

UNIVERSITY OF MORATUWA

015

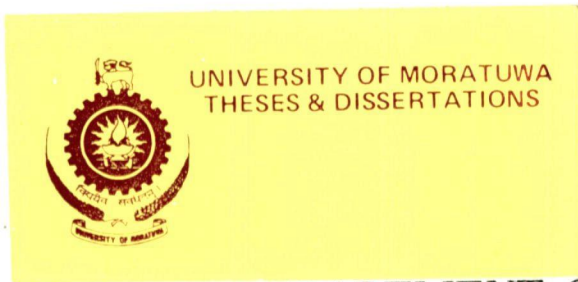
**LIFE CYCLE COST  
ANALYSIS  
FOR ROAD PAVEMENTS**

**BY  
V.R.DALUWATTE**



University of Moratuwa, Sri Lanka.  
Electronic Theses & Dissertations  
[www.lib.mrt.ac.lk](http://www.lib.mrt.ac.lk)

**SUPERVISED BY  
DR.A.A.D.A.J.PERERA**



**DEPARTMENT OF CIVIL ENGINEERING  
UNIVERSITY OF MORATUWA  
MORATUWA  
SRI LANKA**

625"93"  
625.7

# UNIVERSITY OF MORATUWA

සමස්තකාලය  
මොරටුව විශ්ව විද්‍යාලය, ශ්‍රී ලංකාව  
මොරටුව.

## LIFE CYCLE COST ANALYSIS FOR ROAD PAVEMENTS

BY  
V.R.DALUWATTE



University of Moratuwa, Sri Lanka.  
Electronic Theses & Dissertations  
[www.lib.mrt.ac.lk](http://www.lib.mrt.ac.lk)

SUPERVISED BY  
DRA.A.D.A.J.PERERA

60913

4M Thesis  
coll.

DEPARTMENT OF CIVIL ENGINEERING  
UNIVERSITY OF MORATUWA  
MORATUWA  
SRI LANKA

60913

CONSTRUCTION & STRUCTURAL  
ENGINEERING  
DEPARTMENT OF CIVIL ENGINEERING  
UNIVERSITY OF MORATUWA.

**LIFE CYCLE COST  
ANALYSIS  
FOR ROAD PAVEMENTS**

**BY  
V.R.DALUWATTE**

**THE THESIS SUBMITTED IN PARTIAL FULFILLMENT  
OF THE REQUIREMENT FOR THE DEGREE OF  
MASTER OF ENGINEERING**

**IN  
THE FACULTY OF ENGINEERING  
DEPARTMENT OF CIVIL ENGINEERING**

**SUPERVISED BY DR.A.A.D.A.J.PERERA**



Electronic Theses & Dissertations

**We accept this thesis as confirming to the required standard.**

**UNIVERSITY OF MORATUWA  
December 1993**

## LIFE CYCLE COSTING FOR ROAD PAVEMENTS

### ABSTRACT

The construction of roads has become a major Construction Industry in this country. Huge sums of money is being spent on Construction and Maintenance of roads. The cost effectiveness of three Road Pavement types which are currently in use are investigated in this exercise.

Life Cycle Cost (LCC) technique which has become very much popular in the building industry has been used here for that purpose.



University of Moratuwa, Sri Lanka.  
Electronic Theses & Dissertations  
Construction costs and maintenance costs for the three pavement types were collected from a sample of 18 roads in the western province and these data were analyzed in this document.

The results obtained indicate that the present system of road maintenance has increased the LCC of all road types and the Life time of a road can be extended if due maintenance is regularly carried out. This would result in a lower LCC for all road types.

The use of Asphalt Concrete for flexible pavements is recommended on the findings of analysis in this report as the LCC of the other pavement types with a inferior wearing surfaces are not much lower than the LCC of Asphalt Concrete type pavement.

This study also guides further research on the type of data required to carry out a LCC analysis of any road type.

This study also highlights the dearth of recorded expenditure data in many important cost areas.

## ACKNOWLEDGEMENTS

This project would not have been possible without the advice, guidance and encouragement given by Dr. Asoka Perera of the University of Moratuwa.

The cooperation extended by the officials in various government organizations in giving access to forgotten data stored in their records is recorded with much gratitude.

