

A Conditional Study on Life Cycle Cost Analysis for Roads

Pokala Gopichand¹, S.T. Shahid², P. Lakshumaiah Chowdary³

¹M.Tech (PG Scholar), Dept of CE, BHEEMA INSTITUTE OF TECHNOLOGY & SCIENCE

²Assistant Professor, Dept of CE, BHEEMA INSTITUTE OF TECHNOLOGY & SCIENCE

Abstract- An economic analysis method referred to as Life-Cycle analysis (LCCA) is used to gauge the cost-efficiency of alternatives supported World Wide Web present price (WWPV) conception. It's essential to judge the above mentioned cost aspects so as to get optimum pavement life-cycle prices. However, pavement managers are usually unable to consider each vital component that will be needed for acting future maintenance tasks. Over the previous couple of decades, many approaches have been developed by agencies and establishments for pavement Life-Cycle analysis (LCCA). While the transportation community has progressively been utilizing LCCA as an important follow, many organizations have even designed laptop programs for their LCCA approaches in order to assist with the analysis. Current LCCA methods are analysed and LCCA software is introduced in this article. Subsequently, an inventory of economic indicators is provided at the side of their substantial elements. assembling previous literature will help highlight and study the weakest aspects therefore on mitigate the shortcomings of existing LCCA methods and processes. LCCA research will become loads of sturdy if enhancements are created, facilitating personal industries and government agencies to accomplish their economic aims.

Index Terms- Life cycle cost analysis, Optimization model, Maintenance of flexible pavements, Rehabilitation, etc.

I. INTRODUCTION

Nowadays, highway pavement construction, maintenance and rectification prices are unit high completely. It is necessary for highway authorities to use the instruments and approaches that facilitate proper decision-making by applying economic science and operations research such as Life-Cycle cost analysis (LCCA) to achieve economically reasonable long-term investments. LCCA may be a

method based on principles of economic analysis. It improves the evaluation of the entire long-term economic viability of different investment choices. This method finds necessary application in road style and management. variety of authorities worker the LCCA approach to evaluate the economic quality of road styles over the long yield. Thus, it's important for authorities to affordable value pavement economics so as to bring appropriate instruction to the LCCA.

As a approach, it had been within the Fifties that benefit-cost analysis (BCA) was originally practiced as a variety issue for numerous pavement style choices. Then within the Seventies, LCCA principles started being enforced in some key projects at the native and national state levels for pavement design and pavement sort choice. As given in Fig. 1, the aim of LCCA represents the extent and details of successive steps. All managers and stakeholders should completely collaborate so full effectiveness will be achieved. Considering the largely inadequate funding below normal circumstances, road authorities square measure systematically challenged with funding comes because of resource insufficiency. Moreover, with the increasing demand for brand new road infrastructure, the demand for economical management of old and new roads is on the increase still, at the side of safety demands, accessibility and therefore the implementation of advanced traffic management systems for decreasing socio-economic costs by mitigating maintenance-related environmental effects, traffic problems, and losses. Maintenance backlogs none the less increase too. Road authorities so emphasize more on higher potency and lower expenses because of limited funds. Since maintenance expenditures normally comprise 0.5 the annual road infrastructure funds, it's important to grade potency in road maintenance. Thus, with

relevance road objects, life-cycle prices (LCCs) are thought to be having higher priority than simply investments.

Hence, road authorities square measure unremarkably to understand the importance of LCC and management a calculation system. LCCs are suspect to be a moderation in road styles election or the estimate of tenders. once calculating LCCs, each road agencies square measure prices and prices of socio economic nature may be take into study. Road agency (authority) prices includes expenses for plans, construction, design, maintenance, and rehabilitation. of these costs are typically the government's responsibility to hide using tax earnings. Socio-economic prices comprise agency prices, user prices (e.g. delay prices, accident prices and vehicle operation costs), and environmental prices Road network in Republic of India has mature exponentially from zero.4 million kilometer in 1951 to three.32 million kilometer presently with extremely will increase in cars from zero.3 million in 1951 to 108 million in 2008. thanks to this monumental increase in traffic load, its intensity, tire pressure, deficient style of pavement thickness and UN clear effects, main road engineers square measure finding themselves at the greatest disadvantage keep pavements during a traffic- worthy state. The deficiency of resources for the road sector within the past has diode to the adoption of stage wise construction ways with a brief style amount. so construction in our state are going to be a ne'er ending method, with pavement strengthening to be a significant activity for several years to come back. associate overlay could be a layer of acceptable thickness provided on prime of academic degree existing pavement to boost its structural adequacy and riding quality. the two principal decisions for overlay in terms of specification of binder square measure:

versatile overlay, consisting of granular associates of degreed hydrocarbon layers and bituminous layers

