Development of Remaining Service Life (RSL) of pavements for different road networks

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***ABSTRACT*: A PMS (Pavement management system) needs predicting the pavement life. Life of Pavements can be defined by two terms, service life (SL) and remaining service life (RSL). Service life is a measure in years from construction to first rehabilitation or from the last completed work to the next. The main function of RSL of a pavement is to help PMS toknow pavement's current and future projected condition, determine capital fund needs to maintain the average condition of pavement above an accepted level, prioritize projects, and optimize spending of maintenance budgets. Prediction of remaining service life is important because prediction of future pavement condition is one of the most important functions of a PMS, i.e. when the pavement will reach its terminal condition which requires rehabilitation. There are many factors that cause damage to the road so that the RSL of the existing pavement and long-term road maintenance are not predictable. The main aim of this paper is to give idea about RSL concepts and discuss about the various methods of calculating RSL. This paper also tells about how various factors can affect the service life of a pavement and how much % decrease will occur due to a particular factor on RSL of a pavement.**

***Keywords*: PCI, RSL, Service Life, PMS, PSR, PCR**

INTRODUCTION

RSL

Remaining service life (RSL) is the number of years that a pavement will be functionallyand structurally in an acceptable condition with only routine maintenance. Service lifecombines severity and extent of different distresses and rates of deterioration. RSL alsorequires development of aperformance model and establishment of a threshold value foreach distress measurement.

Pavement Condition

It isability of a pavement to take a certain level of serviceability (LOS) under given traffic loadings. Pavement condition indices can be classified into two categories:

1. **Roughness-based**

It is defined as the variation in surface elevation that induces vibrations intraversing vehicles in ASTM E867
Ride Number (RN),Profile Index (PI),International Roughness Index (IRI)

2. **Distress-based**

Evaluate the comprehensive condition of a road by categorizing a pavement's surface distresses by type, frequency, and extent. All distresses are manually inspected for representative pavement sections.

- Present Serviceability Index (PSI),
- Present Serviceability Rating (PSR),
- Mean Panel Rating (MPR),
- Pavement Condition Index(PCI),
- Pavement Condition Rating (PCR),

Factors that affects pavement condition

- Traffic loading,
- Materials
- Treatment type,
- Pavement structure,
- Climates and pavement condition prior to the treatment

LITRATAURE REVIEW

In year 2015, researcher Ary Setyawan, et al [1] select the location of their research on Sumatra East line at the road segment of Jambi-Paninggalan inSouth Sumatera province, Indonesia. The main aim of researcher is to calculate evaluate conditionof road performance and damages and to calculate RSL (Remaining service life) of pavements on East Line of South Sumatera. And also to develop the relationship between these two factors. In this research five sections of the route are taken and all damaged conditionand PCI (Pavement Condition Index)are evaluated. Falling Weight Deflectometer measurements are used to calculate the RSL (Remaining service life) of pavements.

In year 2011, researcher Lu Sunet al [2] did a case study to rank eight road segments using MGP and DWCI. A maximum grade principle (MGP) and a defuzzified weighted cumulative index (DWCI) are proposed to assign a numerical assessment result and a linguistic assessment result to the condition of a road segment.

In year 2013,James W. Mack et al [3] shows that RSL (Remaining service life) concept can be used as a measurement of the time until the next rehabilitation of a pavement section. This paper states United States

