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A REVIEW PAPER ON DEVELOPMENT OF LIFE CYCLE COST ANALYSIS FOR RIGID PAVEMENT

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Abstract: The life cycle cost analysis (LCCA) of the pavement becoming more significant to obtain the proper time for management and action, which should be taken for maintenance. An efficient maintenance policy is essential for a cost-effective, comfortable and safe transportation system. Rigid pavements were costly in preliminary stage of work but are cheap in long run because of its low cost maintenance. Reduction in the cost of concrete pavements can be brought about by developing semi self-compacting concrete techniques and the use of closely spaced thin joints. Moreover, an economic Examination of a road network is dependent upon a number of factors, which are responsible for deciding road serviceability level. Optimization model is an analytical model, which helps to make a cost benefit Examination and compare that with various possible alternatives to give out the best possible activity within the allocated budget, before being carried out in field work. In this paper some of the literatures were reviewed.

Key words: Life cycle cost analysis (LCCA), Cost-Effective, Rigid pavements, Optimization Model, maintenance-free.

I. INTRODUCTION

The purpose of this review is to develop a emphasized idea based on Life Cycle Cost Analysis(LCCA) methodology, which could assist in the pavement selection process and hopefully help to improve the road and street system. The dramatic increase in traffic in built-up areas, such as the Capital Area, results in more and more construction of new roads and modernization of old ones. Therefore, this requires further studies on how road pavements are selected with the help of literature reviews. Using the research papers researchers could make more informed and better investment decisions, because pavement type has a significant impact on future cost and service quality. In many cases, the initial construction cost is the main consideration; the future maintenance and rehabilitation costs may sometimes be forgotten. LCCA is a process that compares the long-term economic worth of competing alternatives and the results could be useful as a decision-supporting tool. LCCA approaches the important hierarchy in the field of pavement. The flow chart defines the overview of the LCCA in the summarized manner. The project locates the objective of study in which project follows the sequence of the activities in both packages (theoritical and software basis). Review of the documents is been viewed in a state of practice of LCCA in pavement design.

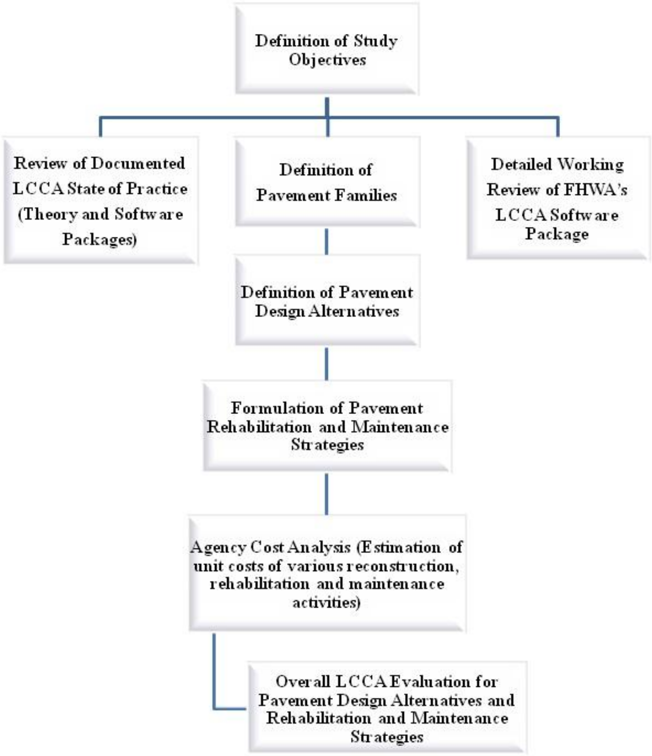

Fig.1 LCCA Approach

Their should be a brief aknowledgement of pavement analysis of which life cycle costing is to be maintained. The heirarchy of the LCCA executes the alternative path to be managed. The first step in the LCCA process is to define realistic design options. For every likely option, it is important to identify initial construction or rehabilitation activities, as well as to predict future rehabilitation and maintenance activities and the times of those individual actions. Some of the costs can be difficult to quantify, so their inclusion in the project can be optional. To be able to fairly compare all opportunities, the discount rate and analysis period should be the same for all alternatives. There are different methods to compare life-cycle costs.

