An Analysis of Life Cycle Cost Rigid And Flexible Pavment

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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.*

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.

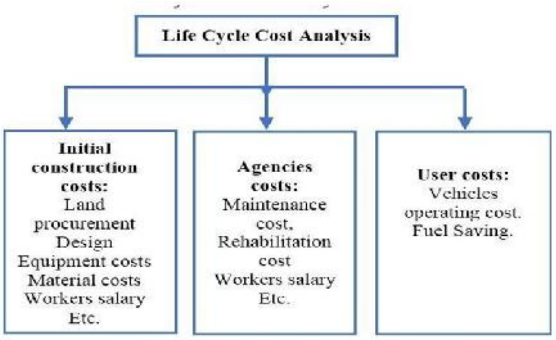
A. LCCA involves the following basic steps

- *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).
- *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

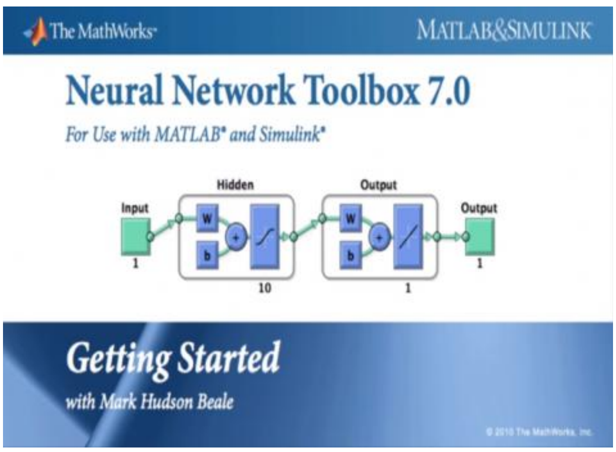


Fig1. MATLAB Software

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.

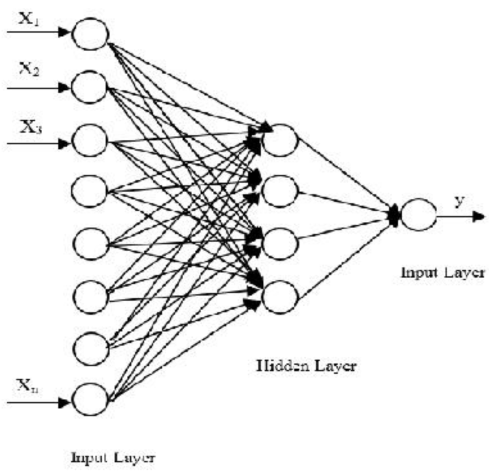
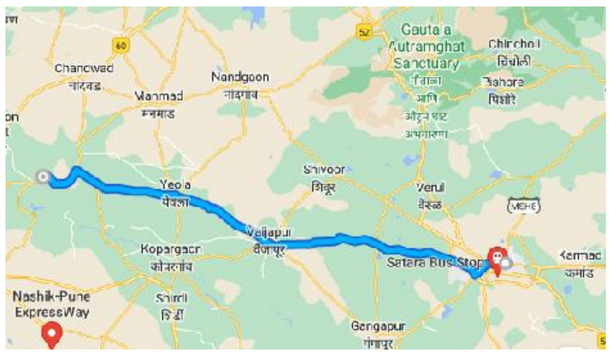


Fig2.Feed forward neural network

V. ANALYTICAL STUDY

Study Aurangabad Highway to Kolwadi Road



For the present case study for ANN input annual maintenance cost was required to predict future maintenance cost. Total 20 years data is gathered from billing engineer Mr.Amol Garole from Stup Consultant

For Rigid Pavement

Up gradation of Package-I from Km. 0+000 to Km. 47+800 to 2 lane with paved shoulder configuration in the state of Maharashtra.

Table 1 General Abstract of Cost for Rigid Pavement

GENERAL ABSTRACT OF COST			
Length of Project -(47.80 Km)			
Bill No	**Item of works**	**Amount (Rs. Crs.)**	**% of Total Cost**
1	Site clearance and dismantling	2.13	0.95%
2	Earth work	41.80	18.70%
3	Granular sub-base	24.51	10.96%
5	Concrete pavement	87.47	39.13%
6	Slab, box and pipe culverts and underpass	18.10	8.10%
7	Major and minor bridges	8.03	3.59%
8	Drainage and protection works	15.85	7.09%
9	Traffic signs, marking and other appurtenances	1.81	0.81%
10	BUS BAY and TRUCK LAY BAY	1.88	0.84%
11	MISCELLANEOUS (Median work and Utilities across the highway)	5.58	2.50%
12	Toll plaza	3.98	1.78%
13	Major and minor junctions	8.17	3.65%
	TOTAL	**223.54**	
	Total project Cost Per Km (Rs. Crs.)	**5.67**	