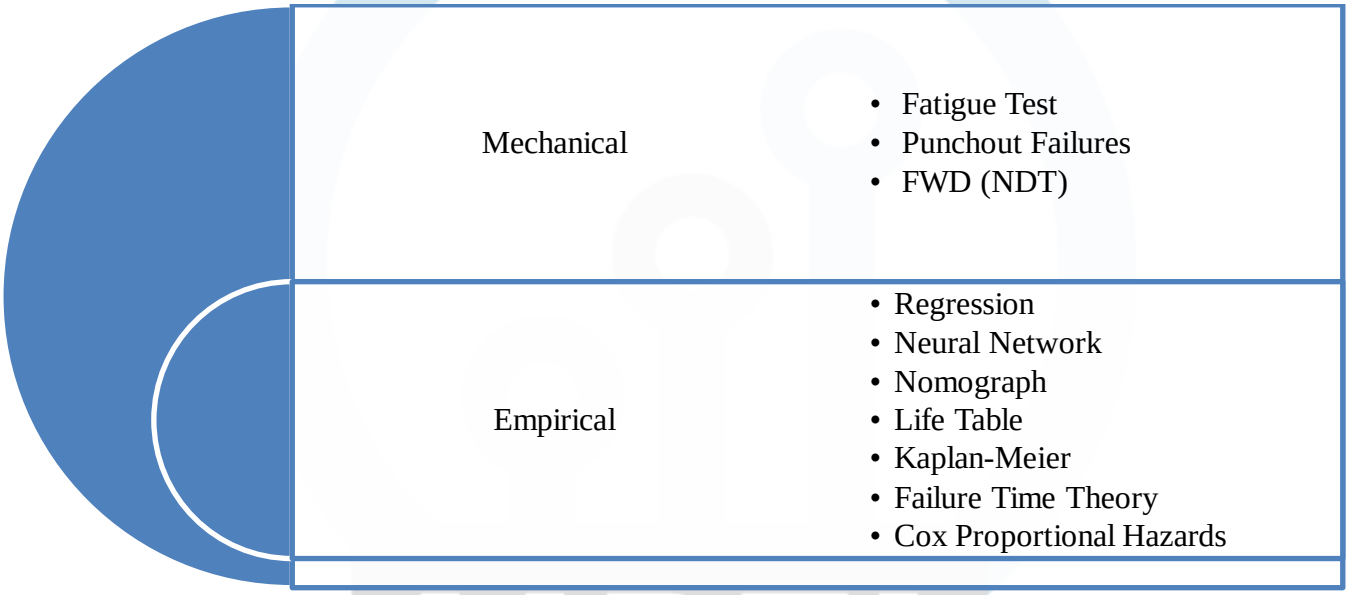
Department of Transportation (USDOT) in MAP-21 have three primary provisions for pavements that are : The principle provision – §150 National Goals and Performance Management Measures, The second provision – §119 National Highway Performance Program, The third provision – §135 Statewide and Nonmetropolitan Transportation planning. Theymainly stated that all these three provisions can be stated by RSL concept.

Inyear 2005,Martin Herold and D.Roberts[4]integratesimaging and groundspectrometry. They also conducted in situ pavement condition surveys forassessment of asphalt road infrastructureseveral spectral measures derived from field and image spectra correlate well with pavementquality indicators (e.g., a pavement condition index).

In year 2001, N. Bandara et al [5]used mathematical techniques of fuzzy sets and take relative importance of each distress type with respect to maintenance and determination of the combined condition index. Many fuzzy aggregation and ranking approaches are used and best computational efficiency is employed for ranking pavement sections, this technique is applied to test on road networks of srilanka and its efficiency is determined.

To overcome the deficiency of traditional PCI (pavement condition index) approach Specific transition probability matrices for different distress types are used in this approach,

METHODOLOGY



Mechanical

It uses destructive or nondestructivetest to obtain thecurrent mechanical strength ofpavements using physical lawsor empirical equations. Theremaining service life is thendetermined by both the currentstrength and projected trafficloadings.Destructive test usually needs totake a sample from the pavementunder investigation which willcause a small damage to thepavement. Non-destructive testoftenmeasures the pavementsurface deflection under specificloading.

Advantages

• No historical conditions ortraffic data are required.
• It is suitable for project-levelmanagement.
• It is direct and easy to comparethe mechanical conditions ofdifferent pavements.
• Operation procedure isstandardized.

Disadvantages

• Destructive test causes damageto a part of pavement and theequipment is often expensive.
•Non-destructive test oftenrequires back-calculationwhose accuracy is sometimesdoubtful.
•Prediction accuracy is affected by sampling locations and traffic projection model.
•The effects of the influentialfactors cannot be directlyestimated.
•It is not appropriate fornetwork-level management.

Empirical

Remaining service life is obtained from observed historical conditions or project data. Effects of the influential factors that could affect pavement service life are estimated either directly or indirectly.

Advantages
• It is less expensive than the mechanical method if historical data are available.
• The effects of the influential factors can be estimated.
• It is relatively easy to implement and integrate into a Pavement management system.

Disadvantages
• Sufficient amount of historical data are required.
• Prediction accuracy largely depends on quality of available historical data and the model format. Determination of the model format usually requires extensive field knowledge and experience.

RESULTS

ADEPT (Association of Directors of Environment, Economy, Planning and Transport) and **RSTA (**Road Surface Treatments Association) have done a joint project in May 2011 to evaluate the service life of various surface treatments. The various effects on service life due to many factors are as follows;

CAUSE	AFFECT ON LIFE
Incorrect design of material	-5%
Use of non-Sector Scheme registered contractor	-10%
Incorrect preparation of works	-5%
Inclement weather conditions	-20%
Surface conditions	-5%
Cleanliness of aggregate (particularly if instructed to use Client owned chippings)	-75%
Incorrect time of year	-75%
Traffic management/aftercare	-75%
Low traffic volume road <100vpd	+75% to +100%
Any others e.g. binder selection, low binder spread rate, poor surface preparation, Contractor not Sector Scheme compliant	-10%
Workmanship (NVQ)	-7.5%
Site selection (location and skid policy)	-7.5%
Substrate condition/Time to overlay asphalt	-7.5%
Time of year/time of day (season)	-7.5%