- Cement concrete overlay

Cement concrete overlay on prime of associate existing organic compound surface is commonly reffered to as white-topping. White-topping supported on thickness and bonding conditions square measure over again classified as: standard white-topping : thickness vary : 200-300 millimetre,

skinny white-topping : thickness vary : 100-200 millimetre and Ultra-thin white-topping : thickness vary : 50-100 millimetre.

Overlay practice in India:

In India, the foremost common strategy for pavement maintenance and rehabilitation was to produce hydrocarbon overlays on existing black topped surface. This was main owing to superabundant offer of hydrocarbon, Additionally to the comfort levels of construction ways among engineers. In recent times benifits are reversed and oil trade is exploitation using in refined processing technology resulting to reduction in the production of hydrocarbons there by increasing imports. The speedy developments in concrete material technology and mechanization are affirmative concrete overlays as a property choice.

A typical combined proportion of concrete overlays by taking into thought polypropylene fiber, mineral admixtures like fly-ash, granulated course furnace scum, oxide fume have shown increase in density of concrete due to particle packing theory Increasing prices related to highway pavement construction, rehabilitation, and repair, in addition to shortfalls in highway revenue has led highway agencies to hunt requisite deciding tools that utilize economic and research techniques to attianlong run and efficient investments. One in all tools is Life Cycle Cost Analysis (LCCA). LCCA, a away supported on the principles of economic analysis, helps with in the analysis of long-run economic potency between competitive various investment choices [AASHTO, 1986], and has neccesary applications in pavement plan and management. The Federal Highway Administration (FHWA) has continuously inspired the utilization of LCCA in analyzing all major selections wherever such analyses are likely to area unit doubtless to extend the potency and effectiveness of investment selections. The current FHWA position on LCCA for pavement style evolved from ISTE A 1991 That needed the consideration of life-cycle cost accounting within the style and engineering of pavements, among alternative facilities. Alternative LCCA driving forces embrace the NHS Designation Act of 1995 (that specifically needed states to conduct LCCA and cost Engineering Analysis on NHS comes whose price exceed a particular threshold), and TEA-21 (which removed LCCA needs established withn the NHS Act, but needed the

event of LCCA procedures on NHS projects) [FHWA, 1998]. Previous studies conducted in Indiana and alternate states powerfully counsel that more practical semi permanent investment selections could be created at lower value if LCCA were adopted properly [AL Mansour and Sinha, 1994; Mouaket et al., 1992, Peterson, 1985, Darter et al., 1987]. Since 1997, Chapter 52 of the Indiana style Manual has enclosed in depth section on the employment of LCCA, however this section doesn't embrace the impact of user prices on LCCA. As such, road user prices throughout regular road usage similarly well as throughout work-zone periods, As an example, don't seem to be continuously enclosed within the state's pavement investment decisions. Due cognizance of such issues would enable the inclusion of the "benefits" (reduction in user costs) perspective as well as the traditional agency "cost" perspective in the analysis of alternative actions. Furthermore, the express result of maintenance in reducing life cycle prices has to be examined in thoroughly. Most LCCA studies didn't provide maintenance its due thought primarily due to of lack of in-house written agreement maintenance knowledge. In recent times, increasing convenience of maintenance value and effectiveness knowledge (typically two created accessible by immensely improved state pavement and maintenance management systems) not to mention revived stress on preventive maintenance on NHS roads, has created it lot of possible to provide major maintenance (such as thin overlays, micro-surfacing, and seal coating) its due thought in LCCA.

The Current knowledge on unit prices, traffic characteristics, state of observe for strategy development and different information associated with road condition and usage are necessary for LCCA. this study doesn't develop a replacement methodology and code for LCCA for pavement style. Rather, FHWA's existing LCCA methodology and code package (Real Cost) are reviewed vis-à-vis INDOT's distinctive information needs (on treatment prices, effectiveness and strategies) and different existing LCCA strategies and packages, and areas are known for sequent enhancements. As such, this study has the most quantity as possible, tailored FHWA's existing LCCA methodology and computer code package to suit current and certain INDOT pavement vogue and pavement management apply.

