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LIFE CYCLE COST ANALYSIS OF ROAD BY USING ANN METHOD

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Abstract- ***Road building needs huge investments not only for construction of new infrastructure but also for the repair and maintenance of the old ones. In case of developing countries, like India, there is a shortage of funds required for new infrastructure projects both for construction and more significantly for their maintenance and repairs. Today's focus is on the construction of long- term performing pavement. Most of our roads are bituminous pavements which are showing early sign of distresses like rutting, cracking, ageing, etc. due to increasing loads, intensity of traffic, high tyre pressure, etc. Concrete pavements can be adopted as an alternative to traditional bituminous pavements. One of the possible alternative rehabilitation solutions to bituminous overlays is the use of white topping overlay on an existing bituminous pavement. In this study an attempt is made to evaluate lifecycle cost analysis of concrete and bituminous pavements by using ANN and suggest a beneficial alternative amongst them.***

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I. INTRODUCTION

This research gives information about LCCA Rigid pavement and LCCA is an economic method to compare alternatives that satisfy a need in order to determine the lowest cost alternative. In this study an attempt is made to evaluate lifecycle cost analysis of concrete and bituminous pavements and suggest a beneficial alternative amongst them.

A. Application of ANN In Life Cycle Cost Analysis

Construction estimating is one of the most crucial functions in project management. Cost and time estimating need to be done in different manners at different stages of a project. Effective estimation is one of the main factors of the success of a construction project. Many factors negatively affect cost estimators and planners to make appropriate decisions. Contractors' experience on previous projects can undoubtedly be considered as an important asset that can help preventing mistakes and also increases the chances of success in similar future encounters. Construction cost data collected from past projects may be used to support cost and time estimation at different stages.There are several methods developed to predict the future cost and few researches attempting to forecast the future highway construction duration. Artificial neural networks (ANN) have recently attracted much attention because of their ability to solve the qualitative and quantitative problems faced in the construction industry. For the estimation of cost and duration different ANN models were developed. The models are trained, tested and validated using MATLAB R2013a Software. The results obtained are the ANN predicted outputs which are compared with the actual data, from which deviation is calculated. For this purpose, two successfully completed highway road projects are considered. The Nf tool (Neural network fitting tool) and Nn tool (Neural network/ Data Manager) approaches are used in this study. Using Nf tool with trainlm as training function and Nntool with trainbr as the training function, both the Projects A and B have been carried out. Statistical analysis is carried out for the developed models. The application of neural networks when forming a preliminary estimate, would reduce the time and cost of data processing. It helps the contractor to take the decision much easier.

B. Scope of Project

- Make better transportation investment decisions.
- Assist in determining the lowest cost way to meet the performance objectives of the project.
- Dwindling resources and reduced purchasing power makes the employment of LCCA even more critical.

C. Objectives

The main objectives of the project are:

1. To study the concept of life cycle cost benefit of rigid pavement and bituminous pavement.

2. To study cost benefit analysis using LCCA and ANN.
3. To prepare comparative analysis of rigid pavement and bituminous pavement using MATLAB or any other equivalent tools
4. Result analysis of comparative analysis of rigid pavement and bituminous pavement which include cost benefit analysis which will be subpart of LCCA

II. LITERATURE REVIEW

Hany El-Sawah **et. al.**This paper presents a study on the use of artificial neural networks (ANNs) in preliminary cost estimating.[1] The choice and the design of the ANN model significantly affect the results obtained from the model and, hence, the accuracy of the estimated cost. The study considered Back Propagation Neural Network (BPNN), Probabilistic Neural Network (PNN) and Generalized Regression Network (GRNN) as well as regression analysis.

H. A. P. Audu et. al. The graphs produced from the sensitivity analysis indicate a decrease in life cycle cost with increasing interest rate for the alternatives.[2] These results are vital for the economic evaluation of flexible pavement and transportation systems.

Mr. Akhai Mudassar et. al. initial investment cost and maintenance cost are taken into consideration. With the help of LCC,[3] alternative pavement design can be selected. This will reduce the cost and will give ample serviceability over the design life of the roads. The use of Fly ash in certain percent instead of cement will further reduce the cost.

Yonas Ketema et. al. the cost of flexible pavement per kilometer was found out to have 7.9 Million ETB more than the rigid pavement because of the incurring costs of maintenance through its design life.[4] Therefore, it is suggested that Portland Cement Concrete Pavement (PCCP) shall be used in pavement construction to cater local material requirements.

Shirole Pratik et. al. One of the possible alternative rehabilitation solutions to bituminous overlays is the use of white topping overlay on an existing bituminous pavement.[5] In this study an attempt is made to evaluate life cycle cost analysis of concrete and bituminous pavements and suggest a beneficial alternative amongst them.

