© December 2017 | IJIRT | Volume 4 Issue 7 | ISSN: 2349-6002

Pavement Serviceability Model for Selected Flexible Pavement Sections along Gynan Sudha Schhol to Chambol in Bidar (Karnataka)

Sunil Birkur
Asst. Prof. Civil Eng. GNDEC Bidar

INTRODUCTION

An efficient and adequate transportation system is one of the key indicators of a nation's prosperity, its developmental status, and overall economic growth. India, being the second most populous and the tenth-largest industrialized country in the world, has an extensive road transportation system. The large and ever-increasing investment demands for the upkeep and for ensuring the desired level of serviceability of road infrastructure facilities that were created at great cost have concerned administrators, policy makers, and highway professionals in India, and caused them to seek appropriate solutions, in view of resource constraints, for road maintenance and rehabilitation problems. The existing road network has shown signs of premature distress because of the unexpected demands of growing traffic volume and heavier axle loads. The network has fallen short of its structural capacity and hence it is greatly overstrained.

The serviceability performance concept, rating technique, and distress evaluation are the attributes used to develop the Present Serviceability Index equation/model. Maintenance strategies of a given pavement section are identified on the data availability of both past and present deficiencies of the pavement system. Rating system is the one technique of assessing the condition of the pavement.

Need for study

The surface condition of a pavement at any time reflects the degree of damage caused by traffic and the environment based upon a visual evaluation of the pavement surface. The surface condition rating is useful as an input for predicting the remaining life of a pavement. It also assists in the preliminary evaluation and programming of appropriate maintenance and rehabilitation treatments. Better riding quality and minimum distress road are the prime motto of any highway designer or engineer. It is therefore necessary for highway engineer to manifest or evaluate the pavement surface characteristics during and after the construction time with the appropriate equipments to have a quality check on the pavement system.

Objectives of present study

1. To study the selected road stretches for its distress levels – types and severity.
2. To evaluate the pavement based on rider rating survey.
3. To develop present serviceability index models using SPSS software.
4. To validate the model with suitable number of stretches
5. To evaluate the pavement condition based on federal highway administration models

Scope of work

In the present study, selected urban road stretch on gynan sudha school to chambol village in bidar district of karnataka state has been considered for development of PSI equation and the rating studies will be carried out by the three panels viz highway, non-highway and mixed panel with six raters in each panel. The pavement condition assessment will be carried out and pavement roughness will be measured with the help of bump integrator.

The pavement condition assessment will be made based on the distress survey flexible distresses considered include rutting, raveling, cracking, pothole and roughness.

Present serviceability models will then be generated based on pavement surface characteristics, rider rating and visual ratings the present serviceability index models for both rider ratings and visual ratings will be generated also keeping the urban pavements into consideration.

LITERATURE REVIEW

Effects of routine maintenance on flexible pavement condition:

The paper addresses an interesting issue: providing a means of selecting routine-maintenance options based on the roughness progression profiles. The discusser discusses some shortcomings relating to the roughness modelling and maintenance effectiveness indices. Maintenance effect is modelled in terms of roughness as a function of age, traffic loading, and environment based on field data. Roughness is modelled as a function of (1) structural deformation (function of modified structural number, traffic loading, etc.); (2) surface defects (function of changes in cracking, patching, and potholing); and (3) environmental and non traffic-related mechanisms (function of pavement environment, time or age, and roughness).

Current and future pavement maintenance prioritization based on rapid visual condition evaluation:

States that" According to this approach, a well-trained rating crew is required to evaluate the condition of every section of the highway pavement network based on their judgment of the severity and the approximate extent of each distress type manifested on it". Knowledge of the deterioration rates of pavements under local environmental and traffic conditions. The capability of predicting the expected future condition of a pavement section affected by a given distress type would be beneficial in identifying the optimum time for the most cost-effective treatment. Moreover, the concept of using specific transition probabilities for each distress type as introduced work would overcome one obvious deficiency of the traditional PCI method in which the particular distresses that need be treated immediately are not made conspicuous.

The factors influencing riding quality are pavement distress and/or roughness. Three major factors of pavement distress are cracking, ratting, and longitudinal profile. The requirements for acquiring these three factors are the following: (1) That data-acquisition cost is as cheap as possible; (2) that data analysis can be done in a short time; and (3) that data acquisition does not influence the speed of other traveling vehicles, in particular on roads with heavy traffic. A survey vehicle that uses laser and video techniques has been developed, enabling rapid and accurate crack-data measurement. The data can be input to a computer directly.