The General Manager of Western Province RDA Engr. D.P.Senanayake, and Mr. Luxman Silva ,the Executive Engineer in the Avissawella Divisional Office, and Mr.S.Liyanage , Senior Engineer at Construction Management and Contracts Division of RDA has been very much helpful in getting required data.

The assistance and the encouragement given by my colleague Engr. A.K.Herath in the difficult phases of this work is recorded with much gratitude.



University of Moratuwa, Sri Lanka.  
Electronic Theses & Dissertations  
[www.lib.mrt.ac.lk](http://www.lib.mrt.ac.lk)

# CONTENTS

|   | Page |
|---|------|
| <b>CHAPTER 1 - INTRODUCTION</b>                                       |      |
| 1.1 INTRODUCTION TO PROJECT   | 1    |
| 1.2 PROJECT OBJECTIVES  | 3    |
| 1.3 METHODOLOGY AND WORK DONE   | 3    |
| 1.3.1 Literature Survey   | 3    |
| 1.3.2 Data Collection   | 4    |
| 1.3.3 Analysis of Data  | 4    |
| 1.4 GUIDE TO THE REPORT   | 6    |
| <b>CHAPTER 2 - CONSTRUCTION AND MAINTENANCE OF ROADS IN SRI LANKA</b> |      |
| 2.1 INTRODUCTION  | 7    |
| 2.2 CONSTRUCTION METHODS  | 10   |
| 2.2.1 Type A Pavement   | 10   |
| 2.2.2 Type B Pavement   | 11   |
| 2.2.3 Type C Pavement   | 14   |
| 2.3 MAINTENANCE OF ROADS  | 14   |
| 2.3.1 History   | 14   |
| 2.3.2 Maintenance Procedure   | 15   |
| 2.4 COSTS   | 16   |
| 2.4.1 Construction Costs  | 16   |
| 2.4.2 Maintenance Costs   | 17   |
| <b>CHAPTER 3 - LIFE CYCLE COST CONCEPT</b>                            |      |
| 3.1 INTRODUCTION TO LIFE CYCLE COSTING                                | 19   |
| 3.1.1 Net Present Value of LCC  | 20   |
| 3.1.2 Equivalent Annual Value of LCC                                  | 21   |
| 3.1.3 Cost of Money   | 22   |
| 3.2 LIFE CYCLE COSTING APPLIED TO BUILDING INDUSTRY                   | 23   |

| <b>CHAPTER 4 - LIFE CYCLE COSTING AS APPLIED TO ROADS</b>               |  | <b>Page.</b>  |
|---|--|---------------|
| <b>4.1</b>  | <b>INTRODUCTION</b>                              | <b>25</b>     |
| <b>4.2</b>  | <b>GENERAL COST COMPONENTS</b>                   | <b>25</b>     |
| <b>4.3</b>  | <b>AGENCY COSTS</b>                              | <b>26</b>     |
| 4.3.1   | Capital Cost                                     | 26            |
| 4.3.2   | Running Cost                                     | 29            |
| <br><b>CHAPTER 5 - ANALYSIS OF DATA AND CONCLUSIONS</b>                 |  |               |
| <b>5.1.</b>   | <b>DATA</b>                                      | <b>30</b>     |
| 5.1.1.  | Construction Cost                                | 31            |
| 5.1.2   | Maintenance Cost                                 | 32            |
| <b>5.2</b>  | <b>ANALYSIS</b>                                  | <b>33</b>     |
| 5.2.1.  | Construction Cost                                | 33            |
| 5.2.2   | Maintenance Cost                                 | 33            |
| 5.2.3   | LCC for Category A Pavement                      | 37            |
| 5.2.4   | LCC for Category B Pavement                      | 38            |
| 5.2.5   | LCC for Category C Pavement                      | 50            |
| 5.2.6   | Comparison of LCC for three pavement types       | 61            |
| <b>5.3</b>  | <b>RESULTS</b>                                   |               |
| 5.3.1   | Construction Cost                                | 62            |
| 5.3.2   | Maintenance                                      | 63            |
| <br><b>CHAPTER - 6 CONCLUSIONS, RECOMMENDATIONS AND FUTURE RESEARCH</b> |  |               |
| <b>6.1</b>  | <b>CONCLUSIONS</b>                               | <b>65</b>     |
| <b>6.2</b>  | <b>RECOMMENDATIONS</b>                           | <b>66</b>     |
| <b>6.3</b>  | <b>FUTURE RESEARCH</b>                           | <b>66</b>     |
| <br><b>APPENDICES</b>   |  |               |
| <b>A</b>  | <b>Construction Cost for Category A Pavement</b> | <b>67</b>     |
| <b>B</b>  | <b>Construction Cost for Category B Pavement</b> | <b>68</b>     |
| <b>C</b>  | <b>Construction Cost for Category C Pavement</b> | <b>69</b>     |
| <br><b>REFERENCES</b>   |  | <br><b>70</b> |