II LITERATURE SURVEY

Jain et al. (2004) presented that the flexible maintenance strategies after an analysis period of twenty years can save more than thirty three percent highway agency cost than that of scheduled maintenance strategies. They compared their adopted model with predefined models on selected pavement sections. As the fund granted for maintenance management is only 60percent of the fund required, they prepared an optimized and prioritized work process for 60 percent budget availability. They showed us that the average roughness value of the highway network increases with reduction in budget levels, which in turn can lead to a very high road user cost values.

Zhang (2009) developed a replacement life cycle improvement model for pavement quality management system. He evaluated 3 potential overlay systems. one in all these may be a concrete overlay system. He determined the applying of dynamic programming as AN improvement tool in life cycle improvement of pavement overlay systems, that acquire outputs significantly quicker and additional accurately compared to standard strategies. His results demonstrate the importance of together with user prices and roughness effects in pavement management accounting.

Whiteley-Lagace et al. (2011) attempted to show us the challenges and successes of implementing a pavement management system for roads. Their project team developed a 5 and a 10 year budget plans for road network and developed a number of recommendations to improve the level of detailed data to be added to the system to refine the models. They collected data for four years. They collected performance based data, which included the distress data for asphalt and concrete, gravel and native roads. They calibrated decision trees and cost models for all pavement types. They translated distress rating scores into individual distress index scores and then combined both to create a single surface condition rating.

Jhonson (2008) discussed about current issues facing roads managers. They discussed new methods to stabilize dirt and gravel roads, reclamation process for full depth of the roads. They provided information to support decision making of when to upgrade gravel roads. They also discussed cost safety

improvements, farm to market road issues, best practices and resources in pavement design methods for roads.

Zhang et al. (2013) described about the development of a new pavement network management system that helps analysis and optimization. This LCCA optimization was implemented to regulate the optimum conservation scheme for a pavement network and to reduce supportability metrics within a given analysis period. They mentioned regarding pavement deterioration, that may be a main side to focus future pavement conservation procedures and is extraordinarily troublesome to focus faultlessly.

Pradhan Mantri Gram Sadak Yojana (2006) conferred the selection of the suitable economical and advantageous pavement sort, was created by finishing up life cycle analysis, that takes under consideration the initial price and also the maintenance price. They also presented the cost of construction for both rigid and flexible pavements. They also estimated an economical cost analysis, which showed us that the life cycle cost of concrete pavement is about twenty to twenty five percent lower than bituminous pavement.

Omkar et al. (2001) developed relationship between international roughness index (IRI) and present usefulness rating (PSR) for rigid, flexible and composite pavement varieties. PSR is outlined as mean user panel rating for ride ability on the standard 0 to 5 scale.

Virginia transportation analysis council report (2002) conferred economic analysis elements and price factors always cycle analysis. The report additionally showed US the various varieties of pavement maintenance possibility for rigid, flexible and composite pavements like asphalt concrete reconstruction, rehabilitation of rigid pavement with overlay, continuously reinforced concrete pavement construction, reconstruction with wide lane and ac shoulder.

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A picture demonstration is given below to show how maintenance strategy and rehabilitation action taken into action for a pavement. The flexible precast Interlocking Concrete Block Pavement (ICBP) is considered as a flexible pavement due to its advantages over HRA in terms of its behavior under flexural load due to vehicular traffic. The Mechanistic-Empirical Pavement Design Guide (MEPDG) by the Transportation Research Board; AASHTO, Guide for Design of Pavement Structure (1993) design procedures amongst others are applicable for flexible road pavement design. The mechanistic based design procedures incorporates the treatment of life-cycle costs and design reliability while the empirical design approach rely more on empirical correlations with past performance, index-value-based characterizations of material properties layer coefficient, R-value, California Bearing Ratio (CBR), etc., and adopted engineering design strategy.

The road and transportation engineer should so begin to look at the varied ways that of rising the world through innovations within the choice of geometrical design parameters, material analysis, traffic flow assessment, work methodology, pavement design approach, maintenance strategy and social science. alternative areas include geotechnical engineering of unchanged materials, application of geo-textiles challenged terrains and native content utilization, as these design variables have an effect on the life cycle price of the infrastructure delivered.