Hence, a plan of activities must be created for each design option. The next step is to estimate costs for all activities. It is recommended to include not only direct agency expenses (construction or maintenance activities) but also user costs, in order to get a better picture of the impact of maintenance/repair. After cost is defined for every possible option, then the total life-cycle costs for each competing alternative can be calculated. LCCA uses discounting to convert future costs to present values so that the lifetime costs of different alternatives can be directly compared. All costs in LCCA are divided into four groups: construction, agencies, user and environmental costs. These costs are individually calculated for each competing alternative. If one of the alternatives does not include a certain cost, then the others should also exclude this cost: only then can the alternatives be fairly compared. For example, if one alternative includes road markings into LCCA, then the other alternatives must include road markings too. Some of the costs can be difficult to quantify, so their inclusion in the project can be optional. To be able to fairly compare all opportunities, the discount rate and analysis period should be the same for all alternatives. There are different methods to compare life-cycle costs.

The most common are the Net Present Worth method (NPW), the Benefit Cost Ratio (B/C ratio), the Internal Rate of Return (IRR), and the Equivalent Uniform Annual Cost (EUAC) method, with the most popular being the IRR and NPW methods. Life Cycle Cost Analysis provides a methodology for computing the cost of a product or service during its lifetime. It is used to compare competing design alternatives over the lives of each alternative, considering all significant costs and benefits, expressed in equivalent monetary units. For infrastructure assets such as roads, a large proportion of the total cost over the lifetime of these assets is incurred after construction, i.e. during their service lives. It is possible to avoid most of the "unknown" costs by introducing long-term costs into the pavement valuation processes instead of comparing only initial material and construction costs.

The steps involved in the LCCA methodology are as follows:-

1. Establish alternative design strategies
2. Determine activity timing
3. Estimate agency costs
4. Estimate user costs
5. Determine life-cycle cost.

II. LITERATURE REVIEW

2.1 General: The American Association of State Highway Officials (AASHO) introduced the concept of life-cycle cost-benefit analysis to highway investments decisions, thereby establishing the concept of economic evaluation of highway improvements at the planning level. In the next major advancement in life-cycle cost analysis, available data on vehicle operating cost into a format usable by highway planners for developing life-cycle costing procedures. Also during the 1960s, two projects advanced the application of life-cycle cost principles to pavement design and pavement-type selection:

- The National Cooperative Highway Research Program (NCHRP) investigated the promotion of the LCCA concept
- The Texas Transportation Institute (TTI) and the Center for Highway Transportation Research developed the Flexible Pavement System (FPS), a methodology and computer program used to analyze and rank alternative flexible pavement designs by overall life-cycle cost.

2.2 Obligations and legislative requirements: LCC application during the design and construction of tunnels, bridges or pavements was mandated by the Intermodal Surface Transportation Efficiency Act. The FHWA stimulated state departments of transportation to carry out LCCA of all pavement projects having costs above US$25 million. [1]As per the National Highway System (NHS) Designation Act of 1995, state highway agencies are supposed to perform an LCCA of every NHS "high-cost usable project segment".

It is legislatively presented in section 303 of the NHS Designation Act that LCCA is an approach for analysing the total economic value of a feasible project segment by evaluating the initial costs and discounted future costs like maintenance, rehabilitation, reconstruction, resurfacing, and restoring costs, over the entire life of the project.

Although LCCA is formally required in certain situations, the FHWA consistently encourages its implementation when evaluating all key investment decisions. This is because such analysis could improve the efficiency and effectives of investment decisions irrespective of whether particular LCCA-mandated requirements are satisfied or not. The requirement for highway agencies to perform LCCA was removed by the 1998 Transportation Equity Act for the 21st century. Nonetheless, utilizing LCCA as a decision support tool is still advocated in the FHWA policy, stressing that the outcomes are not exactly final decisions. This means that the logical analytical framework of this kind of analysis is as significant as the LCCA results themselves. It is the objective of TEA-21 to increase knowledge of LCCA by applying certain notions, as presented in Fig. 2.