The service life of various surface treatments is as follows;

SURFACE TREATMENT	SERVICE LIFE
Surface dressing □ Low to medium traffic □ Medium to high traffic	 15 years 10 years
Micro surfacing □ Carriageway □ Footway	 10 years 15 years
Slurry surfacing □ Carriageway □ Footway	 6 years 10 years
High friction surfacing □ Hot applied □ Cold applied	 4 years 8 years

The service life subjected to various traffic conditions are as follows;

Traffic	SERVICE LIFE
Low to medium traffic	15 years
Medium to high traffic	10 years
Slurry c‟way, low traffic	6 years
Micro c‟way, medium to high traffic	10 years
Slurry footway	10 years
Micro footway	15 years

Ary Setyawan, Jolis Nainggolan & Arif Budiarto Predicts the RSL of road using PCI and the data given as per his study is as follows;

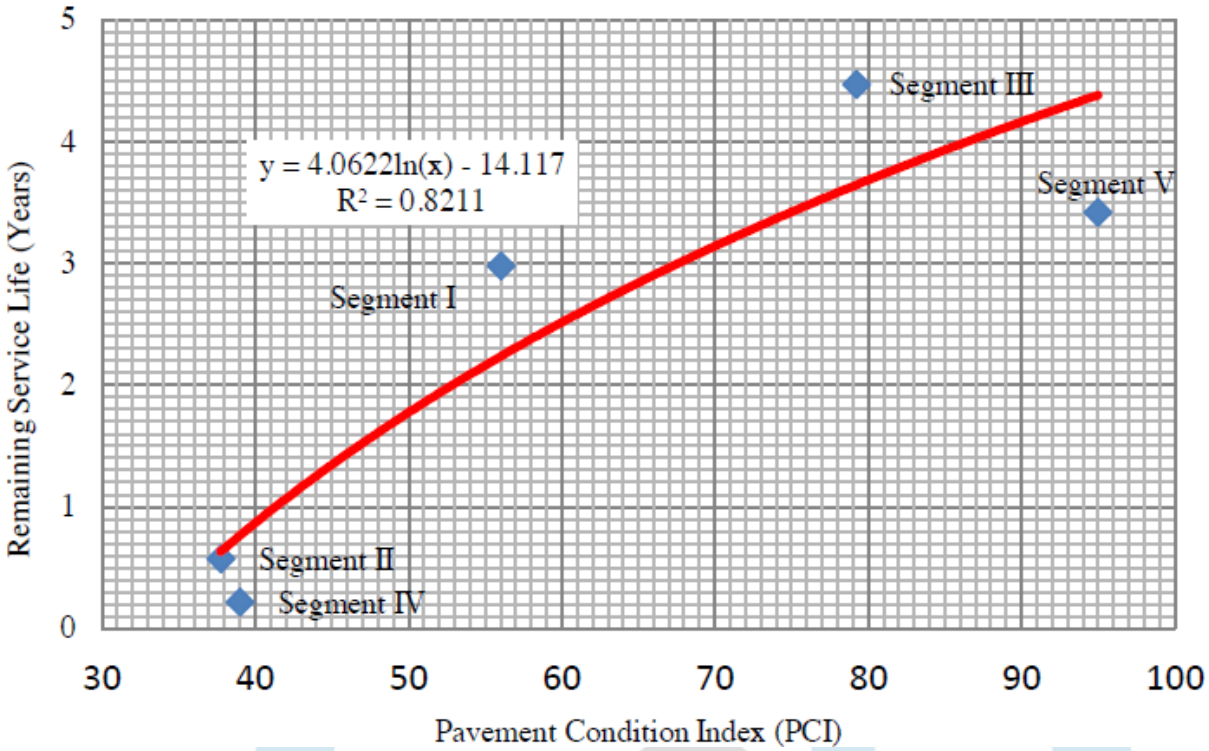


Fig. The correlation between PCI value and The Remaining Life Service

Location (Kilometer)	Traffic Multiplier for Flexible Pavement(TM)	Traffic Growth, (i)%	Remaining Service Life	
			Number of CESA	Years
Segment I (KM 147+600 s/d 148+600)	1.69	5%	37.329.490,25	2.98
Segment II (KM 214+800 s/d 215+800)			6.838.737,45	0.57
Segment III (KM 218+000 s/d 219+000)			57.987.120,72	4.47
Segment IV (KM 221+600 s/d 22+600)			2.623.037,38	0.22
Segment V (KM 234+800 s/d 234+800)			43.246.122,61	3.42