Pavement life cycle cost analysis models

A considerable range of past studies on the appliance of Life Cycle analysis (LCCA) and Life Cycle Analysis (LCA) and property Assessments offer helpful data and results to help the pavement engineer within the pavement choice. The LCCA and LCA applications in infrastructure coming up with and delivery helps the stakeholders and decision makers manage costs implication and property problems in an extremely project era basis exploitation project worth analysis methodologies and BS/ISO 15686-5 Standards.

Key amongst these works of those researchers is their aim at optimizing the advantages of the Life Cycle cost analysis (LCCA) and Life Cycle Analysis (LCA) and property objectives for buildings using varied economic analysis techniques with sets of best design alternatives, variables and assumptions. the present models available within the u. s., Europe, and North American nation ar complicated and unsuitable for application in developing countries due to the environmental condition, information, technological, native systems development pattern and procurance also because the cultural variations from that of the developed countries. Road authorities inside the developed economies have adopted models for life Cycle analysis (LCCA) with the intention to cut back. the full prices for road infrastructure and maximize the socio-economic advantages with a down social economic price and environmental impact. These models are primarily used for the choice of construction sorts or pavement sorts and different road infrastructure like bridges.

These models cannot be used as normal models in developing nations since they're developed consistent with needs for specific road projects in some specific atmosphere in developed countries. Moreover, the

restrictions of those existing models include the utilization of unrealistic and roughly calculated maintenance prices and user's prices, lack of regional attributes and tropical road design. Figure 1 illustrates the analysis period-pavement condition index of a pavement design alternative.

In 1960, the American Association of State Highway Engineers (AASHTO) in its "Red Book" introduced the construct of life-cycle cost-benefit analysis to highway investments selections, thereby establishing the construct of economic analysis of road enhancements at the design level. Within the next major advancement in life-cycle analysis, Winfrey [1963] consolidated accessible information on vehicle overhead into a format usable by road planners for developing life-cycle accounting procedures. In addition throughout the 1960s, a pair of comes advanced the applying of life-cycle worth principles to pavement design and pavement-type choice:

1. The National Cooperative Road Analysis Program (NCHRP) investigated the promotion of the LCCA conception [Lytton and McFarland, 1974].
2. The Texas Transportation Institute (TTI) and also the Center for Highway Transportation Analysis developed the versatile Pavement System, a technique and computer program used to analyze and rank various versatile pavement designs by overall life-cycle price [Hudson and McCullough, 1970]. Subsequently, Texas DOT developed the Rigid Pavement System that is comparable to Federal Protective Service in this it performs a life-cycle cost analysis of rigid pavements and ranks alternative designs by their total life-cycle costs [Kher et al., 1971].

III. OBJECTIVE

It is clear from the higher than study that there's no specific schematic for keeps cycle analysis method. Any general kind for any roads is taken into action. It's obvious from all the literature reviewed during this study that in spite of adapting differing kinds of optimisation models, there have been some common factors of same position. Another issue is that life cycle analysis is a lot of economically effective method for rigid pavements than flexible pavements. The physical phenomenon of a literature review was important for this study. It had been shown that the

construct of life cycle cost accounting in pavement investment selections has matured over the past four decades, and most states have embraced the appliance of LCCA ideas in their decision-making. The literature review conjointly showed that LCCA applications in pavement investments has received robust legislative support, significantly within the Nineteen Nineties, and has received due attention from road connected organizations like AASHTO, FHWA, and NCHRP. The literature review conjointly delineate past efforts that have used LCCA ideas to assess long-run cost-effectiveness of other pavement style, rehabilitation and maintenance selections. The review shows numerous that} by which the prices associated effectiveness of such different call are lived and the way these 2 parameters are combined to yield an applicable measure for cost-effectiveness. The chapter conjointly in brief discusses the long run advantages of national experimental programs like the LTPP SPS and GPS studies that show a lot of promise in providing information to handle unfinished LCCA problems like treatment effectiveness (in terms of service life). Finally, it's been cautioned within the literature that whereas the choice with the bottom life cycle value ought to be wanted, that will not essentially be the simplest possibility, which alternative issues like risk, out there budgets, and political and environmental issues may have to be taken into consideration. This chapter conferred solely a general summary of literature bearing on LCCA use. Reviews of past literature specific to alternative LCCA problems (such as existing software package packages, alternatives methods for pavement style and preservation, agency and user value computations and probabilistic aspects) square measure mentioned at numerous relevant chapters of the report.