5.3 For Flexible Pavement

Up gradation of, Package-I from Km. 0+000 to Km. 47+800 to 2 lane with paved shoulder configuration in the state of Maharashtra

Table 2 General Abstract of Cost for Flexible Pavement

GENERAL ABSTRACT OF COST			
Length of Project -(47.80 Km)			
Bill No	**Item of works**	**Amount (Rs. Crs.)**	**% of Total Cost**
1	Site clearance and dismantling	2.13	1.05%
2	Earth work	41.80	20.59%
3	Granular sub-base	24.51	12.07%
5	Pavement	98.00	48.26%
6	Slab, box and pipe culverts and underpass	18.10	8.91%
7	Major and minor bridges	8.03	3.96%
8	Drainage and protection works	15.85	7.80%
9	Traffic signs, marking and other appurtenances	1.81	0.89%
10	BUS BAY and TRUCK LAY BAY	1.88	0.92%
11	MISCELLANEOUS (Median work and Utilities across the highway)	5.58	2.75%
12	Toll plaza	3.98	1.96%
13	Major and minor junctions	8.17	4.02%
	TOTAL	**203.06**	
K	**Total project Cost Per Km (Rs. Crs.)**	**5.19**	

Life Cycle Cost Analysis **For Rigid Pavement**

Table 3 For Rigid Pavement

	Cost of civil works excluding cent ages			223.54	crores		
	annual routine maintenance for joint repair @ 0.1% of civil cost			0.224	crores	105%	112%
Year	Construction Item	Cost (Crores Rs)	Cost After Inflation (at 5%)	Discounted Cost (at 12%)	Cum Net Present Value(Crores Rs)	Inflation Factor	Discount Rate Factor
2017	1 st year const	22.354	22.35	22.35	22.35	1.000	1.000
2018	2 st year const	67.062	70.42	62.87	85.22	1.050	1.120
2019	3 st year const	134.124	147.87	117.88	203.11	1.103	1.254
2020	Annual maintenance	0.224	0.26	0.18	203.29	1.158	1.405
2021	Annual maintenance	0.224	0.27	0.17	203.46	1.216	1.574
2022	Annual maintenance	0.224	0.29	0.16	203.63	1.276	1.762
2023	Annual maintenance	0.224	0.30	0.15	203.78	1.340	1.974
2024	Annual maintenance	0.224	0.31	0.14	203.92	1.407	2.211
2025	Annual maintenance	0.224	0.33	0.13	204.05	1.477	2.476
2026	Annual maintenance	0.224	0.35	0.13	204.18	1.551	2.773
2027	Annual maintenance	0.224	0.36	0.12	204.30	1.629	3.106
2028	Annual maintenance	0.224	0.38	0.11	204.41	1.710	3.479
2029	Annual maintenance	0.224	0.40	0.10	204.51	1.796	3.896
2030	Annual maintenance	0.224	0.42	0.10	204.61	1.886	4.363
2031	Annual maintenance	0.224	0.44	0.09	204.70	1.980	4.887
2032	Annual maintenance	0.224	0.46	0.08	204.78	2.079	5.474
2033	Annual maintenance	0.224	0.49	0.08	204.86	2.183	6.130
2034	Annual maintenance	0.224	0.51	0.07	204.93	2.292	6.866
2035	Annual maintenance	0.224	0.54	0.07	205.00	2.407	7.690
2036	Annual maintenance	0.224	0.56	0.07	205.07	2.527	8.613

2037	Annual maintenance	0.224	0.59	0.06	205.13	2.653	9.646
2038	Annual maintenance	0.224	0.62	0.06	205.19	2.786	10.804
2039	Annual maintenance	0.224	0.65	0.05	205.24	2.925	12.100
2040	Annual maintenance	0.224	0.69	0.05	205.29	3.072	13.552
2041	Annual maintenance	0.224	0.72	0.05	205.34	3.225	15.179
2042	Annual maintenance	0.224	0.76	0.04	205.39	3.386	17.000
2043	Annual maintenance	0.224	0.79	0.04	205.43	3.556	19.040
2044	Annual maintenance	0.224	0.83	0.04	205.47	3.733	21.325
2045	Annual maintenance	0.224	0.88	0.04	205.50	3.920	23.884
2046	Annual maintenance	0.224	0.92	0.03	205.54	4.116	26.750
2047	Annual maintenance	0.224	0.97	0.03	205.57	4.322	29.960
2048	Annual maintenance	0.224	0.22	0.22	205.79	1.000	1.000
2049	Annual maintenance	0.224	0.22	0.22	206.02	1.000	1.000

