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Analytical Study of Geotextiles in Flexible Pavements : Life-Cycle Cost

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ABSTRACT

In this paper, we using geotextiles in secondary roads to stabilize weak subgrades. However, from an economical point of view, a complete life cycle cost analysis, which includes not only costs to agencies but also costs to users, is urgently needed to assess the benefits of using geotextile in secondary road flexible pavement.

Keywords: Geotextiles, Pavement, TBR.

INTRODUCTION

The study concludes that 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. The study also shows when user costs are considered, the greater Traffic Benefit Ratio (TBR) value may not result in the most effective life-cycle cost. Hence, for an optimum secondary road flexible pavement design with geotextile incorporated in the system, a life cycle cost analysis that includes user cost must be performed. This is justification of the study.

Two design methods were used to quantify the improvements of using geotextiles 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 geotextile is used for the design methods. The effects of three flexible pavement design parameters were evaluated; and their impact on the results was investigated.

SERVICE LIFE COMPARISON

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.

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. Table 5.1 using Al-Qadi's design method and Perkin's design method. As expected, the service life extension based in Al-Qadi's design model gives more uniform results compared to Perkins' design method. This is because the TBR values obtained from Al-Qadi's design method are between 2.1 and 2.6.

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	Perkin's 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

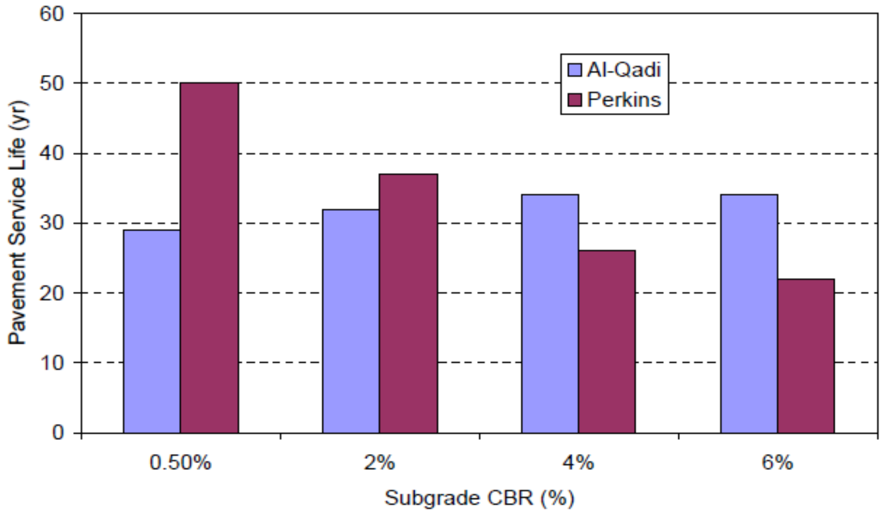

Figure 1: Service Life Comparison among Different Subgrade Stengths

COST-EFFECTIVENESS RATIO

Another parameter usually used in LCCA is comparing the cost-effectiveness of selected design alternatives. First, the effectiveness of the representative pavement alternatives of different design methods is evaluated by calculating the area under the present service index (PSI) versus the time (t) curve. The cost-effectiveness is then obtained by taking the ratio of the effectiveness and total pavement life cycle costs for the selected pavement alternative. Once the cost-effectiveness is obtained, the cost effectiveness ratio can be calculated by comparing the cost-effectiveness value of one design method to another design method. In this study, the design methods of Al-Qadi and of Perkins are compared to the AASHTO design method to acquire the cost effectiveness ratio of the first two design methods.

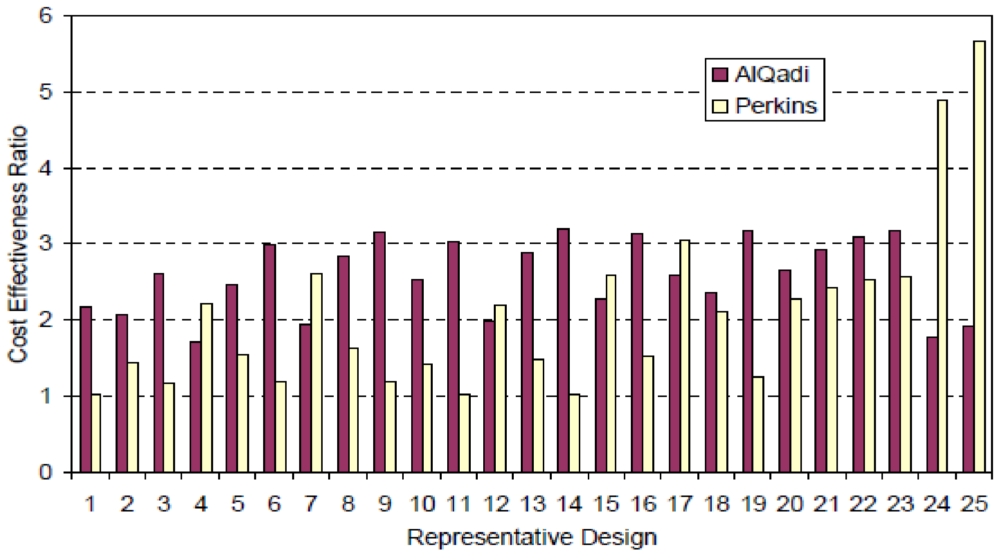

Figure 2: Cost-Effectiveness Ratio of Adopting Al-Qadi's and Perkin's Design Methods

RESULTS AND DISCUSSION

However, the TBR obtained from Perkins' prediction model are varied from 1.1 up to 8.34. Besides, although the improvement values from the two design models are greater than one, this does not mean the pavement can actually extend its service life by simply multiplying the obtained TBR value by the original service life.

The improvement obtained here is improvement in the pavement's allowable ESALs rather than pavement service life. For example, the 13th representative design, which considers a pavement with a 75mm thick HMA layer, a 150mm thick granular base layer and a subgrade at a CBR of 4%, has a TBR of 2.44 from Al-Qadi's design model and a TBR of 1.45 from Perkin's design model, respectively. The effect of subgrade CBR on pavement service life is also compared.

CONCLUSION

As shown in the Figure 1, pavement service life decreases with increasing subgrade strength when Perkin's design model is used and increases slightly when Al-Qadi's design method is used. Perkin's design method gives very high a TBR value when the subgrade is weak. In this instance, with subgrade CBR at 0.5%, the model gives TBR values of 19. This means that when geotextiles are used in the pavement, then the allowable ESALs can increase to 19 times the original design ESALs which is unrealistic.

The result of the cost-effectiveness ratio of the two design methods is shown in Figure 2. Therefore, if a design method shows a higher cost-effectiveness ratio, this means that the design method suggests that such a pavement design alternative is better. If the result is less than unity, this means that the design method suggests that incorporating geotextiles into the pavement is worse than not incorporating geotextiles into the pavement. If the value is equal to one, it means the pavement does not get any benefit from having geotextiles incorporated. If the value is greater than one, it means the pavement benefits from having geotextiles added. Therefore, the higher the value, the greater the benefit. From the figure, 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 Perkin's design method, the lowest value is 1.01 and the highest value is 5.7. The average is 2.1.

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