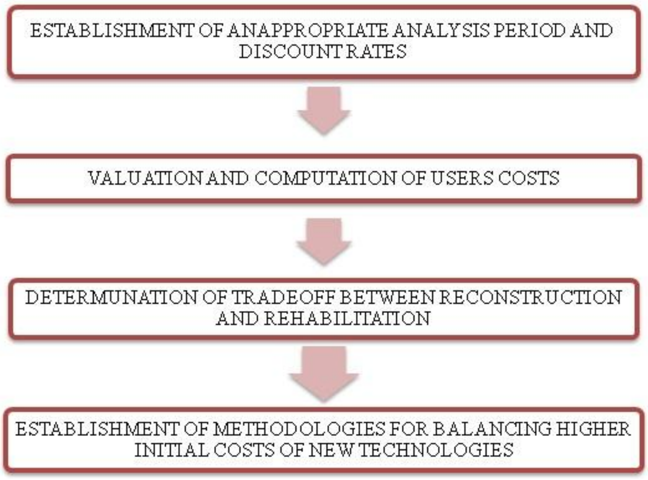

FIG. 2 PROCESS OF LCCA BY TEA-21.

Walls and Smith presented technical instructions and suggestions in the FHWA Interim Technical Bulletin regarding the most suitable method of performing LCCA in pavement design. The Bulletin is aimed at state highway agency personnel who perform and/or evaluate pavement design LCCAs. It is specifically related to the technical aspects of continuing economic efficiency possibilities of other prospective pavement designs. Risk analysis is also included as a probabilistic method for understanding unpredictability in the design process.

2.3 COST FACTORS

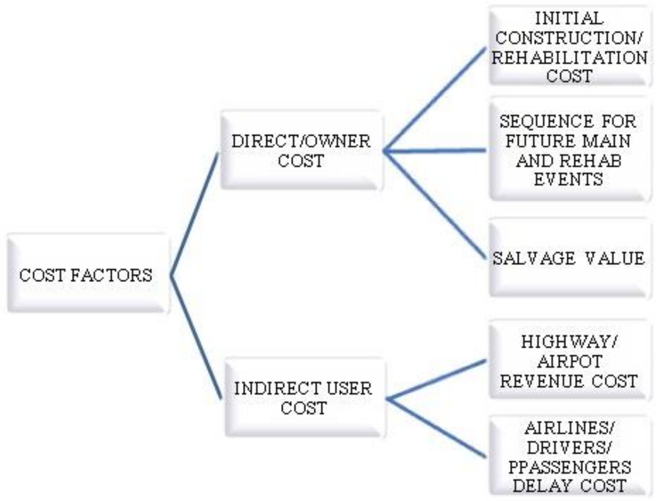

Fig. 2-2 Hierarchy of Cost Factors

Cost-effectiveness evaluation is a method of economic evaluation. It involves comparing what is sacrificed (i.e. the cost) to what has been gained (effectiveness) so the alternatives can be evaluated. “if preventive maintenance is applied too infrequently, user costs and reactive maintenance costs increase and overall life-cycle costs can be very high. On the other hand, if preventive maintenance is applied too frequently, it is uneconomical because the excessive expenditure outweighs the additional benefits of extended pavement life and increased average pavement condition.”

2.3.1 Initial construction

The initial costs are determined at year zero of the analysis period. Although numerous activities are performed during the construction, reconstruction or major rehabilitation of a pavement, only those activities that are specific to a pavement alternative should be included in the initial costs. By focusing on these activities, the specialist can concentrate on estimating the quantities and costs related to these activities. It can be rather difficult to forecast exact initial construction costs. Each situation is very unique and depends on many aspects: geological, economic, environmental, qualifications (work-specific) etc. In the end, total construction costs can exceed estimated costs but can also be less than expected. Therefore, it is recommended to add an extra percentage for unexpected costs

2Jain et al. 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 60 percent 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.

2.3.2 Maintenance and rehabilitation costs

All pavement types need maintenance, which can be preventive (routine) or corrective, during their service life. At a certain time, a pavement must be renewed. Maintenance and rehabilitation cost includes materials, equipment, staff salaries etc. The timing and amount of these activities vary from year to year. In Iceland, they are usually concentrated on the summer months, June to September. Cost data for preventive type maintenance are often not very easy to obtain or to predict. Some agencies do not include maintenance and operation costs in their LCCA of pavements, but exclusion of these costs would mean inaccurate results in the end, especially when comparing asphalt and concrete pavements. This is mainly because the difference between asphalt and concrete pavements is primarily due to differences in maintenance and rehabilitation costs.

