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Economic Evaluation of Road Pavement Maintenance Options Using the Real Cost Software (Case study: Semnan-Firoozkooh Road in Iran)

GholamAli Shafabakhsh[1*] and Saber Kie Badroodi[2]

1- Associate Professor, Faculty of Civil Engineering, Semnan University, Semnan, Iran
2- Graduate Student, Faculty of Civil Engineering, Semnan University, Semnan, Iran

***Corresponding author*:** GholamAli Shafabakhsh

ABSTRACT: Roads are considered as the national capital of every countries and a large part of the development budget is spend for maintenance and improvements of roads. Therefore, it is necessary to use a management and maintenance system as a tool for decision making and optimizing the maintenance costs. In this article, one of the most used software for management and maintenance of roads, called Real Cost is introduced. The Semnan-Firoozkooh road was considered as a case study to further understand the real situation compared with theoretical conditions. First, the required input data were collected. Then, the software determined the most cost-effective alternative for pavement maintenance for both users and employer regarding the net present value (NPV).

***Keywords*:** Semnan-Firoozkooh Road, Real Cost Software, Pavement Maintenance Options, the Net Present Value, Maintenance.

INTRODUCTION

In the past, only pavement maintenance had received much attention and pavement management was an unknown issue. The decisive factor in choosing an appropriate method of maintenance was the engineers' experience, while little attention had been paid to life cycle costs or necessity-based prioritization on the roads network level. In today's economy, as the existing pavement life goes on, a need for a systematic approach for determining the maintenance necessities will feel more (Shahin, 2006). The bottlenecks and low quality services in other modes of transportation of goods and passengers as well as the use of personal vehicles due to the relative more well-being in trips have increased the public demand for road use. Accordingly, the share of transport of goods and passengers by roads relative to the entire transport in Iran have been 80% and 90%, respectively. This indicates the importance and special role of roads in the current life of community economy (Zakeri, 2008).

After extensive investigations, Higz, Ran and Moltra concluded that if road is designed and implemented properly, then after 16 years of the pavement life, its quality will be reduced only about 40%. However, pavement degradation is accelerated after 16 years, so that after another four years at the end of the project, the pavement will completely collapse (Hicks et al, 1997). One of the problems with road maintenance management system is the lack of experts to understand and report on the overall condition of the pavement. Many of planes and procedure proposed for the pavement evaluation require special technical knowledge in this field. Therefore, it is not easy for everyone to use those methods. Establishment of a road assessment system regarding the various alternatives at the project level can largely solve this problem. The system developed by Ritchie, Mahoney and Jackson, takes information from the users by a continuous and stepwise Q & A procedure and provides a simple answer for problem (Ritchi et al., 1987).

The present paper aims to examine various maintenance alternatives by introducing one of the most used software for management and maintenance of roads, called Real Cost. Furthermore, the Semnan-Firoozkooh road

will be considered a case study to further understand the real situation compared to theoretical conditions. This study provides a suitable bed for violating some experiences that have no scientific basis and sometimes may lead to wrong decisions. Furthermore, this can promote the use of scientific-based software used in most advanced countries in the world.

Introduction to Real Cost

Real Cost is a macro in Microsoft Excel developed by the Federal Highway Administration (FHWA) of the United States. The California Department of Transportation employee use the Real Cost as an administrative software to estimate the costs affecting pavement design alternatives for a new or an existing road using basic preventative maintenance, improvement and rebuilding (Life-cycle Cost Analysis Procedures Manual, 2007).

Inputs

Analysis Options

Table 1 shows the existing information of the Semnan-Firoozkooh road in Iran.

