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Review on Cost and Benefit Analysis of Rigid and Flexible Pavement

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ABSTRACT: In many countries with developed road networks, new road construction typically accounts of more or less 50% of the road budget. While the remainder of national road budgets is spent on maintenance and rehabilitation of existing roads. Long-life Pavements (LLP) project is approved if the costs of future maintenance, rehabilitation and the resulting road user delay costs are economically justified. There has been historically difference of opinion as to whether Hot Mix Asphalt (flexible) pavements are more economical or less economical over time, than Portland Cement Concrete (rigid) pavements. Even experienced state highway agencies and highway engineers disagree on the subject. In this study will evaluate initial construction cost for one kilometer of both flexible and rigid pavement and evaluate Life cycle cost analysis (LCCA) for both pavements by present worth method for 30 year analysis period.

KEYWORDS: Cost, LCCA, LLP, Rigid Pavement, flexible Pavement

1. INTRODUCTION

In many countries with developed road networks, new road construction typically accounts of more or less 50% of the road budget. While the remainder of national road budgets is spent on maintenance and rehabilitation of existing roads. Long-life Pavements (LLP) project is approved if the costs of future maintenance, rehabilitation and the resulting road user delay costs are economically justified. 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. 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

A. Flexible pavement

Flexible Pavements are constructed from bituminous or unbound material and the stress is transmitted to the sub-grade through the lateral distribution of the applied load with depth. Flexible pavement is composed of a bituminous material surface course and underlying base and sub base courses. The bituminous material is more often asphalt whose viscous nature allows significant plastic deformation. Most asphalt surfaces are built on a gravel base, although some 'full depth' asphalt surfaces are built directly on the subgrade.

B. Rigid Pavements

A rigid pavement is constructed from cement concrete or reinforced concrete slabs. Grouted concrete roads are in the category of semi-rigid pavements. The design of rigid pavement is based on providing a structural cement concrete slab of sufficient strength to resists the loads from traffic. The rigid pavement has rigidity and high modulus of elasticity to distribute the load over a relatively wide area of soil. Rigid pavements are composed of a cement concrete surface course and concealed base and sub base courses.

II. STATE OF DEVELOPMENT

Ralph A. Moyer et. al. This study provides the results for more than 600 solutions of annual costs of pavements in which the effect on the annual cost of eight major variables is clearly set forth. The variables included in the study consisted of: (1) subgrade quality for six subgrade resistance values; (2) traffic indexes for light, medium, and heavy traffic; (3) contract bid prices for all state highway pavement construction in California in 1958 and 1960 in the low range (10 percentile value), in the high range (90 percentile value), and for the arithmetic mean of all bid prices; (4) interest rates of 3 percent and 6 percent; (5) a service life of initial pavement of 13 years and 18 years was used for flexible pavements and 18 years and 26 years for rigid pavements and a service life of 13 years for the first and second asphalt concrete resurfacing was used for both flexible and rigid pavements; (6) the annual costs were computed for analysis periods of 26 years and 35 years; (7) average maintenance costs for California flexible and rigid pavements were used in the primary study and the effect of doubling and tripling the maintenance cost of flexible pavements versus no change in these costs for rigid pavements was determined on a sampling basis; and (8) a total shoulder width of 22 ft and a 2-lane pavement width of 24 ft was used in the primary study and an analysis of the effect of reduced shoulder width for 6- lane and 8- lane freeways was made on a sampling basis.