## LIST OF FIGURES

Page

|         |  |    |
|---------|--|----|
| Fig 1.1 | Road Maintenance Cost Vs Time                                | 5  |
| Fig 2.1 | Existing Road Cross Sections                                 | 8  |
| Fig 2.2 | Category A Pavement Cross Section                            | 9  |
| Fig 2.3 | Category B Pavement Cross Section                            | 12 |
| Fig 2.4 | Category C Pavement Cross Section                            | 13 |
| Fig 2.5 | General Cost Variation of Maintenance                        | 18 |
| Fig 3.1 | Transformation of Annual Costs to a Base year                | 20 |
| Fig 3.2 | Transformation of Base Year Costs to Equivelant Annual Costs | 21 |
| Fig 3.3 | Life Cycle Costing Technique                                 | 22 |
| Fig 5.1 | LCC for Road Pavements                                       | 36 |



University of Management, Sri Lanka.  
Electronic Theses & Dissertations  
[www.lib.mrt.ac.lk](http://www.lib.mrt.ac.lk)



| <b>LIST OF TABLES</b>  | <b>Page</b> |
|--|-------------|
| Table 1.1 Expenditure for Roads in Sri Lanka                             | 1           |
| Table 4.1 Agency Costs   | 27          |
| Table 5.1 Composition of LCC of few major Road Projects                  | 30          |
| Table 5.2 Construction Costs for Category<br>A, B and C Pavements        | 31          |
| Table 5.3 Maintenance Costs for Category B Pavements                     | 34          |
| Table 5.4 Maintenance Costs for Category C Pavements                     | 35          |
| Table 5.5 Mavathagama - Pitipana Road<br>Maintenance Cost Transformation | 36          |
| Table 5.6 Summary of Regression Coefficients for<br>Category B Pavements | 49          |
| Table 5.7 Annual Maintenance Costs for Category B<br>Pavement            | 49          |
| Table 5.8 Summary of Regression Coefficients for<br>Category C Pavements | 59          |
| Table 5.9 Annual Maintenance Costs for Category C<br>Pavement            | 60          |
| Table 5.10 Comparison of LCC in three Pavement types                     | 61          |
| Table 5.11 Construction Cost as a percentage of LCC                      | 61          |

## ABBREVIATIONS

|        |   |
|--------|---|
| AASHTO | American Association of State Highway and Transport Officials |
| ASTM   | American Society of Testing Materials                         |
| ADB    | Asian Development Bank  |
| AI     | Asphalt Institute .USA  |
| BOQ    | Bill Of Quantities  |
| BOI    | Board of Investments  |
| CMC    | Colombo Municipal Council                                     |
| CEB    | Ceylon Electricity Board                                      |
| DBST   | Double Bituminous Surface Treatment                           |
| HD     | Highways Department   |
| IE(SL) | Institution Of Engineers (Sri Lanka)                          |
| ICTAD  | Institute of Construction Training & Development              |
| IBRD   | International Bank of Rehabilitation & Development            |
| ILO    | International Labour Organization                             |
| LLC    | Life Cycle Costing  |
| NIC    | Newly Industrialized Country                                  |
| NPV    | Net Present Value   |
| ODA    | Overseas Development Agency                                   |
| PWD    | Public Works Department                                       |
| RCDC   | Roads Construction & Development Company                      |
| RDA    | Roads Development Authority                                   |
| RIBA   | Royal Institute of Building Architects                        |
| RMA    | Road Maintenance Agent  |
| RMC    | Road Maintenance Contractor                                   |
| RICS   | Royal Institute of Chartered Surveyors                        |
| SBST   | Single Bituminous Surface Treatment                           |
| TCEO   | Territorial Civil Engineering Organization                    |



University of Moratuwa, Sri Lanka.  
Electronic Theses & Dissertations  
www.tho.mru.ac.lk

