Life Cycle Cost Analysis About Geotextiles Used In Flexible Pavement

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Abstract-*Using geo-textiles in secondary roads to stabilize weak sub-grades has been a well accepted practice over the past thirty years. However, from an economical point of view, a complete life cycle cost analysis (LCCA), which includes not only costs to agencies but also costs to users, is urgently needed to assess the benefits of using geo-textile in secondary road flexible pavement. Two design methods were used to quantify the improvements of using geo-textiles in pavements. One was developed at Virginia Tech by Al-Qadi in 1997, and the other was developed at Montana State University by Perkins in 2001. In this study, a comprehensive life cycle cost analysis framework was developed and used to quantify the initial and the future cost of 25 representative low volume road design alternatives. A 50 year analysis cycle was used to compute the cost-effectiveness ratio when geo-textile is used for the design methods. The effects of three flexible pavement design parameters were evaluated.*

Keywords-lifecyclecostanalysis, geotextiles,low, low volume roads.

I. INTRODUCTION

Geo-textiles were one of the first textile products in human history. Excavations of Ancient Egyptian sites show the use of mats made of grass and linen. Geo-textiles were used in roadway construction in the days of the Pharaohs to stabilize roadways and their edges. These early Geo-textiles were made of natural fibers, fabrics or vegetation mixed with soil to improve road quality, particularly when roads were made on unstable soil. Only recently have Geotextiles been used and evaluated for modern road construction. Geo-textiles today are highly developed products that must comply with numerous standards. To produce tailor-made industrial fabrics, appropriate machinery is needed. Geo-textiles have been used very successfully in road construction for over 30 years. Their primary function is to separate the sub base from the sub grade resulting in stronger road construction. The Geo-textiles perform this function by providing a dense mass of fibers at the interface of the two layers. Geo-textiles have proven to be among the most versatile and cost-effective ground modification materials.

1.1 PROBLEM STATEMENT: Geo-textiles have been used in pavements to either extend the service life of the pavement or to reduce the total thickness of the pavement system. The economic benefits of using this material are not well documented. Only initial cost is usually reported. A study considering the LCCA of geo-synthetically stabilized pavements, including initial construction, future maintenance, rehabilitation, and user costs, is needed.

II.METHODOLOGY

2.1..LIFE CYCLE COST ANALYSIS:

In the National Council of Highway Research Programs (NCHRP) Synthesis of Highway Practice, Peterson (1985) defined LCCA as follows: To evaluate the economics of a paving project, an analysis should be made of potential design alternatives, each capable of providing the required performance. If all other things are equal, the alternative that is the least expensive over time should be selected. According to FHWA recommendations, an analysis period of at least 35 years should be used. The different economic indicators commonly used in the LCCA procedure are present worth (PW), method (of benefits, costs, benefits and costs-NPV),equivalent uniform annual cost (EUAC), internal rate of return (IRR), and the benefit cost ratio (BCR). Therefore, LCCA can be perceived as an analysis technique used to evaluate the overall long-term economic efficiency of different alternative investment options. This is a decision support tool that helps to choose a cost effective alternative from several competitive alternatives. It includes all current and future costs associated with investment alternatives (NCHRP, 1985). The different steps involved in a LCCA are described as follows (FHWA, 2002; Hass et al., 1993; Hicks and Epps, 2002): Develop alternative pavement design strategies and relevant activities: This step is to assume the type of pavement and its related rehabilitation and maintenance strategies for the analysis period. Each type of pavement has its own specific service life (Figure 1).

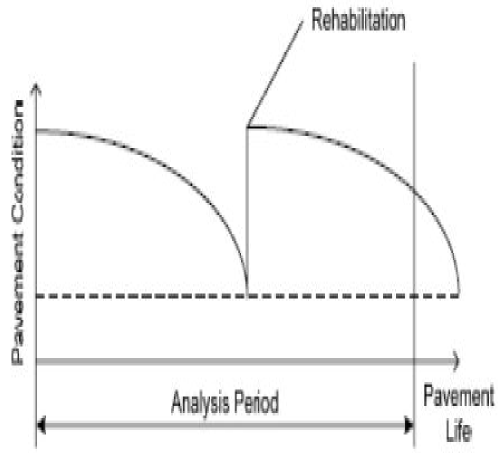

Fig.1.Life cycle analysis

2.3. PAVEMENT STRUCTURE CONSIDERATIONS:

Life Cycle Cost Analysis can be used to determine the relationship between performance and cost when Geotextiles are incorporated in pavements. The AASHTO 1993 Pavement Design Guidelines were used in this study. Pavement reliability is considered as 70%, and the standard deviation is considered as 0.49 (secondary road). Table shows the matrix of possible secondary road pavement design combinations based on four different HMA thickness (50, 75, 100, and 125mm), four different granular base thicknesses (100, 150, 200, and 250 mm), and four different sub-grade strengths (CBR=0.5, 2, 6 and 8%). The design layer coefficient was considered as 0.44 for the HMA layer and the drainage coefficient as 1.0. Using a combination of the aforementioned pavement composition and characteristics, there are 64 design combinations; however, only a fraction of these combinations are considered to be realistic and somewhat representative of secondary road traffic conditions