Yonas Ketema (2016) Road construction projects have been implemented all over Ethiopia as part of the national development plan. Roads are one of the country's basic infrastructural facilities where high amounts of budget allocated every fiscal year planning period. Since the cost comprises of a large portion of government investment, a careful evaluation of the alternatives is utmost importance to make the right choice for a particular project. In the history of Ethiopia road development program, almost all of the road pavements are flexible, and it demands high foreign currency for asphalt material importing from abroad. In addition, flexible pavement needs to be maintained and rehabilitated within a few years after its initial construction. In view of the emerging cement factories and the availability of cement in Ethiopia, it is practical to consider rigid pavement as one of the alternatives. While the data considered was gathered through investigation at the actual rigid and flexible pavement projects, examination of specifications, drawings and pavement design, Ethiopian Road Authority manuals, rehabilitation and maintenance strategy. In this regard, the cost parameters investigated are initial construction cost, maintenance cost, rehabilitation cost, user's cost and salvage value, in addition to other qualitative and quantitative data. Based on the results of the research project, it revealed that the initial cost of rigid pavement was almost twice of the flexible pavement, but in the long run, 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. Therefore, it is suggested that Portland Cement Concrete Pavement (PCCP) shall be used in pavement construction to cater local material requirement.

H. A. P. Audu (2016) Sensitivity analysis is a tool used in the assessment of a model's performance. This study examined the application of sensitivity analysis on a developed flexible pavement life cycle cost model using varying discount rate. The study area is Effurun, Uvwie Local Government Area of Delta State of Nigeria. In order to determine one of the vital geotechnical engineering properties (i.e. California Bearing Ratio) of the soil samples required for this study, soil samples were taken from the subgrade of the study area using the disturbed sampling method. The laboratory test was carried out at geotechnical laboratory in Warri and in accordance with AASTHO 1993 to determine the subgrade strength. Existing data such as maintenance records, vehicular traffic counts, material costs, discount rate and pavement design data were sourced from the Delta State Ministry of Works, Effurun. These acquired data and CBR results of 5% and 6% were used for the design of three competing flexible pavement systems and Bill of Engineering Measurements obtained. These were used for the evaluation of the Life-Cycle Costs (LCCs) using present worth cost (PWC) method; varying discount rates in MS Excel spread sheets for a design life of 20 years. Regression modeling of the three scenarios was done with sensitivity analysis carried out on the developed model. The project age was used as its independent variable, while discount rate is a secondary independent variable varied by ±4%, ±8% and ±12% of the initial discount rate of 5.4% applied with the accuracy of 95%. The coefficient of determination (R2) for the Hot Rolled Asphalt (HRA), Interlocking Concrete Pavement Block (ICPB) and Do-nothing models are 0.97, 0.95 and 0.99 respectively indicating a robustness of the developed models. The graphs produced from the sensitivity analysis indicate a decrease in life cycle cost with increasing interest rate for the alternatives. These results are vital for the economic evaluation of flexible pavement and transportation systems.

Mr. Akhai Mudassar Mohammed Shafi (2016) India is developing very fast and to become a developed country more importance has to be given to the infrastructure sector. Infrastructure basically consists highways, airports, seaports, bridges etc. Of these, the road sector is very necessary because more than 60 % of all goods in the country and 85% of India's total passenger traffic is transported through this network. Now the road connectivity in India is good only around the metro cities. So more emphasis has to be given to the rural areas so as to make them well connected with the major cities. Good connectivity will ensure faster movement of people and goods with safety and economy. For achieving this, an efficient road infrastructure plan has been chalked out because of which India economy will grows about 6% per annum in next 20 years. The government has planned Rs3 lakh crore of road projects in current fiscal to meet the target of 30 km per day highway construction. The transport sector contributes 6% of Indian GDP out of which 70% share comes from the road sector. The road pavement cost is around 50% of the total cost of construction of the road. This research paper deals with the cost analysis of Cement Concrete road and bituminous road. Basically it differentiates the rigid pavement and the flexible pavement and provides information about which pavement is more economical and cost effective. This is done with the help of NPV method of Life Cycle costing. In this method initial investment cost and maintenance cost are taken into consideration. With the help of LCC, 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.