The automation solves the problem of individual difference in data analysis. Additionally, computer image processing allows easy and flexible output of various parameters calculated from information such as length, width, direction, and number of cracks for entry into pavement-data bank.

METHODOLOGY

The test sections in Bidar city were found and the section considered was from gynana school to chambol village and the pavement surface along the test section varies from good to worst and the test section was subdivided in to sub sections of 300 meter; each on both the directions based on the distress- type and severity levels; for distress evaluation and rating studies along the subsections. The test section is straight and has uniform riding quality and pavement surface characteristics. Thirty-four subsections each of 300 m length were selected along each direction with varying carriageway width.

Rating Panel:

The present serviceability rating (PSR) studies were carried out and for these studies, rating panel was formed. The panel constituting of three categories viz highway panel, non-highway panel and mixed panel, each panel consisting of six members each. An initial orientation program was conducted for the raters for assessing the pavement by both ride rating and visual rating technique. The raters were trained to rate the pavement surface for typical road stretches.

Ride rating and Visual rating:

In visual rating method, the members of the rating panel were trained to walk through the left and right wheel path, through the given stretch of road for assessing the section for pavement characteristics-unevenness, cracking, patching and potholes, the pavement surface was assessed by each member in the five-point scale. The rating scale adopted for visual rating is shown in table. In rider, rating method the members of rating panel were taken in a standard test drive vehicle driven at a speed of 30±1 kmph along the stretch to assess the PSR value for riding comfort, the rating scale adopted for ride rating is

shown in table. Care is taken that the results obtained from the raters are unbiased.
The results of all three categories of panel members are checked for any errors and deviations and the corrected results are obtained. The PSI model is then developed from the corrected and unbiased results using SPSS package and the model developed is then validated using suitable number of stretches.

Description of Visual Rating Scale

Sl. No	Description Based on Visual Condition of Pavement Surface	Numerical Scale
1	Perfectly even surface without undulations, cracking, patching or rutting	4-5
2	Slightly uneven surface with some undulations, slight cracking, no potholes and rutting	3-4
3	Moderately uneven surface, visible patching, medium cracking, slightly rutting	2-3
4	Uneven surface with improperly patched potholes, medium to heavy cracking and rutting	1-2
5	Uneven surface with different type of undulation, unpatched and badly patched potholes, heavy cracking and deep rutting, edge cracking	0-1

Description of Ride Rating Scale

Sl. No.	Description Based on Riding Condition of Pavement Surface	Numerical Scale
1	Without discomfort, perfect smoothness	4-5
2	Little distortion, fairly smooth riding	3-4
3	Medium distortion, fair to uneven riding	2-3
4	Heavy distortion, uncomfortable riding	1-2
5	Intolerable, very Discomfortable riding	0-1

Description of sub stretches

Selected pavement test stretches for rider and visual rating		
Stretch no	Chain age m	Location
1	0-300	Outer ring road to Kotarki construction gate
2	300-600	
3	600-900	
4	900-1200	
5	1200-1500	
6	1500-1800	Kotarki construction gate to Hanuman temple
7	1800-2100	
8	2100-2400	
9	2400 -2700	Hanuman temple to Global sainik school
10	2700 -3000	
11	3000 -3300	
12	3300 - 3600	
13	3600-3900	Global sainik school to Banaknalli temple
14	3900-4200	
15	4200-4500	
16	4500-4800	
17	4800-5100	Banaknalli temple to Government School Banaknalli
18	5100-5400	
19	5400-5700	
20	5700-6000	
21	6000-6300	Government School Banaknalli to Daddapur cross
22	6300-6600	
23	6600-6900	
24	6900-7200	
25	7200-7500	
26	7500-7800	
27	7800-8100	
28	8100-8400	
29	8400-8700	
30	8700-9000	
31	9000-9300	
32	9300-9600	
33	9600-9900	
34	9900-10100	

Mean visual rating value of all panels

Stretch no	High way panel	Non high way panel	Mixed panel	Mean of all panel
1	4.80	4.84	4.79	4.81
2	4.49	4.87	4.81	4.72
3	4.52	4.90	4.83	4.75
4	4.90	4.91	4.87	4.89
5	4.91	4.93	4.88	4.91
6	4.89	4.96	4.91	4.92
7	4.96	4.99	4.94	4.96
8	4.95	4.98	4.96	4.97
9	4.98	4.98	4.99	4.99
10	4.99	4.99	4.99	4.99
11	1.74	2.51	2.27	2.17
12	1.78	2.56	2.39	2.24
13	1.81	2.65	2.47	2.31
14	2.53	2.75	2.74	2.67
15	2.61	2.84	2.75	2.73
16	2.67	2.87	2.87	2.80
17	2.72	2.95	2.85	2.84
18	2.89	3.52	3.04	3.15
19	2.91	3.66	3.17	3.25
20	2.96	3.73	3.20	3.30
21	3.08	3.84	3.27	3.40
22	3.26	3.88	3.50	3.55
23	3.70	4.17	3.73	3.87
24	3.75	4.25	3.79	3.93
25	3.81	4.38	3.76	3.98