In this study the motive was to develop a model for the following cases

- Low traffic growth
- Moderate weather in term of rainfall
- Stable area development

In this study associate improvement model was developed, with relation to the higher than conditions. The pavement may be thought-about as a general pavement. For the chosen pavement an occasional traffic growth had been thought-about.

The atmospheric condition was taken as moderate condition. which means the impact of precipitation thereon space is average. Urbanization and development of the world were additionally thought-about as average.

IV. EXPERIMENTAL INVESTIGATION

As the study isn't case specific, from the past studies, assumptions were created to develop the improvement model. the weather thought of square measures

- Traffic growth
- Climate
- External features
- Environment

Table Primary factors for cost analysis & their values adopted from report of annual conference of transportation association of Canada, 2001)

Year	Traffic growth	Impact Climatic condition	Impact of External features	Impact of Environmental condition
5	9.693%	20	8.0	20
10	9.932%	25	8.5	20
15	5.806%	30	9.0	20
20	2.118%	35	9.5	20
25	1.128%	40	10.0	20
30	0.925%	45	10.5	20

Traffic growth: Traffic growth denotes the increment or growth of traffic volume in the given road section over past years. In this study traffic is represented as the axle load of vehicles. It showed the growth of traffic in percentage with a gap of five years.

28

Climate: Climate is a measure of the average pattern of variation in temperature, wind, precipitation and other factors. Rainfall or precipitation is the main factor for pavement deterioration. And assumptions were also made to present the climatic condition as a factor.

Other factors: In this study urbanization and development of the area were considered as the other factors in percentage. These factors have huge impact on pavement life.

Environment: Environment is the surroundings of a physical system that may interact with the system by exchanging mass, energy, or other properties. This environmental factor which is presented in percentage is more or less same throughout the life period of a pavement.

By considering the factors traffic growth, climate, external features and environment a graph was developed as shown below.

By slope analysis and regression model criteria an equation was developed.

It is evident from the table and the C programming output results that, (B) b is having the least value, whenever any kind of maintenance is needed. For major maintenance (C) a is having the value among all major maintenances. So it can be said that, when the PSR values are between, 3.120 to 2.800 the cost incurred for maintenance seems to be least.

$$Z1 \text{ (min)} = 0.412Xa + 0.5Xb + 5Xc + Xd + \text{PSR (B)}$$

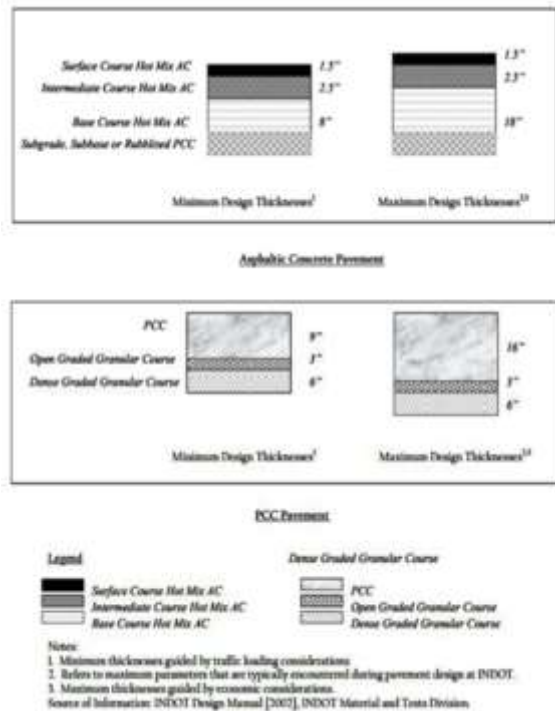
$$Z2 \text{ (min)} = 0.412Xa + 0.5Xb + 5Xc + Xd + \text{PSR (C)}$$

The equation contains Z1 is the most generalized form of life cycle cost analysis for general roads which needs minor maintenance.

The equation contains Z2 is the most generalized form of LCCA for general roads which needs major maintenance.