Pooja B. Kale et. al. (2016) Life cycle costing is the process of identifying and documenting all the costs involved over the life of an asset. The cost of road construction consists of design expenses, material extraction, construction equipment, maintenance and rehabilitation strategies, and operations over the entire service life. An economic analysis process known as Life-Cycle Cost Analysis (LCCA) issued to evaluate the cost-efficiency of alternatives based on the Net Present Value (NPV) concept. It is essential to evaluate the above mentioned cost aspects in order to obtain optimum pavement life-cycle costs. However, pavement managers are often unable to consider each important element that may be required for performing future maintenance tasks. Over the last few decades, several approaches have been developed by agencies and institutions for pavement Life-Cycle Cost Analysis (LCCA). While the transportation community has increasingly been utilising LCCA as an essential practice, several organisations have even designed computer 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, a list of economic indicators is provided along with their substantial components. Collecting previous literature will help highlight and study the weakest aspects so as to mitigate the shortcomings of existing LCCA methods and processes. LCCA research will become more robust if improvements are made, facilitating private industries and government agencies to accomplish their economic aims. I have done a literature study on various papers related to life cycle co is costing. The data is collected related to the case study of life cycle costing of roads and one work on have done an analytical work on life cycle costing of rigid and flexible pavement of JNPT –Package IV.

Ralph A. Moyer et. al. This study provides the results for more than 600 solutions of annual costs of pavements in which the effect on the annual cost of eight major variables is clearly set forth. The variables included in the study consisted of: (1) subgrade quality for six subgrade resistance values; (2) traffic indexes for light, medium, and heavy traffic; (3) contract bid prices for all state highway pavement construction in California in 1958 and 1960 in the low range (10 percentile value), in the high range (90 percentile value), and for the arithmetic mean of all bid prices; (4) interest rates of 3 percent and 6 percent; (5) a service life of initial pavement of 13 years and 18 years was used for flexible pavements and 18 years and 26 years for rigid pavements and a service life of 13 years for the first and second asphalt concrete resurfacing was used for both flexible and rigid pavements; (6) the annual costs were computed for analysis periods of 26 years and 35 years; (7) average maintenance costs for California flexible and rigid pavements were used in the primary study and the effect of doubling and tripling the maintenance cost of flexible pavements versus no change in these costs for rigid pavements was determined on a sampling basis; and (8) a total shoulder width of 22 ft and a 2-lane pavement width of 24 ft was used in the primary study and an analysis of the effect of reduced shoulder width for 6- lane and 8- lane freeways was made on a sampling basis

Greg White et. al The construction and maintenance costs, as well as the residual value, were calculated for structurally equivalent rigid and flexible airfield pavements, for a range of typical commercial aircraft, as well as a range for typical subgrade conditions. Whole of life cost analysis was performed for a range of analysis periods, from 40 years to 100 years. For the standard 40-year analysis period and a residual value based on rigid pavement reconstruction, the rigid pavements had a 40% to 105% higher whole of life cost than equivalent flexible pavements, although this comparison is limited to the pavement compositions and material cost rates adopted. However, longer analysis periods had a significant impact on the relative whole of life cost, although the rigid pavements always had a higher cost than the flexible pavements. The assumed condition of the rigid pavement at the end of the design life was the most influential factor, with a 60-year service life resulting in the rigid pavements having a lower whole of life cost than the flexible pavements, but assuming a requirement for expedient rigid pavement reconstruction resulted in the rigid pavements costing approximately 4–6 times the cost of the flexible pavements over the 40-year analysis period.

III. CONCLUSION

This research is solely discussed in terms of a literature review. The study's findings suggest that the cost of road construction consists of design expenses, material extraction, construction equipment, maintenance and rehabilitation strategies, and operations over the entire service life. The application of sensitivity analysis on a developed flexible pavement life cycle cost model using a varying discount rate led to these findings. It differentiates between rigid pavement and flexible pavement and provides information about which pavement is more economical and cost-effective. This will be done with the help of the NPV method of life cycle costing. In this method, both initial investment costs and maintenance costs will be taken into consideration. With the help of LCC, alternative pavement designs can be selected. This will reduce the cost and provide ample serviceability over the design life of the roads.

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