2.3.3 User costs

By calculating users’ costs, we can see the impact of road works on road users. User costs will differ during maintenance and rehabilitation periods. During rehabilitation and maintenance, user costs can increase dramatically. It is obvious that road works cause delay and increase vehicle operating costs, as well as the number of traffic accidents.

(3)Zhang developed a new life cycle optimization model for pavement asset management system. He evaluated three potential overlay systems. One of these is a concrete overlay system. He observed the application of dynamic programming as an optimization tool in life cycle optimization of pavement overlay systems, which obtain outputs considerably faster and more accurately compared to conventional methods. His results demonstrate the importance of including user costs and roughness effects in pavement management accounting. User costs can be divided into following categories:

2.3.3.1 Vehicle operating costs

Mostly as a result of increased fuel usage, wear on tyres and other parts, and other factors, vehicle operating costs increase during maintenance periods. In service vehicle operating costs are a function of pavement serviceability level, which is often difficult to estimate.

2.3.3.2 User delay costs

(4)User delay costs are connected with road users' time. Usually time saving is mentioned as one of the key benefits in transportation projects. User costs mostly increase during maintenance and rehabilitation periods, when traffic is completely shut down or diverted into other lanes. Time delay cost is mostly due to changes in speed. Speed changes are the additional cost of slowing from one speed to another and returning to the original speed. Time value depends on the vehicle type and the purpose of the trip. However, user delay costs are one of the most difficult and most controversial life-cycle cost analysis parameters: they are extremely difficult to calculate because it is necessary to put a monetary value on individuals' delay time. The average value of the time for passenger vehicle was calculated to be 1695 km/ hour.

2.3.3.3 Crash costs

Crash costs include damage to the users’ and others’ vehicles and public/private property, as well as injuries. Road accident cost is usually 10 calculated from accident rate and economic costs specified for various types of accident severity and functional road classes. This LCCA model is not going to include any vehicle operation costs due to lack of information, since specific studies must be performed for these cost components.

2.3.3.4 Salvage Value

The pavement worth that the agency has at the end of the LCCA period is called the salvage value. However, if maintenance or rehabilitation is scheduled close to the end of the analysis period, then it is obvious that it extends the life of the pavement, and therefore the agency gains from that, since it increases total pavement value. The FHWA, in its Interim Technical Bulletin on LCCA, recognizes that a pavement's functional life represents a more significant component of salvage value than does its residual value as recycled material. According to the Bulletin, the salvage value has very little impact on LCCA results when value is discounted over 35 years or more. Therefore this LCCA model is not going to include salvage value.

2.4 LCCA EFFECTIVENESS IS PRESERVATION TREATMENT

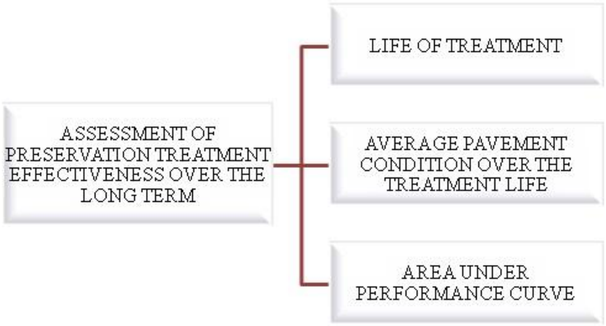

Fig. 2-3 PRESERVATION TREATMENT EFFECTIVENESS

In LCCA, the effectiveness of pavement maintenance or rehabilitation is a major input. Short-term analysis of treatment effectiveness may be done, for instance the decline in deterioration rate or performance improvement, or there could be long-term assessments. Such assessments of preservation effectiveness are more pertinent to LCCA. One of the three approaches is mainly used for the long-term evaluation of the effectiveness of preservation treatment (usually over the entire treatment duration). Effectiveness can be measured by forecasting how much extension is available in the remaining service life through the preservation treatment.

