International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 08, August-2015

An Evaluation of Life Cycle Cost Analysis of Airport Pavement

Anik Das
Lecturer,
Department of Civil Engineering
University of Information Technology and Sciences (UITS)
Dhaka, Bangladesh

Md. Nasim Khan
Lecturer,
Department of Civil Engineering
University of Information Technology and Sciences (UITS)
Dhaka, Bangladesh

Saurav Barua
Lecturer,
Department of Civil Engineering
University of Information Technology and Sciences (UITS)
Dhaka, Bangladesh

Md. Mizanur Rahman, PhD
Professor,
Department of Civil Engineering
Bangladesh University of Engineering and Technology (BUET)
Dhaka, Bangladesh

***Abstract*— A runway pavement is considered as one of the central facilities in an airport. Ensuring safety for aircraft operations and providing adequate comfort to the passenger are the major features while budgeting the construction cost of a pavement. The target of this research is to render a life cycle cost analysis (LCCA) approach for newly designed runway pavements to select the most cost effective pavement. Some particular groups of aircraft traffic from the website of Hazrat Shahjalal International Airport in a particular day were taken for the analysis. A flexible and a rigid runway pavement were designed considering annual departures and growth rate for the respective aircrafts by using FAARFIELD software. The thickness of flexible and rigid pavement was found about 37 inch and 31.5 inch respectively. As per FAA standard, an analysis period of 20 years was selected. The costs for the both pavements were evaluated for this analysis period by an excel spreadsheet. Initial costs and maintenance costs were incorporated and the result was checked by the FAA method of economic analysis with a recommended discount rate. Comparative results showed that initial construction costs of concrete pavement was higher (about 21%) than the asphalt pavement. However, total life cycle cost of concrete pavements served much lower than that of asphalt pavement at the end of the design period including maintenance and rehabilitation costs in it. In this case, around 4% of costs would be saved if rigid pavement was used instead of flexible pavement.**

Keywords*— *Runway pavement, FAA, FAARFIELD, Rigid pavement, Life cycle cost analysis

I. Introduction

The installation of pavements in airport that can affirm their total predicted load applications over a 20-year design life is the requirement of FAA in Advisory Circular 150/5320-6E. Sometimes, the main consideration is only focused to the initial construction cost and the maintenance and rehabilitation costs sometimes not to take as a consideration. Life cycle cost analysis (LCCA) is a necessary economic evaluation tools for providing necessary guidance to choose the most cost effective alternative decisions of many transportation officials. The final outcomes of LCCA approach is the choice of one alternative to another as well as the choice of most cost effective solution for a particular situation. Now a days, LCCA is being used as a decision making tool when selecting a pavement type and is also used to measure different maintenance and rehabilitation strategies within the same pavement type. The intent of this paper is to explore the application of LCCA in pavement type selection and developing a comparative relationship of runway pavements (flexible and rigid) with comparative costs that influence the analysis procedure for selection of the pavement types.

II. LITERATURE REVIEW

After the introduction of the concept of LCCA methodology for the design and selection of pavement type in 1960s, the principles have been progressed by the various agencies and officials. The concept of life cycle cost along with different other costs should be considered in the analysis life cycle cost was recommended by the AASHTO Pavement Design Guide in 1972 [1]. The application of the life cycle cost concept and detailed discussions about the various costs that should be regarded in LCCA was encouraged by the AASHTO Pavement Design Guide 1993 [2]. To demonstrate the application of LCCA concept in pavement investment decisions, FHWA in 1994 stated that 28 out of 38 states responded [3]. RealCost, a Microsoft Excel based deterministic and probabilistic LCCA program was developed by FHWA in 2004 to perform the LCCA operations. [4].

III. FAARFIELD

FAARFIELD stands for Federal Aviation Administration Rigid and Flexible Iterative Elastic Layered Design is an airport pavement thickness design software program. The software was developed by FAA (Federal Aviation Administration) for designing of new and overlay flexible and rigid pavement. Both layered elastic and threedimensional finite element based design theories are implemented in it. In Advisory Circular (AC) 150/5320-6E “Airport Pavement Design and Evaluation”, it is referenced that FAA developed this computer program for the easement of pavement engineers by implementing the thickness design procedures in it [5]. The internal airplane library of the FAARFIELD consists of six airplane groups: Generic, Airbus, Boeing, Other Commercial, General Aviation, and Military [5]. Also the aircrafts maximum gross weights, landing gear configuration, and contribution to CDF are implemented in it. For a newly pavement design, the number of annual departures are introduced as well as the annual growth that expected in the following years [5]. Finally, the design life of 20 years for any project according to the FAA criteria must be introduced usually [5].