Table1. Analysis options

Include User Costs in Analysis	yes
Include User Cost Remaining Life Value	yes
Use Differential User Costs	yes
User Cost Computation Method	calculate
Include Agency Cost Remaining Life Value	yes
Traffic Direction	both
Analysis Period (Years)	15
Beginning of Analysis Period	2012
Discount Rate (%)	0
Number of Alternatives	6

The Time Value of User

The time value of users to enter the estimated costs is calculated based on an hour of the user time. The users' time value can be different for different types of vehicles. To calculate the users' costs for delays in the work zone, the default values are entered assuming the exchange rate of 35,000 Rials/1$ (Life-cycle Cost Analysis Procedures Manual, 2007):

- For private cars per hour =10.46 $ or 36,610 Rials
- For single-unit trucks= 27.83$ or 97,450 Rials
- For multi-unit trucks= 27.83$ or 97,450 Rials
-

Traffic Inputs

The following table shows traffic inputs obtained from the National Highway Administration of Iran.

Table 2. Traffic Data

AADT Construction Year (total for both directions)	26627
Cars as Percentage of AADT (%)	100
Single Unit Trucks as Percentage of AADT (%)	7.2
Combination Trucks as Percentage of AADT (%)	13.3
Annual Growth Rate of Traffic (%)	12
Speed Limit Under Normal Operating Conditions (mph)	56
No of Lanes in Each Direction During Normal Conditions	2
Free Flow Capacity (vphpl)	2170
Rural or Urban Hourly Traffic Distribution	Rural
Queue Dissipation Capacity (vphpl)	1376
Maximum AADT (total for both directions)	65774
Maximum Queue Length (miles)	11.27

Table3. Traffic Hourly Distribution

Hour	Rural	Urban	Inbound - Rural	Inbound - Urban	Outbound - Rural	Outbound - Urban
0 - 1	1.85	1.85	48.0	47.2	52.0	52.8
1 - 2	1.30	1.30	48.0	48.1	52.0	51.9
2 - 3	0.60	0.60	45.0	46.3	55.0	53.7
3 - 4	0.78	0.78	53.0	43.4	47.0	56.6
4 - 5	0.81	0.81	53.0	44.2	47.0	55.9
5 - 6	1.23	1.23	53.0	45.1	47.0	54.9
6 - 7	3.92	3.92	57.0	47.1	43.0	52.9
7 - 8	4.28	4.28	56.0	50.3	44.0	49.7
8 - 9	6.34	6.34	56.0	50.2	44.0	49.8
9 - 10	7.78	7.78	54.0	53.1	46.0	46.9
10 - 11	4.44	4.44	51.0	51.5	49.0	48.5
11 - 12	7.87	7.87	51.0	54.6	49.0	45.5
12 - 13	5.75	5.75	50.0	52.3	50.0	47.7
13 - 14	4.44	4.44	52.0	53.5	48.0	46.5
14 - 15	6.32	6.32	51.0	52.5	49.0	47.5
15 - 16	4.12	4.12	53.0	53.2	47.0	46.8
16 - 17	6.32	6.32	49.0	49.5	51.0	50.5
17 - 18	6.89	6.89	43.0	50.0	57.0	50.0
18 - 19	5.68	5.68	47.0	49.5	53.0	50.5
19 - 20	6.65	6.65	47.0	49.0	53.0	51.0
20 - 21	3.31	3.31	46.0	46.9	54.0	53.1
21 - 22	3.98	3.98	48.0	43.7	52.0	56.4
22 - 23	3.11	3.11	48.0	46.9	52.0	53.2
23 - 24	2.23	2.23	47.0	48.5	53.0	51.5
Total	100.00	100.00				

Time and Extra Cost of Vehicles

Like the users' time value, to obtain the operating cost of a vehicle, the traffic weighted average for three classes of vehicles will be determined. The following procedure is employed to calculate the time and extra cost of vehicles. The operation costs for each vehicle class is multiplied with the lost time for 1000 stop at different initial speeds. The required values have been provided by Winfrey (Winfrey, 1969). The operating cost of a vehicle per 1,000 stop is obtained at different initial speeds. Then, the values are entered the software (Table 4). Real Cost calculates the operating cost of a vehicle for speed changes in the work zone.