2.3. PAVEMENT PERFORMANCE PREDICTION:

The evaluation of pavement performance is a crucial step in the life cycle cost framework. The ability to predict the remaining life or the distress levels of a pavement section allows engineers, planners, and highway agencies to plan ahead for maintenance and rehabilitation activities, budget for future expenditures, and makes decisions about the timing ofthose rehabilitation activities. With ample time to plan, state transportation agencies can minimize their costs as well as minimize the impact of their construction activities on the traveling public and others affected by such construction. Therefore, the first step in the life cycle cost framework is to evaluate a pavement design and the conditions under which it isexpected to operate throughout its design life or its analysis period. The framework presented in Figure 2. shows the steps required to prepare an analysis for the life cycle cost procedure. The general inputs relating to the project as a whole, independent of pavement type must be defined prior to identifying pavement design alternatives. These inputs include such conditions as predicted traffic patterns, pavement loading, and economic variables.

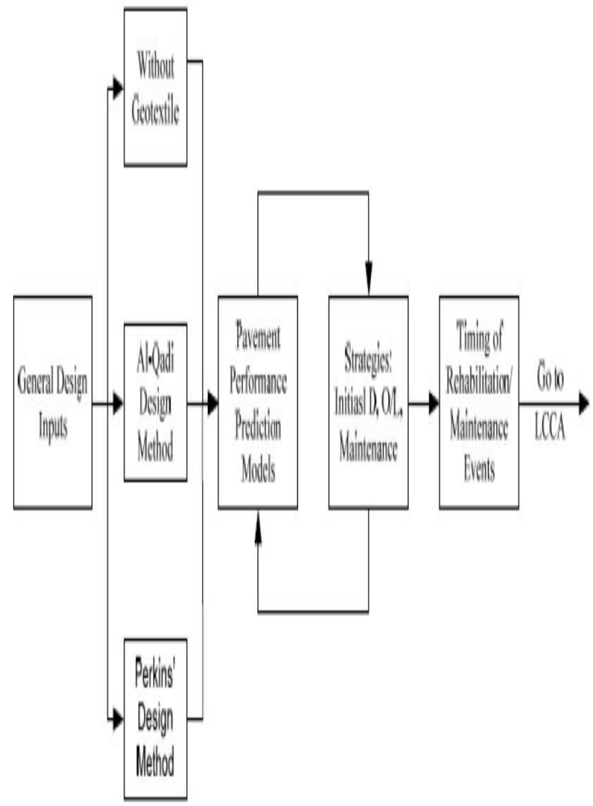

Fig.2. steps required to prepare an analysis for the life cycle cost

III.LIFE COST ANALYSIS AND RESULTS

The service lives of the representative pavements were compared using the AASHTO pavement design equation. Table 1.lists the service life predictions of the pavements without Geotextiles and the pavements with Geotextiles for all 25 pavement cases considered in the study.

Table.1. Service Life Estimates for the 25 Representative Pavement Designs

Representative Design	Pavement without Geotextile (year)	Pavement with Geotextile (year)	
		Al-Qadi Design Method	Perkins' Design Method
1	20, 30, 37 42, 46, 50	32, 44, 50	22, 32, 39, 44, 48, 50
2	20, 30, 37 42, 46, 50	32, 44, 50	27, 38, 46, 50
3	20, 30, 37 42, 46, 50	32, 44, 50	23, 34, 41, 46, 50
4	20, 30, 37 42, 46, 50	32, 44, 50	39, 50
5	20, 30, 37 42, 46, 50	33, 45, 50	27, 38, 46, 50
6	20, 30, 37 42, 46, 50	34, 46, 50	23, 34, 41, 46, 50
7	20, 30, 37 42, 46, 50	32, 44, 50	39, 50
8	20, 30, 37 42, 46, 50	34, 46, 50	27, 38, 46, 50
9	20, 30, 37 42, 46, 50	34, 47, 50	23, 34, 41, 46, 50
10	20, 30, 37 42, 46, 50	33, 45, 50	26, 37, 44, 50
11	20, 30, 37 42, 46, 50	34, 46, 50	22, 32, 39, 44, 48, 50
12	20, 30, 37 42, 46, 50	32, 44, 50	37, 50,
13	20, 30, 37 42, 46, 50	34, 46, 50	26, 37, 44, 50
14	20, 30, 37 42, 46, 50	34, 47, 50	22, 32, 39, 44, 48, 50
15	20, 30, 37 42, 46, 50	33, 45, 50,	37, 50
16	20, 30, 37 42, 46, 50	34, 46, 50	26, 37, 44, 50
17	20, 30, 37 42, 46, 50	33, 46, 50	37, 50
18	20, 30, 37 42, 46, 50	33, 45, 50	34, 46, 50
19	20, 30, 37 42, 46, 50	34, 46, 50	24, 35, 42, 48, 50
20	20, 30, 37 42, 46, 50	33, 45, 50	34 ,46, 50
21	20, 30, 37 42, 46, 50	34, 46, 50	34, 46, 50
22	20, 30, 37 42, 46, 50	34, 47, 50	34, 46, 50
23	20, 30, 37 42, 46, 50	34, 46, 50	31, 43, 50
24	20, 30, 37 42, 46, 50	32, 44, 50	50
25	20, 30, 37 42, 46, 50	32, 44, 50	50