IV. RESEARCH METHODOLOGIES

Airplane were selected from a library and placed in a list of design airplane. For selecting required airplane lists, a comprehensive tabulation of different airlines of Hazrat Shahjalal International Airport had been enlisted for a particular day. Then the forecasting of the annual departures in each airline groups was conducted. Forecasted annual growth factor for Asia region was taken From ICAO Environmental Report 2010 [6]. The value was in the range of 2% to 4%. Table I shows the assumed annual departures of each airline groups.

TABLE I. DETERMINATION OF APPROXIMATE ANNUAL DEPARTURES [7]

Airlines	No. of Departures (Approximate) Per Day	No. of Annual Departures (Approximate)	Airplane Name
United Airways	9	3240	A 310-325, MD 83, A 72-212, Dash 8-100
Turkish Airlines	3	1080	A 340-300, A 330-300, A 330-200, A 321-200, A 320-200, B 777-300 ER, B 737-800, B 737-900 ER
Regent Airways	10	3600	B 737-700, Dash 8
Biman Bangladesh Airlines	10	3600	A 310-300, B 737-800, B 777 ER, B 787-8, DC 10-30
Novoair	4	1440	Jet MB 145 EU
Qatar Airways	2	720	A 330-200 Cargo, A 320-200, A 330-200, A 330-300, A 340-600
Air Arabia	3	1080	A 320
Kingfisher Airlines	2	720	A 320
Eithiad Airways	2	720	A 319-100, A 320-200, A 330-300, A 330-200, A 321-200, A 340-500, A 340-600, B 777-200
Lufthansa	2	720	B 777 Freighter(Cargo)

Both the flexible and rigid pavements were designed by FAARFIELD based on FAA Advisory Circular AC 150/5320-6E [5]. The thickness of flexible and rigid pavement were found 37 inch and 31.5 inch respectively. Layer thicknesses are presented in the following Fig. 1 and Fig. 2.

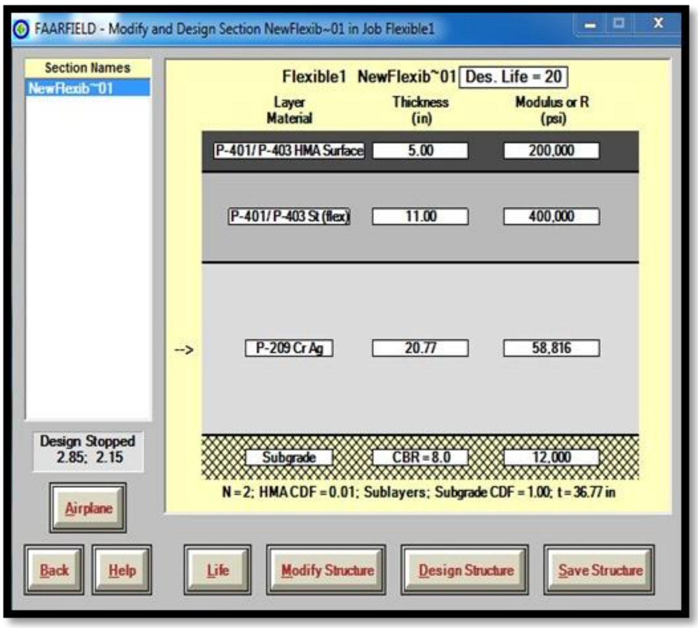

Fig. 1. Final Design Thickness of the Flexible Pavement

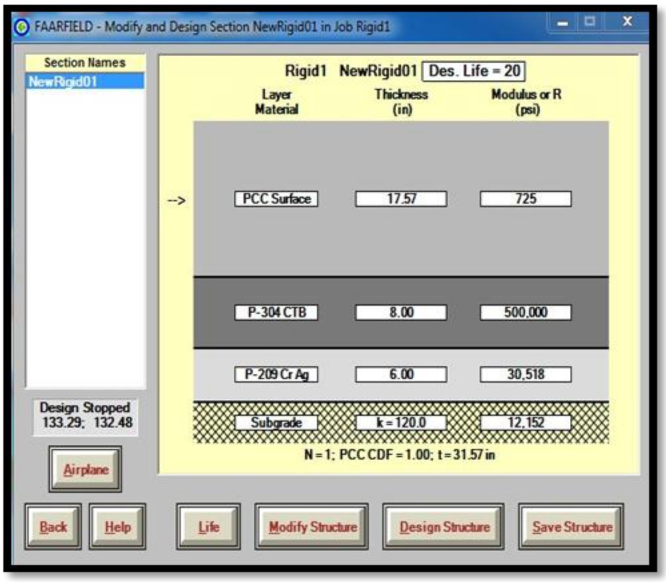

Fig. 2. Final Design Thickness of the Rigid Pavement.

A runway surface area of Hazrat Shahjalal International Airport was considered for the calculation shown in Fig. 3. The runway length was 3200 m and width 46 m.