Igor Peško et. al. The best SVM has shown higher precision, when estimating costs, with mean absolute percentage error (MAPE) of 7.06% compared to the most precise ANNs which has achieved precision of 25.38%. Estimation of works duration has proved to be more difficult.[6] The best MAPEs were 22.77% and 26.26% for SVM and ANN, respectively.

Mostafa Batouli et. al. The analysis also examined the sensitivity of the results to different parameters such as the discount rate and future traffic growth rate.[7] The results of the sensitivity analysis indicated that the flexible pavement design has lower agency costs compared to rigid pavements at discount rates less than 4%. For discount rate values greater than 4.5%, the rigid pavement leads to lower life cycle costs.

III. CONCEPT OF LIFE CYCLE COST

The SHRP2 R-23 Guidelines provide a number of possible alternative designs using either rigid of flexible pavements. There is usually not a single design that meets the design criteria but a number of alternative designs that can be considered as viable solutions. The method of selecting the best possible approach may consist of an economic evaluation, a decision matrix, or a combination of those approaches. There are several types of economic or criteria based evaluations that can be carried out as part of conducting a life cycle cost analysis (LCCA): cost- benefit analysis, cost effectiveness analysis, multi-criteria analysis, risk-benefit analysis, etc. At one extreme lies the purely multi-criteria analysis, which employs weights from a variety of sources that contain a large degree of subjective assessment. At the other extreme lies the purely cost-benefit analysis that exclusively employs monetary valuation and has generally more explicitly defined criteria. Most Highway Agencies have established some form of selection process and it is expected that those Agencies will apply those to select between different options.

A. LCCA involves the following basic steps

- *Make initial strategy and analysis decisions*. Certain baseline decisions, estimates and assumptions are needed in order to establish the parameters under which a LCCA can be carried out.
- *Estimate costs*. Costs associated with the owning agency and users are calculated for each alternative.
- *Compare alternatives*. Comparison usually involves expressing each alternative using a common metric such as net present value (NPV) or benefit-cost ratio (B/C).

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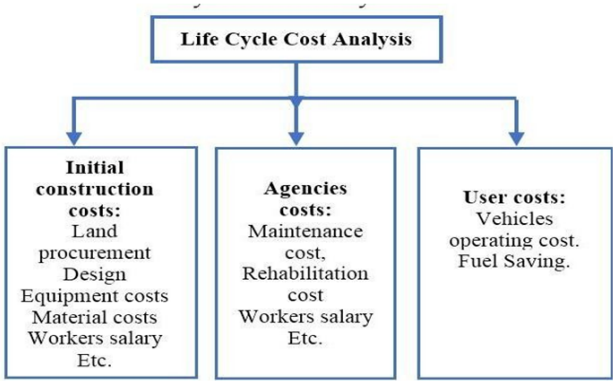
- *Analyze the results and reevaluate alternatives*. Results should be scrutinized for the most influential costs, factors and assumptions. A sensitivity analysis is often used to do this. Original design strategy alternatives should be reevaluated base on these results analysis in order to improve the cost-effectiveness of each alternative

Concrete is known to be a relatively stiffer material and is relatively less sensitive to high temperature. Accordingly, concrete pavements can be adopted as an Alternative to traditional bituminous pavements. One of the possible alternative rehabilitation solutions to bituminous overlays is the use of white topping which is a Portland Cement Concrete (PCC) overlay on an existing bituminous pavement.

IV. METHODOLOGY

A. Life Cycle Cost Analysis Procedure



The steps involved in the LCCA methodology are as follows:

1. Estimate the initial construction cost.
2. Estimate maintenance cost.
3. Estimate road user costs Determine life-cycle cost

B. Procedure of Ann For Construction

In this project we applied Artificial Neural Network using MATLAB to analyze construction delay. MATLAB is software in which we can analyze time delay by using neural network toolbox. NN toolbox includes several network algorithm. By using NN algorithm we provide time input and get optimize output. Following are the step by step procedure to analyze time delay

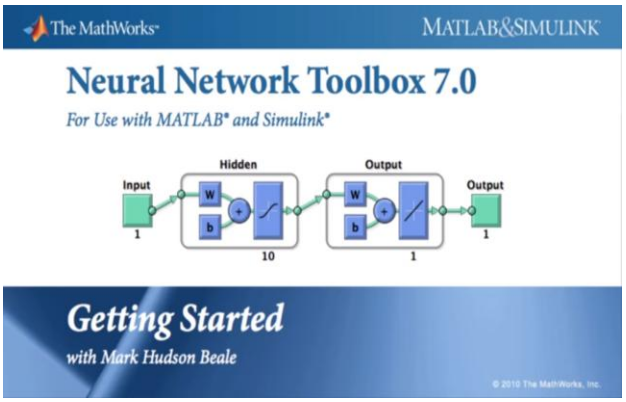


Fig1. MATLAB Software

Step 1: First we install MATLAB software.
Step 2: By clicking on start button we start MATLAB. MATLAB software includes Neural Network Toolbox (ANN).
Step 3: Select ANN Toolbox. ANN toolbox consist of several implemented NN algorithm
Step 4: We gives time (in terms of days) as input.
Step 5: We get several output by ANN algorithm.
Step 6: Analyze all the output and select one which is optimize. That is considering as best output.
Step 7: Optimized output will be compared with desired output. The desired output is zero.