Table 4. Added Time and Vehicle Stopping Costs

Initial Speed (mph)	Added Time (Hr/1000 Stops)			Added Cost (Rial/1000 Stops)		
	Pass Cars	Single Unit Truck	Combo Truck	Pass Cars	Single Unit Truck	Combo Truck
-	-	-	-	-	-	-
8.05	1.02	0.73	1.10	2.70	9.25	33.62
16.09	1.51	1.47	2.27	8.83	20.72	77.49
24.14	2.00	2.20	3.48	15.16	33.89	129.97
32.19	2.49	2.93	4.76	21.74	48.40	190.06
40.23	2.98	3.67	6.10	28.67	63.97	256.54
48.28	3.46	4.40	7.56	36.10	80.23	328.21
56.33	3.94	5.13	9.19	44.06	96.88	403.84
64.37	4.42	5.87	11.09	52.70	113.97	482.21
72.42	4.90	6.60	13.39	62.07	130.08	562.14
80.47	5.37	7.33	16.37	72.31	145.96	642.41
88.51	5.84	8.07	20.72	83.47	160.89	721.77
96.56	6.31	8.80	27.94	95.70	178.98	798.99
104.61	6.78	9.53	31.61	109.02	195.84	849.64
112.65	7.25	10.27	39.48	123.61	209.06	921.03
120.70	7.71	11.00	47.90	139.53	224.87	992.42
128.75	8.17	11.73	57.68	156.85	240.68	1,063.82
Idling Cost ($/Veh-Hr.)				0.69	0.77	0.82

Maintenance Options

One of the key steps in the analysis is specifying the methods for maintenance and improvement of the roads network. Several alternatives are defined for each segment of the road network. The first alternative is commonly known as a base option which includes regular maintenance, while it does not put any additional operations. For defining other alternatives, the maintenance engineer should specify the possible alternatives among the

appropriate options to allocate them to a certain road. Real Cost is not an administrator for the maintenance system, but its role is to support decision making. This means that when an administrator has several decision alternatives and the long term differences of options is not obvious for him/her, the Real Cost, with the help of prediction sub-models says the maintenance engineer that choosing any alternative will associated with which profits and losses.

Table 5 shows the proposed alternatives introduced to the software along with their prices according to the prices existing in Iran.

Table5. Alternatives (David, 2000)

Alternatives	Type of	Effective year	Price)Rial(
Base Alternative	Patching	2012	351750
	Joints Making	2012	53900
2 Alternative	Slurry coating	2012	73500
	rejuvenation	2012	113750
3 Alternative	Patching	2012	351750
	Joints Making	2012	53900
	5 cm asphalt coating	2012	361600
4 Alternative	Slurry coating	2012	73500
	rejuvenation	2012	113750
	5 cm asphalt coating	2012	261600
5 Alternative	Patching	2012	351750
	Joints Making	2012	53900
	Reconstruction(5 cm asphalt coating)	2012	1050000
6 Alternative	5 cm asphalt coating	2012	261600

Results and Outputs of Real Cost

Alternative 6 is associated with the lowest cost to users due to lower maintenance options, thereby it does not take much time. Alternative 2 has the lowest cost to the employer, because it is a preventive maintenance alternative. The Alternative 3 is associated the most costs to users (slurry coating and rejuvenation). This is because of the number of improvement operations during the analysis period. While Alternative 3includes five improvement operations during the period of analysis, the Alternative 6 has only one improvement operation. Accordingly, the Alternative 6 is the most economic alternative in terms of users' costs. The Alternative 5, a corrective maintenance alternative, is associated with the largest costs to employer(slurry plating, rejuvenation, 5 cm coating). The Alternative 2, a preventive maintenance alternative, is the most cost-effective option in terms of employer costs (slurry coating, rejuvenation).(Figures 1 and 2)