Fig. 3. Runway Location Map of Hazrat Shahjalal International Airport

V. COST ANALYSIS

We estimated life cycle costs of flexible and rigid pavement considering initial costs and maintenance and rehabilitation costs. Unit prices for each item were taken from Pavinars-Webinars for the Pavement Community, "New developments in airfield pavements", 2013 [8].

1) *Initial Costs*

Thickness related items are calculated in terms of cubic meter and rest of the items are computed through the square meter. The cost calculations of both the pavements are shown in Table II and Table III.

TABLE II. INITIAL COSTS OF FLEXIBLE PAVEMENT

Item/Layer	Cost	
	Per Cubic Meter ($)	Per Square Meter ($)
Subgrade Compaction		$441,600.00
Crushed Aggregate Subbase	$4,271,109.56	
Stabilized Asphalt Base	$7,896,514.56	
Lower Surface Course HMA	$2,691,993.60	
Upper Surface Course HMA	$2,333,061.13	
Prime Coat (1 Layer)		$142,784.00
Tack Coat (4 Layer)		$388,608.00
Inset Light Premium		$471,040.00
Runway Grooving		$294,400.00
Sub Total	$17,192,678.85	$1,738,432.00
Total	$18,931,110.85	

TABLE III. INITIAL COSTS OF RIGID PAVEMENT

Item/Layer	Cost	
	Per Cubic Meter ($)	Per Square Meter ($)
Subgrade Compaction		$441,600.00
Crushed Aggregate Subbase	$1,233,830.40	
Cement Treated Base	$4,187,545.60	
PCC Surface	$16,423,030.40	
Prime Coat (1 Layer)		$142,784.00
PCC Joint Sealing		$2,815.08
Inset Light Premium		$471,040.00
Sub Total	$21,844,406.40	$1,058,239.08
Total	$22,902,645.48	

Initial cost of rigid pavements is about 20.98 % higher than flexible pavement in the following Fig 4.

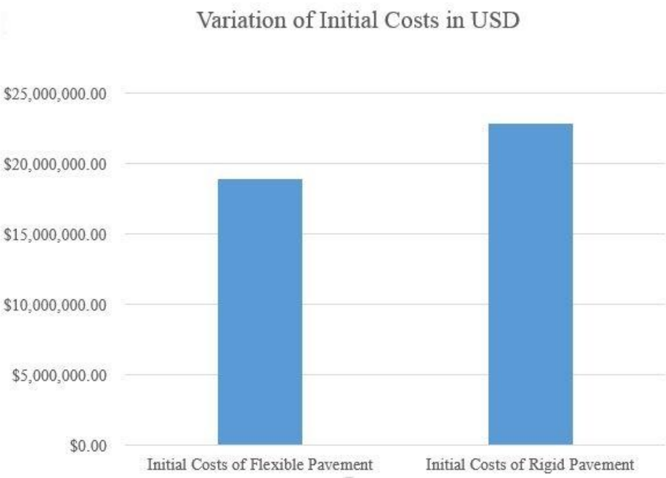

Fig. 4. Variation of Initial Costs between the two Pavements

2) *Maintenance and Rehabilitation Costs*

Calculation of maintenance and rehabilitation costs are derived with the percentage of initial costs required for each year. The results are shown in the Table IV and Table V.

TABLE IV. MAINTENANCE AND REHABILITATION COSTS OF FLEXIBLE PAVEMENT

Year	Description	Cost ($)
1 to 4	Crack Sealing and Patching	$75,724.44
5 to 9	Crack Sealing and Patching	$236,638.89
10 to 14	Crack Sealing and Patching	$378,622.21
15	Mill and Replace 0.05m HMA	$5,549,440.00
16 to 19	Crack Sealing and Patching	$75,724.44
20	Crack Sealing and Patching	$56,793.34
Total		$6,372,943.33

TABLE V. MAINTENANCE AND REHABILITATION COSTS OF RIGID PAVEMENT

Year	Description	Cost ($)
1 to 9	None	$0.00
10 to 14	Crack Sealing and Patching	$343,539.69
15	Slab Replacement	$114,513.23
15 to 19	Crack Sealing and Patching	$515,309.53
20	Slab Replacement	$274,831.75
20	Crack Sealing and Patching	$137,415.88
Total		$1,385,610.05

Maintenance and rehabilitation costs requires for rigid pavement are about 78.26% lower than the asphalt pavement. The main reason behind this lower costs that there are no costs required for the maintenance activities of rigid pavement in first 9 years in this case. The results are almost follow the same pattern for other different data sets. The bar diagram in Fig. 5 shows the variation of the costs.