C. How ANN Works

A vast application of ANN in the fields of construction Engineering and Management for solving crucial construction decisions are based on the simple back propagation algorithm. The Back Propagation (BP) training algorithm is the most popular typology and learning method. Several other neural networks other than the BP such as the regularization neural network had been developed to deal with noise and over-fitting problems in data. The typical architecture of the feed forward Neural Network illustrated in Fig. 1 consists of an input layer, hidden layers and output layer. The neurons in the input layer are connected to those in the hidden layers by the synaptic weights. The common transfer functions used are the summation function and the sigmoid squashing function.

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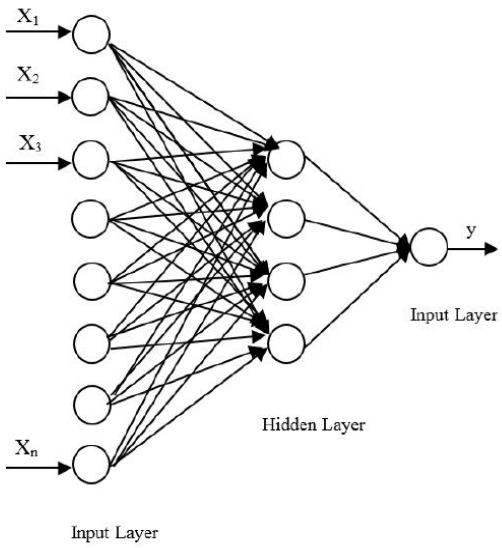

Fig2.Feed forward neural network

V. ANALYTICAL STUDY

A. LCCA of Rigid Pavement over Flexible Pavement

Table 1 LCCA of Rigid Pavement over Flexible Pavement

RW/NH/12014/135/2017-MAH(P-4) Life Cycle Cost Comparison for Flexible Pavement vs Rigid Pavement				
	Assumptions			
	Rate of Inflation		5%	
	Discount Rate		12%	
	Year	**Cum. (Initial cost + Maintenance cost) Rigid Pavement**	**Cum. (Initial cost + Maintenance cost) Flexible Pavement**	**Remarks**
	2017	22.35	20.31	Initial Construction cost is high for Rigid Pavement by 10.08%
	2018	85.22	77.42	
1.00	2019	**203.11**	**184.50**	
2.00	2020	203.29	184.92	
3.00	2021	203.46	185.31	
4.00	2022	203.63	185.68	
5.00	2023	203.78	186.03	
6.00	2024	203.92	195.67	
7.00	2025	204.05	195.98	
8.00	2026	204.18	196.26	
9.00	2027	204.30	196.53	
10.00	2028	204.41	196.77	
11.00	2029	204.51	203.76	
12.00	2030	204.61	203.98	
13.00	2031	204.70	204.19	
14.00	2032	204.78	204.38	
15.00	2033	204.86	204.56	
16.00	2034	204.93	220.80	Break even point
17.00	2035	205.00	220.96	
18.00	2036	205.07	221.11	
19.00	2037	205.13	221.25	
20.00	2038	205.19	221.38	
21.00	2039	205.24	225.77	
22.00	2040	205.29	225.88	
23.00	2041	205.34	225.99	
24.00	2042	205.39	226.09	
25.00	2043	205.43	226.19	
26.00	2044	205.47	229.36	
27.00	2045	205.50	229.45	
28.00	2046	205.54	229.52	Life cycle cost for rigid pavement is cheaper by -10.39%
29.00	2047	205.57	229.60	
30.00	2048	205.79	229.67	

i) Rate of Inflation:- The inflation rate is the percentage increase or decrease in prices during a specified period, usually a month or a year. The percentage tells you how quickly prices rose during the period.

ii) Discount Rate :- It's the rate of return that the investors expect or the cost of borrowing money.

VI. CONCLUSION

The LCCA process comprises several assessments, predictions and assumptions. Differences in inputs can considerably impact analyst's confidence with the LCCA results. Input accuracy is essential for all aspects. Lifecycle cost analysis of concrete and bituminous pavements by using ANN and suggest a beneficial alternative amongst them. Initial Construction cost is high for Rigid Pavement by 10.08% and Life cycle cost for rigid pavement is cheaper by -10.39%

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