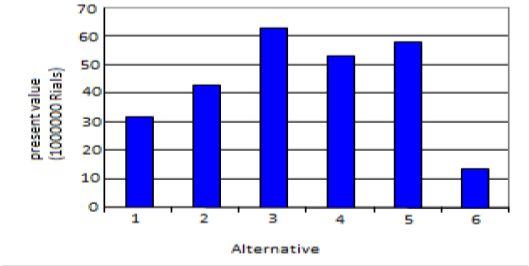

Figure 1. User Cost

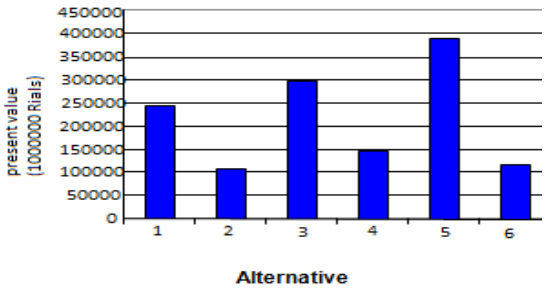

Figure 2. Agency Cost

Furthermore, as shown in Figure3, the users' costs during the analysis period will further increase due to the growing traffic for each improvement operation.

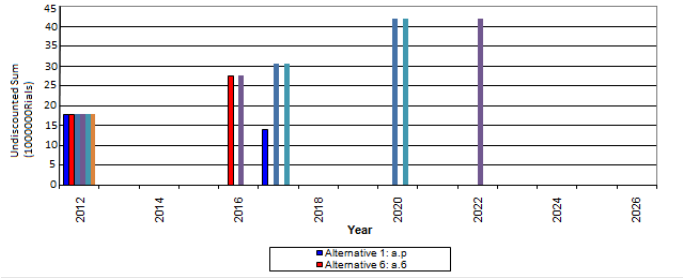

Figure 3. Expenditure Stream: User Cost

Figure 4 shows that the employer costs will increase in 2020, due to need for implementing a 5 cm pavement which is a corrective action.

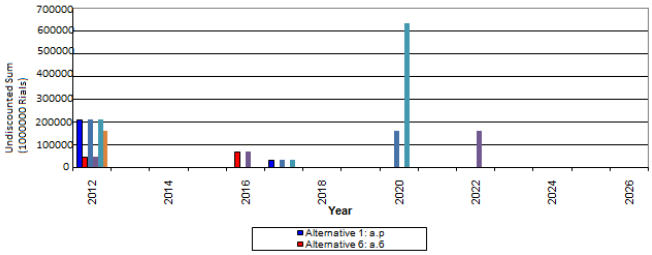

Figure 4. Expenditure Stream: Agency Cost

CONCULSION

According to the results of the present study, the Alternative 6 (a 5 cm asphalt coating) is recommended as the most cost-effective option among other alternatives, because its results provide a better balance of user and employer costs. But in countries like Iran, the employer costs are more important, so the Alternative 2 (slurry coating, rejuvenation) can also be an appropriate option.

REFERENCES

David C. 2000. The Highway Development and Management, volume three Software User Guide.

Hicks RG, Dunn K and Moulthrop JS. 1997. Framework for selecting Effective Preventive Maintenance Treatments for Flexible Pavements, Transportation Research Report .

Life-cycle Cost Analysis Procedures Manual. 2007. State of California Department of Transportation, Pavement Standards Team & Division of Design.

Ritchi S, Yeh C, Mahoney JP and Jackson NC. 1987. Surface condition expert system for pavement Rehabilitation, ASCE Journal of Transportation Engineering, Vol. 113, No.2.

Shahin M Y. 2006. Pavement Management for Airports Roads and Parking Lots. New York, springer.

Winfrey R. 1969. Economic Analysis for Highways, International Textbook Company.

Zakeri H. 2008. Presentation of Solutions for Improving Road Maintenance Management and Financing in Iran. International Seminar on Road Maintenance Management Techniques and Financing methods, Ouagadougou (BURKINA FASO).