This means the time remaining till the pavement weakens to a specific threshold level, which is also stated as the treatment service life or treatment life. Treatment life can be measured through performance curves (made from past data), or by using expert opinion and a treatment performance threshold. Compared to these two methods, the area-under-the-curve method is much more data intensive but is based on simple logic. There are numerous benefits of a well-kept pavement; however, it is quite difficult to quantify the benefits in monetary terms. The area under the performance curve can serve as a substitute for user benefits.

(5)T. S. Bagwan studied about the rigid pavements. Besides the easy available of cement, concrete roads have a long life and are practically maintenance-free. Another major advantage of concrete roads is the savings in fuel by commercial vehicles to an extent of 14- 20%. The fuel savings themselves can support a large program of concreting. Cement concrete roads save a substantial quantity of stone aggregates and this factor must be considered when a choice pavement is made, Concrete roads can withstand extreme weather conditions – wide ranging temperatures, heavy rainfall and water logging. Reduction in the cost of concrete pavements can be brought about by developing semi-self-compacting concrete techniques and the use of closely spaced thin joints. Research and development R&D efforts should be initiated in this area.

(6)The Foundation of Pavement Preservation (FPP) funded a study to provide information on the various types of pavement preservation treatments. The study specifically addresses flexible pavement preventive maintenance including types of pavements that are candidates for preventive maintenance, the available treatments, where and when they should be used, their cost effectiveness, and the factors to be considered in selecting the appropriate treatment strategy, and a methodology to determine the most effective treatment for a particular pavement.

The objectives of the study were to:

1. Review existing practices related to selecting appropriate preventive maintenance strategies.
2. Develop a framework for the selection of the most appropriate preventive maintenance treatments.
3. Prepare a summary report which documents the findings.
4. Establishing a Pavement Preservation Program

A successful and efficient pavement preservation program will have the support and cooperation of upper management as well as a comprehensive education effort aimed at the customer.

The following elements should be considered when developing a pavement preservation program:

1. Establish program guidelines
2. Determine maintenance needs
3. Provide framework for treatment selection
4. Develop analysis procedures to determine the most effective treatment
5. Include a feedback mechanism to determine program effectiveness

2.4.1 Preventive Maintenance Treatments

There are a number of preventive maintenance treatments for flexible pavements. The timing of the various treatments are applied determines whether they are preventive or corrective treatments. Common distress types in flexible pavements include:

- Rutting
- Cracking
- Bleeding
- Roughness
- Weathering
- Raveling

2.5 ECONOMIC ANALYSIS COMPONENTS

2.5.1 Evaluation Methods

(7)Several economic analysis techniques can be used to assess pavement type options. The two most popular are the Net Present Worth (NPW) method and the Internal Rate of Return method (IRR). The IRR method simply asks what rate of return makes the Net Present Worth equal to zero. In some countries, the Equivalent Uniform Annual Cost (EUAC) method is also common. The EUAC method is developed from the NPW so as to explain the average cost an agency will pay per year over the analysis period. All costs including initial construction and future maintenance are distributed equally. This method can be used to evaluate and compare options even though this value system may not seem realistic in times when little pavement action is required. The result of the NPW method is a lump sum of initial and future costs in today's monetary value. For actions that take place in the first year of the analysis period, the NPW cost is the same as the actual cost, as there is no correction for inflation and interest.

Initial construction costs: Land procurement Design, Equipment costs, Material costs, Workers salary, Etc.

Agencies costs: Maintenance cost, Rehabilitation cost, Workers salary, Etc.

Environmental costs: Pollution, Noise, Visual impact, Etc.

User costs: Vehicles operating cost, Time delay costs, Accident costs, Etc.

LCCA Outputs: NPW, EUAC, B/C ratio, IRR

Financial costs: Discount rate, Analysis period, Etc.

Future maintenance and rehabilitation activities, the NPW cost is less than the actual cost (based on today's unit prices) since total costs are discounted. It should be noted that for two identical actions that occur 30 years apart, the later action will cost much less once they are discounted to the present cost. The NPW method is the more widely used approach for pavement LCCA. It gives an indication of how much a pavement alternative will cost over the analysis period and it can be used to compare alternatives to find the lowest cost.