26	3.86	4.39	3.80	4.02
27	3.90	4.50	3.85	4.09
28	3.93	4.62	3.86	4.14
29	3.97	4.67	3.92	4.18
30	4.19	4.85	4.10	4.38

DEVELOPMENT OF MODEL:

The model was developed along the lines of AASHO equation using field data and SPSS software package. The equation was developed for both visual and ride rating. The dependent variable in this model is the visual rating of pavement condition which is dependent on the pavement surface characteristics and pavement surface characteristics like unevenness, cracking, patching, rutting and ravelling are independent.

Multiple linear regression models for visual ratings

PSI = 5.171 - 0.100IRI - 0.028CRKPCH - 0.032RD - 0.013RV

PSI = Pavement serviceability index for the range of 0.00 to 5.00

IRI = International roughness index for the range of 1.69 to 13.25 m/km

CRKPCH = Cracking and patching for the range of 0.00 to 50.30 %

RD = Rut depth for the range of 0.00 to 27.00 mm

RV = Ravelling for the range of 0.00 to 20.1 %

Multiple linear regression models for ride ratings

PSI = 4.615 - 0.062IRI – 0.037RD – 0.555PTHPCH

PSI = Pavement serviceability index for the range of 0.00 to 5.00

IRI = International roughness index for the range of 1.69 to 13.25 m/km

RD = Rut depth for the range of 0.00 to 27.00 mm

PTHPCH = Pothole patching for the range of 0.00 to 1.34%

Index values for the selected pavement test stretches:

Pavement distress indices were computed using the formulae given by federal highway admistration for data collected from the thirty test stretches.

Stretch no.	RCI	Patching index %	Crack index %	Rut index %	SCR	PCR	Condition
1	333	89	Nil	Nil	89	100	G
2	269	97	100	Nil	97	100	G
3	158	94	Nil	94	88	100	G
4	158	100	100	100	100	100	G
5	156	100	100	100	100	100	G
6	157	100	100	100	100	100	G
7	156	100	100	100	100	100	G
8	160	100	100	100	100	100	G
9	154	100	100	100	100	100	G
10	156	100	100	100	100	100	G
11	151	80	84	63	50	59	P
12	151	84	98	91	28	60	P
13	152	99	88	99	76	58	P
14	157	82	80	93	54	96	G
15	158	91	90	90	29	81	F
16	157	94	93	91	77	100	G
17	158	91	90	95	24	77	F
18	157	96	89	95	20	75	F
19	156	94	94	61	51	93	G
20	149	78	84	71	73	59	P
21	157	93	92	73	58	93	G
22	151	75	78	69	62	59	P
23	158	80	78	100	58	98	G
24	151	77	75	80	51	59	P
25	158	87	85	87	59	99	G
26	158	91	90	100	81	100	G
27	158	91	90	70	52	94	P
28	157	91	90	100	82	100	G
29	157	92	91	74	58	98	G
30	146	75	71	74	46	60	P

Validation of model: model validation was done on the similar lines of the development of model for both ride rating and visual rating.