In the current Indiana pavement intension processes, candidate pavements projects are typically proposed by the districts and reviewed by INDOT's Program Development Division and are evaluated for the appropriate treatment the pavement type and thickness of a proposed pavement structure is generally determined by giving due consideration to subgrade conditions, expected traffic loading, and economic considerations. Also, the pavement intension engineer takes into consideration the route type. Pavement intension is carried out not only for new construction (replacement of entire pavement structure from subgrade up) but also to determine the appropriate thickness of new overlays as part of pavement rehabilitation or resurfacing projects. As such, the present study includes pavement intension alternatives for both new construction and resurfacing of existing pavements. Project scopes may be driven by non-pavement issues such as budget constraints, capacity, safety, drainage, short or long term needs, truck loadings, or geometric

deficiencies. According to the INDOT Intension Manual, a pavement reconstruction project includes removal of the existing pavement structure, including any base or sub-base layer, and preparation of the subgrade prior to placing a new pavement structure. The Manual recommends that pavement sections associated with structural deficiencies should be reconstructed, while structurally sufficient pavements are candidates for rehabilitation-type projects such as resurfacing. Projects requiring 50 % or a lot of new pavement are usually thought of for complete reconstruction. Figure 5.1 presents a schematic illustration of different pavement layer sorts (and several thickness boundary values) when pavement reconstruction or replacement that's in line with current INDOT Pavement import follow. Also, Figure 5-2 shows the alternative pavement layers types (new overlays only) for existing pavements.



INDOT's import Manual states that the minimum thicknesses are unit 300mm and 225mm for HMA pavements and concrete block pavements, severally, on the freeway System. The Manual recommends that new composite pavements (typically used for widening sections for existing roadways) should follow a import in step with that for the prevailing pavement. The Manual any recommends adjustment of those minimum thicknesses by ± 100 metric linear unit for HMA, and ± 50 metric linear unit for PCCP,

supported the preliminary import year traffic data and therefore the minimum thickness shown on the INDOT Typical Sections.

Pavement Intension Alternatives at Selected States

The Structural Number (SN) equation [AASHTO, 1993] suggests that there is an infinite number of combinations of layer thicknesses of the various paving materials that will satisfy the Structural Number requirement specified in the Intension Procedure. The number of potential solutions is reduced somewhat when considering the practical limitations of placing the various pavement layers. In the state of Kentucky for instance, typical ranges of layer thicknesses of common AC pavement layer materials given in the Pavement Intension guide used are as follows: 1.25 to 1.5 inches (32 to 39mm) per course for AC Surface and Binder; 2.0 to 5.0 inches (51 to 129 mm) per course for AC base depending on the class. Also, the aggregate base of 4 to 6 inches (103 to 154 mm) per course is used prior to laying the AC base. In a study that investigated feasible pavement intension alternatives for Wisconsin DOT, Crovetti and Owusu-Ababio [1999] demonstrated that existing LCCA procedures at WisDOT can include certain pavement intensions that were not considered in the initial development of pavement intension LCCA at WisDOT, such as thick AC (150mm (5.8 inches or more) and thin PCC pavements (225mm (8.75 inches) or less). From that research, a valuable lesson for all state DOTs is that any initial effort for LCCA in pavement intension should be carried out for as many material and thickness types as possible, so that future questions of LCCA applicability to certain intensions can be avoided. In California, experimental test sections were constructed on the I-710 using several intension options [Beckman Center, 1998]. The section of reference was about 4.8 km (3 mile) long where the intensioners based their project on using the existing PCC pavement and base, but repairing and patching slabs where needed. The team proposed a 200-mm (8-in) hot-mix asphalt overlay, composed of 154 mm (6 inches) of coarse graded stone matrix asphalt wearing course. The pavement structure consisted of 19mm (0.75 inches) new open graded friction course, 50.8 33 mm (2 inches) new SMA fine grade, 152.4mm (5.9 inches) SMA course grade 200mm (7.8 inches) recycled PCC and 200mm (7.8 inches)