(8)Han Zhang discussed regarding the pavement systems which provide the critical infrastructure services to society but also significant impacts related to large material consumption, energy inputs, and capital investment. A life-cycle model was developed to estimate environmental impacts resulting from material production and distribution, overlay construction and preservation, construction-related traffic congestion, overlay usage, and end of life management. Hence to improve the sustainability in pavement design, a promising alternative material, engineered cementitious composites ECC was explored in this study. Compared to conventional concrete and hot-mixed asphalt overlay systems, the ECC overlay system reduces life-cycle energy consumption by 15 and 72%, greenhouse gas emissions by 32 and 37%, and costs by 40 and 47%, respectively. The sensitivity analysis indicated that traffic growth has much greater impact on the life-cycle energy consumption and environmental impacts of overlay systems compared to fuel economy improvements.

Benefit-cost ratio identifies the relationship between the cost and benefits of each alternative projects with a benefit-cost ratio greater than one have greater benefits than costs as well as positive net benefits. The higher the ratio is, the greater the benefits relative to the costs are.

2.5.2 Analysis Period

(9)According to the FHWA Technical Bulletin, life cycle cost analysis periods should be long enough to reflect long-term differences associated with reasonable maintenance strategies. In general, the analysis period should be longer than the pavement design period and long enough to include at least one complete rehabilitation activity (VDOT, 2002). The FHWA recommends an analysis period of at least 35 years for all pavements projects, including new or total reconstruction projects and rehabilitation, restoration, and resurfacing projects (Walls & Smith, 1998). However, in Norway, it is more common to use 10- or 20-year analysis periods in road design (NPRA, 2005a). The main reason for that is that over a long period, such as 40 years, significant changes in the economic situation, traffic, and even technology are more likely.

2.5.3 Discount Rate

(10)The time value of money must be taken into account in order to calculate the cost of the future activities: for that reason, in LCCA, the discount rate is used. The discount rate accounts not only for the increased costs related to the future activities but also for the economic benefit that the agency would get if those funds were instead put into a saving (interest-bearing) account. The FHWA suggests using discount rates in the range of 3 to 5%.

2.5.4 Sensitivity Analysis

As with any kind of analysis or research, it is important to understand which parameters make the biggest contribution to the final results. For example: the pavement subgrade strength and traffic loading have the major impact on the design outcome in the pavement design procedure. For LCCA, many variables can affect the final NPW for a pavement alternative. For instance, the unit price of a material is very important and can cause an alternative to go from the lowest NPW to the highest. Therefore, it is very important to use reasonable unit prices that reflect reality.

(11)Douglas D. Gransberg study defines the life-cycle cost which will minimize the pavement that will enhance the sustainability of the nation's highways by delivering pavements that last longer and reduce user impact costs. This study provides best-value award algorithms that can be used to procure pavement on the basis of life-cycle cost rather than low-bid initial costs. The study uses the Federal Highway Administration life-cycle cost analysis (LCCA) design algorithm as a basis of the best-value award. The analysis proves that many of the best-value award algorithms currently used in design/build projects have a strong bias toward minimizing the capital cost of design and construction.

Other factors that can greatly influence the LCCA results are the discount rate, analysis period and timing of activities. By changing some parameters, it is relatively easy to find out which inputs have major impacts on the final results.

2.6 NEED IN PAVEMENT DESIGN, MAINTENANCE AND REHABILITATION

The Federal Highway Administration (FHWA) guidelines are published in order to examine the various cost effectiveness of pavement rehabilitation design approaches. The model framework contained four stages: a pavement condition and analysis module, suitable maintenance and rehabilitation approaches, computing the costs and benefits of all approaches and selecting approaches on a network basis.

(12)Asta Guciute Scheving the report describes a life cycle cost analysis (LCCA) for road pavements and evaluates its impact on pavement type choice. Working from literature, historical data and interviews, the LCCA technique is described and an overview of the road and street system in Iceland is presented. The LCCA methodology developed here is tested on a hypothetical project. The purpose of this project was to develop a calculation model based on LCCA methodology.

(13)Johnson 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.