Visual rating model

PSI = 4.948 – 0.030RI - 0.016CRKPCH - 0.59RD – 0.212R

PSI = Pavement serviceability index for the range of 0.00 to 5.00

IRI = International roughness index for the range of 3.94 to 10.34 m/km

CRKPCH = Cracking and patching for the range of 2.84 to 28.88 %

RD = Rut depth for the range of 0.00 to 20.50 mm

RV = Ravelling for the range of 0.54 to 4.78 %

Ride rating model

PSI = 3.975 - 0.037IRI – 0.002RD – 0.050PTHPCH

PSI = Pavement serviceability index for the range of 0.00 to 5.00

IRI = International roughness index for the range of 3.94 to 10.34 m/km

RD = Rut depth for the range of 0.00 to 20.50 mm

PTHPCH = Pothole patching for the range of 0.00 to 2.34 %

DISCUSSIONS

1. Thirty test stretches were selected for the distress measurement and rating studies and stretches were in varying condition. The test stretches selected for the development of PSI model were having PSR values in the range of 1.74 to 4.99.
2. Various distress measurements were carried out such as roughness, rutting, raveling, cracking, and patching. IRI expressed in m/km varied from 1.69 to 13.25, rut depth expressed in mm varied in the range 0.00 to 27.00, raveling expressed in % area varied in the range 0.00 to 20.10, cracking and patching expressed in % area varied from 0.00 to 50.30.
3. The rating studies (both ride and visual) include a subjective method of analysis in which six raters were considered in each panel with a permissible error of -0.18 to 0.28. The rating studies were carried out by constituting three panels viz, highway panel, and non-highway panel and mixed panel for the selected thirty stretches. The mean values for rider rating varied from 2.91 to 4.93 for highway panel, 3.00 to 4.50 for non highway panel and 2.90 to 4.74 for mixed panel. The visual rating varied from 1.74 to 4.99 for highway panel, 2.51 to 4.99 for non highway panel, 2.27 to 4.99 for mixed panel.
4. After rating studies error elimination was carried out viz., leniency and central tendency error. The halo effect was considered because the rating was not carried out a particular distress. The type of leniency error and the magnitude were constant for each rater which indicates that it was a function of the rater though by definition it is a function of the rating matrix. The appearance of this error indicates that the rater tends to rate either too high or too low and the type and magnitude of central tendency error are fairly constant indicating that this error is also a function of the rating matrix as a whole. The leniency error for the rider rating varied is in the range of -0.09 to 0.06 for highway panel. Similarly for non highway panel -0.14 to 0.28 and -0.18 to 0.13 for mixed panel respectively. The central tendency error for rider rating varied from -0.26 to 0.12 for highway panel, -0.26 to -0.32 for non highway panel, -0.11 to 0.15 for mixed panel.

CONCLUSIONS

1. The percentage difference between the ratings of first ten stretches and second ten stretches is 44.89. The percentage variation of rating between the second ten stretches and third ten stretches is 28.94 in highway panel for visual rating.
2. The percentage difference between the first ten stretches and second ten stretches is 44.89. The percentage variation of rating between the second ten stretches and third ten stretches is 99.35 in non-highway panel for visual rating.
3. The percentage difference between the first ten stretches and second ten stretches is 45.89. The percentage variation of rating between the second ten stretches and third ten stretches is 27.02 in highway panel for visual rating.
4. The percentage difference between the first ten stretches and second ten stretches is 32.65. The percentage variation of rating between the second ten stretches and third ten stretches is 8.33 in highway panel for rider rating.
5. The percentage difference between the first ten stretches and second ten stretches is 22.72. The percentage variation of rating between the second ten stretches and third ten stretches is 10.53 in highway panel for rider rating.
6. The percentage difference between the first ten stretches and second ten stretches is 28.26. The percentage variation of rating between the second ten stretches and third ten stretches is 10.81 in highway panel for rider rating.
7. The percentage variation in the IRI among the thirty stretches is 87.24. The percentage variation in cracking and patching is 91.0. The percentage variation between the rutting is 81.48. The percentage variation between the raveling is 98.00.
8. The percentage variation in potholing is 94.55 in the distress measurement among the selected stretches.

Future scope of work

1. Multiple non linear regression studies can be carried out for the data collected from the field studies to develop present serviceability index model.

2. The drainage condition, pavement age, and commercial traffic effects on the model can be studied.
3. The work can be extended to urban cement concrete pavements if any.
4. Other type of flexible pavement distresses needs to be addressed.

REFERENCES

[1] Satish Chandra, “Effect of Road Roughness on Capacity of Two-Lane Roads”, Journal of Transportation Engineering, Vol. 130, No. 3, May 1, 2004. Pp no.360-364

[2] K. Ragunath, “Development of PSI model for the rural roads”, M.E thesis report UVCE, Bangalore university, Bangalore 2011

[3] B. Balabhaskara reddy, “Development of failure criteria for flexible pavements”, PhD report UVCE, Bangalore University, Bangalore 1996.

[4] Barzin Mobasher, Michael S. Mamlouk, How-Ming Lin, “Evaluation of crack propagation properties of asphalt mixtures”, Journal of Transportation Engineering, Vol. 123, No.5, September/ October, 1997, Pp No11198.

[5] M. A. Castell, A. R. Ingraffea, and L. H. Irwin, “Fatigue crack growth in pavements”, Journal of Transportation Engineering, Vol. 126, No. 4, July/August, 2000. , Pp No. 21515.