field and perform analysis of distress using an expert system. It is simple to perform and uses less expensive techniques and individuals to subjectively rate pavement sections based on observed distresses. Most of the sections of the pavement found as deteriorated and highly distressed. Requisite pavement maintenance works were needed to be adopted.

Based on the information obtained during this evaluation, it is recommended to consider using the expert system and it should be tested in a bigger project to evaluate whether it will be labor intensive.

## APPENDIX

### Pavement Surface Condition Rating Form

Project: Sylhet-Sunamganj road (madina market-tuker bazar portion) (section:15). Beginning station: 0+700; End station: 0+750

| Distress type         | Severity | Extent | Deduct value |
|-----------------------|----------|--------|--------------|
| Longitudinal cracking | H        | M      | 60           |
| Edge cracking         | H        | M      | 26           |
| Patching              | L        | L      | 2            |

Total deduct value = 88%; Corrected deduct value = 64%

### Result:

PCR = 100-64 = 36%

Condition rating of the section: Very poor

Maintenance alternative: Crack filling and sealing, then shoulder maintenance is required

Project: Sylhet-Sunamganj road (madina market-tuker bazar portion) (section: 28). Beginning station: 1+350; End station: 1+400

| Distress type         | Severity | Extent | Deduct value |
|-----------------------|----------|--------|--------------|
| Longitudinal cracking | M        | H      | 60           |
| Alligator cracking    | L        | L      | 10           |
| Rutting               | L        | -      | -            |

Total deduct value = 70%; Corrected deduct value = 60%

### Result:

PCR = 100-60 = 40%

Condition rating of the section: Very poor

Maintenance alternative: Milling then thin hot mix overlay application is required

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