recycled PCC. The Georgia DOT has successfully used a similar combination of mixes for 5 years and found it capable of bridging the joints, broken slabs, and transverse longitudinal joints in the pavements where natural faulting occurs with no evidence of reflective cracking. It was concluded that two applications of milling-and-resurfacing treatment would be needed during the pavement's 40-year life to sustain the wearing surface. In the state of Illinois, the IDOT is hoping to extend the life of its roads to 40 years by adopting a new pavement intension [Zeyer, 2001]. Three miles of pavement on I-290 and a stretch I-270 from Route 157 west to I-55 merge, was replaced with a new pavement using the new intension. The new pavement consisted of a compacted "dirt" sub-base, overlaid by a minimum of 12-in. of gravel (porous granular mound (PGE)), followed by a 6-inch (154 mm) layer of asphalt, and at last flat-top by a 12- to 13-inch (308 to 334 mm) layer of endlessly concrete. it had been expected that tighter specifications for materials (such as less susceptibleness of cement and aggregates to alkali reactivity) would cause extended pavement life. The Illinois 40-year pavement idea continues to be at signification section and construction work was regular to begin in 2003. Over its 4-year life, the reconstructed I-290 section is anticipated to hold 263,000 vehicles per day, of that just about seven-membered square measure trucks.

Pavement signification Alternatives for the current Study New Pavements

Development of alternate pavement intensions ought to usually take due thought of minimum and most thicknesses of the constituent layers for every pavement sort. alternative alternate pavement intensions is thought-about wherever specific project concerns indicate a necessity. supported INDOT pavement classifications, pavement signification alternatives for reconstruction of asphalt and concrete pavements (Figures 5-2 and 5-3, respectively) were developed within the gift study. INDOT's minimum and most thickness signification criteria were thought- about because the boundary cases and progressive thickness in between were wont to reach variety of alternatives. This way, the prices and advantages (service lives) related to numerous thicknesses of every pavement sort and layer

configuration, is investigated over pavement life cycle. 34

V.SUMMARY

The present chapter duly recognizes that pavement intension is carried out not only for new construction (replacement of entire pavement structure from subgrade up) but also for existing pavements (to determine the appropriate thickness of new overlays as part of pavement rehabilitation or resurfacing projects). As such, the chapter presents pavement intension alternatives for both new construction and resurfacing of existing pavements. This has been done on the basis of current and foreseeable INDOT practice. The chapter presents details of alternative pavement layer types (and respective thickness boundary values) for new and as well as for existing pavements

VI. CONCLUSION

In this work an attempt was made to determine the most general equation for any general road at moderate weather. The application of LCCA and CBA provides U.S. with fund allocation methods and creation of web site specific plans for MR&R actions, i.e. plans for meeting the performance objective. the appliance proved that the resources area unit allotted to road sections that have the best demand for repairs, therefore monetary funds are used effectively. The saved funds are successively used as extra resources for any repairs. Another necessary reality is that this systematic approach increased the discipline of subcontractors of repair works, utilized by road directors. The road network administrator has, by suggests that of LCCA, a large range of results, sanctioning him to optimize his activities; as an example, the trend lines of roughness, skid resistance or surface harm. RNMS provides a full set of outputs for network and project level assessment. especially, the prioritization of fund expenditures allotted for MR&R policies and creation of web site specific plans for MR&R actions, i.e. plans for meeting the performance objective. additionally, many others outputs are generated, as an example pavement distress information and traffic connected information, information concerning the results of the analysis – pavement operational condition index, IRI, selected MR&R technology, their prices, traffic load and internal rate of comeback.. The LCCA method

includes several assessments, predictions and assumptions. Variations in inputs will significantly impact analysts' confidence with the LCCA results. Input accuracy is crucial for all aspects. The precise estimation of pavement performance, traffic for quite 30 years within the future and future prices by analysts determines the responsibility of LCCA results. In managing forecast uncertainties, the probabilistic risk analysis approach is gaining popularity. It allows to quantitatively capturing input parameters, helping to provide LCCA results. A large part of literature also states that LCCA implementation is as complicated as selecting the correct discount rate and agency costs, quantifying non-agency costs as user costs, securing credible supporting data including traffic data, estimating the salvage value and useful life, modelling asset deterioration, and estimating maintenance costs, effectiveness and travel demand throughout the analysis period. Further studies may determine the most generalized life cycle cost equation for any type of roads at any given condition. In future this study and the past studies can be combined to get the most generalized and economical LCCA equation. Time, traffic load, road roughness parameters, weather condition, user comfort these factors can be combined to get a relationship, which can be used to develop the most generalized equation, among them.

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