The study incorporated relationships that link maintenance costs with the pavement serviceability index (PSI) and user cost with the PSI according to road classification. The development and assessment of maintenance approaches got the beneficial tip. Their study indicated that the model was basically developed for rehabilitation strategy analysis, but it can be changed to address preventive maintenance practices as well. The LCCA principles served to assess the benefits and costs of one particular design for flexible and rigid pavements separately over their respective life cycles. It indicates that current LCCA processes could comprise some pavement designs not taken into account in the initial LCCA development. In 1984, the long-term pavement programed (LTPP) and strategic highway research program (SHRP-related) were initiated. The purpose was to provide tools to better understand pavement behavior and to aim for efficient management of highway infrastructure without large increases in funds.

(14)Jin Cheol Lee described the benefits of using recycled materials in highway pavements was assessed quantitatively by conducting life-cycle analysis and life-cycle cost analysis on pavements consisting of conventional and recycled materials for a highway construction project in Wisconsin. Results of the analysis indicate that using recycled materials in the base and sub base layers of a pavement can result in reductions in global warming potential (20%), energy consumption (16%), water consumption (11%), and hazardous waste generation (11%) while also extending the service life of the pavement.

It was anticipated that quantifying the ability of various maintenance treatments to prolong the service life or decrease distress rates would be facilitated by analysing the pavement performance data achieved from the sites or the family sites. The purpose of the experiment was also to investigate how different environmental regions, traffic rates, pavement types (plain or reinforced), subgrade types (course-grained or fine-grained) and base types (stabilized or dense granular) impact the preventive maintenance of rigid pavements. The FHWA stated that the lowest LCC option might not exactly be the most ideal, since there are other factors that must also be taken into account, such as available budget, risk, and political and environmental concerns. Moreover, the LCCA provides information that is critical to the total decision-making process but it does not offer the final answer. It was indicated that less than half of these 28 states included user costs in their LCCA. In comparing the survey outcomes with a similar attempt made in the past, the states are gradually accepting and implementing LCCA concepts during pavement design.

(15)Geoffrey Lamptey aims at producing a comprehensive project-level tool for making pavement design and preservation decisions on a life-cycle basis, using FHWA's existing LCCA methodology and software as a basis. The systems approach for pavement LCCA modeling typically includes the entire management and decision-making process for design, construction, and maintenance, at both the project and network levels.

Road authorities are required to focus on decreasing costs and improving efficiency, since maintenance costs constitute a large portion of annual road infrastructure expenditure. Universally, road authorities can only carry out new road projects and adequately maintain current roads by lowering costs and enhancing efficiency, as funds for road infrastructure have been continually declining.

(16)Zhang et al. 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 discussed about .pavement deterioration, which is a main aspect to focus future pavement conservation procedures and is extremely difficult to focus faultlessly.

Factors that should be considered, or presented in a set of recommendations for pavement preservation include the following.

- Pavement deterioration
- Treatment timing
- Treatments attribute
  - Purpose of the treatment
  - Applicability (traffic, environment, pavement condition)
  - Contraindications
  - Construction considerations
  - Expected performance and cost
  - Customer satisfaction
- Evaluation factors
  - Climate
  - Traffic
  - Conditions addressed
  - Contraindications

The report lists six methods common to strategy selection, including:

1. Data collection,
2. Pavement evaluation,
3. Selection of rehabilitation techniques,
4. Formation of rehabilitation strategies,
5. Life-cycle cost analysis, and

6. Selection of one pavement rehabilitation strategy from among the alternatives considered.

(22)Dr. Arpad Horvath stated the objective of this project that to develop a life-cycle assessment (LCA) framework and computer-based tool, which draws on environmental and economic parameters, and assists decision-makers in evaluating the use of recycled materials in highway construction and maintenance activities. Subsequently, they used the tool structure which introduces the environmental module, and a discussion of the economic module.

III. CONCLUSIONS

Use of LCCA must be carried out appropriately and data utilised must be from records that are accurate in terms of initial costs, salvage value, rehabilitation timing and costs as well as discount rates. It is essential to understand that LCCA is only a tool and the results must not be taken as decisions. Several other factors apart from LCCA must be taken into account when deciding which kind of pavement should be considered. The LCCA process comprises several assessments, predictions and assumptions. Differences in inputs can considerably impact analysts' confidence with the LCCA results. Input accuracy is essential for all aspects. The precise estimation of pavement performance, traffic for more than 30 years in the future and future costs by analysts determines the reliability 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. During major rehabilitation and construction activities, the vast majority of LCCA only use delay costs as part of user costs.

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