The purpose of this study is to compare the service life among the pavements with or Without geotextiles instead of comparing different pavement design methods. The service life predictions of the pavements without geotextiles are all the same because the input traffic volume used corresponds to its design traffic Therefore, the service life of the pavements with Geotextiles are presented

3.1. TOTAL COST:

Using the aforementioned information, the total life cycle cost for the 25representativedesign alternatives is calculated and the results are shown , It is worthwhile to notice that when only agency costs are included in the LCC analysis, the difference among the three design methods is not obvious. However, when the user costs are taken into consideration, the three design methods are clearly distinguished from one another. Al-Qadi’s design method suggests that when a geotextiles is placed in a pavement as a separator, the range of the total pavement life cycle cost savings can be as high as 70% to as low as 40%. This depends on the selected design alternative. When Perkins’ design method is used, the suggested total pavement life cycle cost savings varies from no savings to 70% savings compared to the AASHTO’s design method.

IV. CONCLUSIONS

Based on the information evaluated and the inputs established for the LCCA over the 50 year analysis period, the following conclusions are made: For agency costs, Al-Qadi’s design method suggests that there is a 20% reduction among the 25Preventative pavement design alternatives, and Perkins’s design method gives from no cost reduction to a 40% cost reduction.

For user costs, Al-Qadi’s design method suggests a 70% cost reduction among the 25 representative pavement design alternatives. Perkins’ design method gives from almost no cost reduction to a 100% cost reduction. The cost effectiveness ratio from the two design methods shows that the lowest cost effectiveness ratio using Al-Qadi’s design method is 1.7 and the highest is 3.2. The average is 2.6. For Perkins’ design method, the lowest value is 1.01 and the highest value is 5.7. The average is 2.1.

REFERENCES

[1] American Association of State Highway and Transportation Officials AASHTO. Guide for Design of Pavement Structures. AASHTO, Washington, DC, 1993.

[2] American Association of State Highway and Transportation Officials AASHTO. Guide for Design of Pavement Structures. AASHTO, Washington, DC, 1986.

[3] Al-Qadi, I. L... The Proper Use of Geosynthetics in Flexible Pavements. 7th International Conference on Geosynthetics, Ph. Delmas and P. G. Grous, Eds., Nice France, Sep 22- 27, 2002, pp. 907-912

[4] Al-Qadi, I. L. and S. A. Bhutta. Designing Low Volume Roads with Geosynthetics. In Transportation Research Record: Journal of the Transportation Research Board, No. 1652, TRB,National Research Council, Washington, DC, 1999, pp. 206-216.

[5] Al-Qadi, I. L., B. J. Coree, I. L. Brandon, S. A. Bhutta, and A. K. Appea. Quantifying the Separation Characteristics of Geosynthetics in Flexible Pavement. Sixth International Conference on Geosynthetics, Atlanta, GA, Mar 25-29, 1998, pp. 945-950.

[6] Al-Qadi, I., T. I. Brandon, and S. A. Bhutta. Geosynthetics Stabilized Flexible Pavements. Proceedings of Geosynthetics '97, Long Beach, CA, Mar 10-13, 1997, pp. 647-661.

[7] Al-Qadi, I. L., T. L. Brandon, R. J. Valentine, and T. E. Smith. Laboratory Evaluation of Geosynthetics Reinforced Pavement Sections, In Transportation Research Record: Journal of the Transportation Research Board, No. 1439, TRB, National Research Council, Washington, DC, 1994, pp. 25-31.

[8] Austin, D. N., and D. M. Coleman. A Field Evaluation of Geosynthetics-Reinforced Haul Roads over Soft Foundation Soils. Proceedings of Geosynthetics Conference, Vancouver, BC, Canada. March 30- April 1, 1993, pp. 65-80.

[9] Barksdale, R. D., S. F. Brown, and C. Francis. Potential Benefits of Geosynthetics in Flexible Pavement Systems. National Cooperative Highway Research Program, Report No. 315,Transportation Research Board, Washington, DC, 1989.