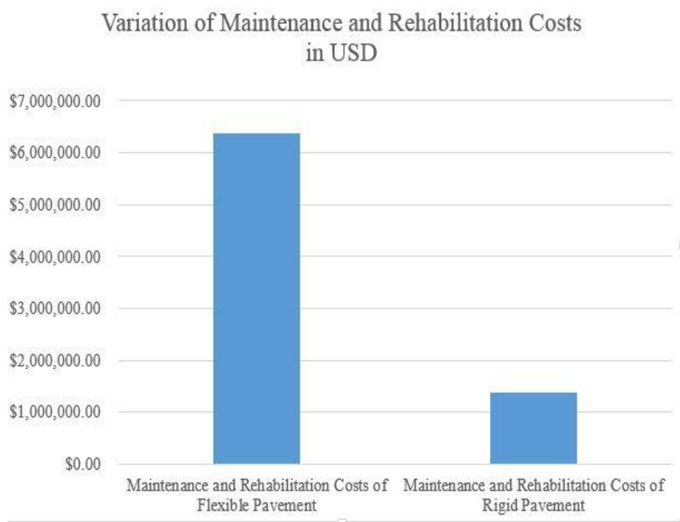

Fig. 5. Variation of Maintenance and Rehabilitation Costs between the Two Pavements

3) *Life Cycle Costs*

Calculation of the life cycle costs involves the summation of the initial, maintenance and rehabilitation costs of both the pavement to make a comparative decision. Rigid pavement serves much lower costs (about 4%) in its whole design life than the flexible pavement. This is shown in the following Fig. 6.

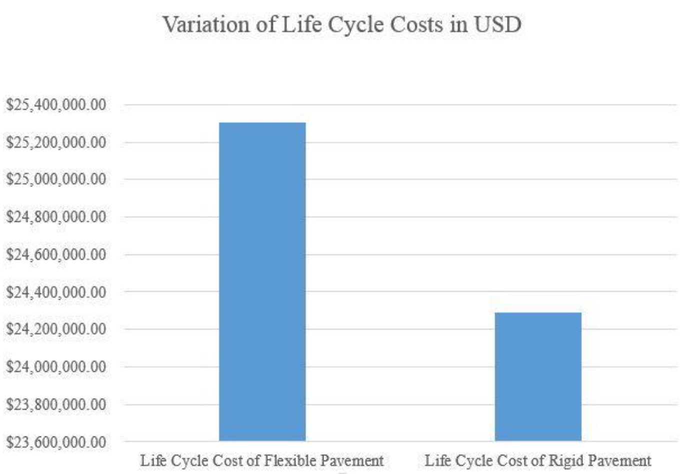

Fig. 6. Variation of Life Cycle Costs between the two Pavements

VI. VERIFICATION OF COST ANALYSIS WITH FAA METHOD

The outcomes of the costs of flexible and rigid pavements are verified by a method provided by FAA procedures. The desired results are found as the rigid pavement serves lower costs (about 4.58%) throughout its design period than flexible pavement. The percentage of the cost efficiency of rigid pavement is almost same as the previous calculations. Despite some variations, this checking ultimately ensures the results and decisions are similar that came from the previous calculations.

CONCLUSIONS

The overall study is made to find an answer of the question and that is which pavement type is the most cost-effective throughout its design life. From this research work, it is found that rigid pavement serves about 4% lower costs than the flexible pavement throughout its design period. Later the results was verified by the FAA method of economic analysis without considering other alternatives and it was observed that rigid pavement serves about 4.58% lesser amount of costs than flexible pavement.

ACKNOWLEDGMENT

We would like to express our earnest and deepest gratitude to Dr. Md. Mizanur Rahman, Professor, Department of Civil Engineering, Bangladesh University of Engineering and Technology for his constant guidance, invaluable supervision and hearty support at every stage of this research work.

REFERENCES

[1] AASHTO, "AASHTO Interim Guide for Design of Pavement Structures", American Association of State Highway and Transportation Officials, Washington, D.C, 1972.

[2] AASHTO, "AASHTO Guide for Design of Pavement Structures", American Association of State Highway and Transportation Officials, Washington, D.C, 1993.

[3] Applied Research Associates, Inc (ARA), "Life Cycle Cost Analysis For Airport Pavement", Final Report, Airfield Asphalt Pavement Technology Program, 2011.

[4] FHWA, "RealCost (version 2.1) User Manual," Pavement Life-Cycle Cost Analysis," Office of Asset Management, FHWA, Washington, D.C, 2004.

[5] FAA , A/C: 150/5320-6E, "Airport Pavement Design and Evaluation", Washington, D.C, 2009.

[6] International Civil Aviation Organization , "ICAO Environmental Report 2010: Aviation and Climate Chang", Montreal: ICAO & FCM Communications Inc, 2010.

[7] DAC Departures, Hazrat Shahjalal International Airport. http://shahjalalairport.com/index.php/departures, [accessed on 19/01/2014]

[8] Braham, A., "New developments in airfield pavements." Pavinars: Webinars for the pavement community, University of Arkansas, 2013.