For Flexible Pavement

Table 4 for Flexible Pavements

	Cost of civil works excluding cent ages			203.06	crores		
	Annual routine maintenance for shoulder rain cut repair, potholes etc. @ 0.25% of civil cost			0.51	crores	105%	112%
Year	**Construction Item**	**Cost (Crores Rs)**	**Cost After Inflation (at 5%)**	**Discounted Cost (at 12%)**	**Cum Net Present Value(Crores Rs)**	**Inflation Factor**	**Discount Rate Factor**
2017	1 st year const	20.31	20.31	20.31	20.31	1.000	1.000
2018	2 st year const	60.92	63.97	57.11	77.42	1.050	1.120
2019	3 st year const	121.84	134.33	107.08	184.50	1.103	1.254
2020	Annual maintenance	0.51	0.59	0.42	184.92	1.158	1.405
2021	Annual maintenance	0.51	0.62	0.39	185.31	1.216	1.574

2022	Annual maintenance	0.51	0.65	0.37	185.68	1.276	1.762
2023	Annual maintenance	0.51	0.68	0.34	186.03	1.340	1.974
2024	Annual maintenance	15.16	21.33	9.65	195.67	1.407	2.211
2025	Annual maintenance	0.51	0.75	0.30	195.98	1.477	2.476
2026	Annual maintenance	0.51	0.79	0.28	196.26	1.551	2.773
2027	Annual maintenance	0.51	0.83	0.27	196.53	1.629	3.106
2028	Annual maintenance	0.51	0.87	0.25	196.77	1.710	3.479
2029	Annual maintenance	15.16	27.22	6.99	203.76	1.796	3.896
2030	Annual maintenance	0.51	0.96	0.22	203.98	1.886	4.363
2031	Annual maintenance	0.51	1.01	0.21	204.19	1.980	4.887
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2034	Annual maintenance	48.66	111.52	16.24	220.80	2.292	6.866
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2044	Annual maintenance	18.14	67.74	3.18	229.36	3.733	21.325
2045	Annual maintenance	0.51	1.99	0.08	229.45	3.920	23.884
2046	Annual maintenance	0.51	2.09	0.08	229.52	4.116	26.750
2047	Annual maintenance	0.51	2.19	0.07	**229.60**	4.322	29.960
2048	Annual maintenance	0.51	2.30	0.07	229.67	4.538	33.555
2049	Annual maintenance	18.14	86.46	2.30	***231.97***	4.765	37.582

VI. CONCLUSION

- LCCA finds that concrete pavement may be regarded as more advantageous than bituminous pavement and concrete overlays as a good alternative for the recovery of existing bituminous pavement.
- Mat lab predicted value for flexible was 0.993 and which is for rigid was almost 1, where R indicates range for periodic maintenance cost.
- It has been discovered that rigid pavement are operating longer than a flexible pavement, based on the findings of this research study. The life cycle cost of a rigid pavement cover is 1 kilometer less than the flexible pavement cover in a period of forty (40) years of analytics for a total of 64 million ETB (Existing-To-Bank). Routine and regular maintenance expenses of the same one-kilometer length for flexible pavement for three decades are 1.1 times more than inceptional building costs, and need an increase of 7,3million for construction and maintenance than rigid pavement. Initial construction costs are 10.08 percent greater for rigid pavement.
- Flexible pavement can be built and maintained fast and thus minimise congestion. These pavements are usually black in colour, offering a substantial decrease in the clearing of the road surface and contribute to the development of line marks. These pavement are robust, safe and durable compared to rigid pavement.
- In this research, the life cycle cost studies for the road are completed for 1 km using Rigid and Flexible pavements, and they are performed in MATLAB software.
- From the research study of LCCA of Road with rigid and flexible pavement it is conclude that road with flexible pavement have Initial Construction cost is high for Rigid Pavement than road with flexible Pavement by 40-45%.
- After the analyzing life cycle cost road for 30 years, LCC for road with flexible pavement are 128.73 Cr and LCC for road with rigid pavement are 119.94 Cr, and it is conclude that Life cycle cost for road with rigid pavement is cheaper by 6.83% than road with flexible Pavement.
- Similarly from the MATLAB analysis output results for road with rigid are 99.5% and outputs for flexible pavement are 99.94% ,so its conclude that road rigid pavement are more economic than flexible.

- In order to realize an optimal trade-off between investment and maintenance of road projects, LCCA should be applied. LCCA has several applications, including help in selecting the best alternative to meet a project objective.
- The feasibility study on selecting a road goes beyond costs and LCCA e.g. the geological conditions; duration of construction, environmental impact, technology availability, constructability and ecological and even political consideration dominates the decision.
- To properly plan for future repairs or scheduled maintenance in a road, it is beneficial to perform a LCCA of the different options involved for each anticipated major repair to ensure the greatest cost efficiency over the life of the road

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