Table . The remaining service life calculated based on FWD deflection measurement

Lu Sun and Wenjun Guuses Pavement Condition Assessment Using FuzzyLogic Theory and Analytic Hierarchy Process (AHP) and his observations are as follows;

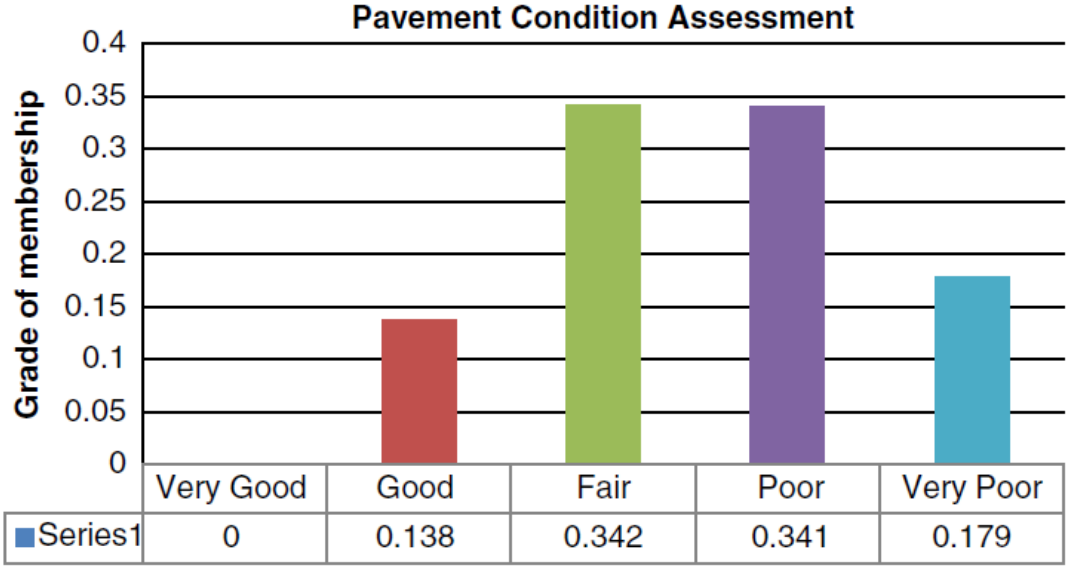


Fig. . Condition assessment resulted from the fuzzy weighted averagemethod

Road segment	Fuzzy comprehensive evaluation set	After applying MGP	After applying DWCI	Ranking by DWCI alone	Ranking by MGP and DWCI
A	(0.30, 0.11, 0.41, 0.10, 0.08)	Fair	0.22993	7	7
B	(0.27, 0.29, 0.24, 0.16, 0.04)	Good	0.23930	4	5
C	(0.36, 0.23, 0.18, 0.14, 0.09)	Very good	0.24194	3	3
D	(0.50, 0.24, 0.19, 0.07, 0.00)	Very good	0.27789	1	1
E	(0.37, 0.35, 0.15, 0.10, 0.03)	Very good	0.26197	2	2
F	(0.32, 0.30, 0.11, 0.17, 0.10)	Very good	0.23797	5	4
G	(0.18, 0.39, 0.20, 0.17, 0.06)	Good	0.23070	6	6
H	(0.14, 0.16, 0.20, 0.26, 0.24)	Poor	0.18000	8	8

Table -Fuzzy Comprehensive Evaluation Results of Eight Road Segments

CONCLUSIONS

- With the help of regression model the correlation of PCI value and remaining life service is developed and the relationship and the correlation coefficient are calculated.
- The correlation between the PCI value and the service life of the pavement is **y = 4,1872ln (x) -14.728** where correlation coefficient is 0.88.
- The road segments I, II, III, IV, and V have a PCI value of 56.1 (good), 37.8 (poor), 9.3 (very good), 39.0 (poor), and 95.0 (excellent) respectively and RSL are 2.39 years, 0.65 years, 4.43 years, 0.11 years and 3.57 years.
- The various factors that can affect the service life of a pavement and how much % decrease will occur due to a particular factor on RSL of a pavement are given.
- In other paper they mainly consider five main performance indicators Roughness, deflection, surface deterioration, rutting, and skid resistance which affects most to evaluate pavement condition And used the advantages of the fuzzy logic theory and analytic hierarchy process (AHP) and develops their own new approach for prioritizing projects on the basis of pavement condition.
- The potential for mapping can be limited by fine spatial resolution requirements (as fine as 0.5 m) and by the spectral confusion between pavement material aging and asphalt mix erosion on the one hand and structural road damages (e.g., cracking) on the other.

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