Predictive Building Life Cycle Cost Model and Architectural Design in Building Maintenance

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Abstract

This research project addresses the forecasting of maintenance funding for buildings under the management of Department of Housing and Works (DHW). The research studies the theoretical background of Government maintenance funding policy, and conceptual development of a life cycle cost (LCC) model for public building maintenance. Attempts to develop a predictive LCC model from the database of the DHW are illustrated. Other factors, such as architectural design that impact on the cost of building maintenance are briefly described.

1.0 Introduction

The Government of Western Australia is committed to ensuring that its buildings are adequately maintained. The Department of Housing and Works (DHW), in conjunction with the Cooperative Education for Enterprise Development (CEED) of the University of Western Australia, proposed this research utilising available data to develop a predictive building maintenance funding model. The objective is to prove the usefulness of the data collected by DHW over a period of fourteen years; then as results of the successful completion of this project to provide a basis for the Department to develop a predictive maintenance funding model based on building age, which in turn, will influence government maintenance funding policy.

The research also briefly discusses the role that architectural design plays in the cost of building maintenance.

2.0 The Issues and Challenges

Maintenance of public buildings has always had the challenge of increased needs and insufficient funding. Increasing backlogs of maintenance indicate that the funds available in recent years for the maintenance of public buildings have not been sufficient to keep pace with the actual rate of degradation. Compounded with a portfolio of aging facilities, inadequate funding for replacements of building systems and modernization for current and new functions result in an accumulated backlog of maintenance. Under these conditions, public buildings and infrastructure are subject to potential failures and disruption to normal activities, threats to health and safety, inadequacies for supporting intended programs, deterioration in public building appearance, and a reduction in capital asset value.

Others have struggled with identifying maintenance needs and presenting a persuasive and credible argument for funding support. The latest maintenance funding bench mark for the Government is based on the Bromilow Life cycle cost of university buildings (1987). According to the model, the maintenance lifecycle of an individual building needs a maintenance expenditure commencing at approximately 0.5% of replacement value (RV) and leveling out at approximately 2% after 30 years (see Figure 1).

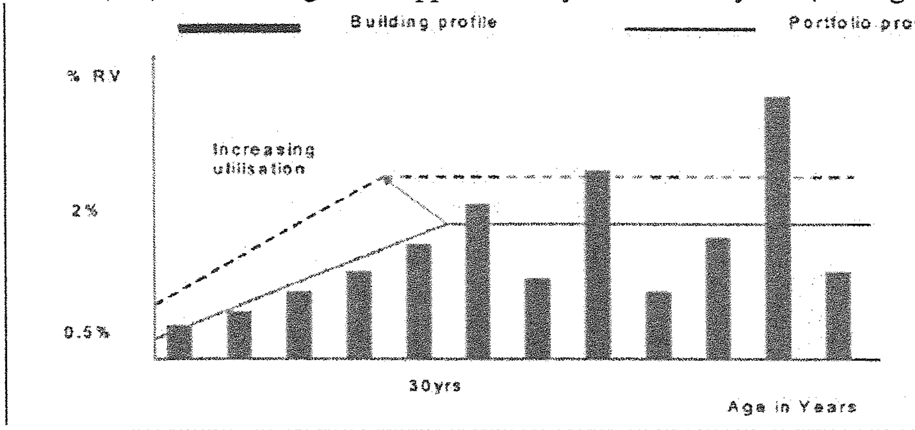


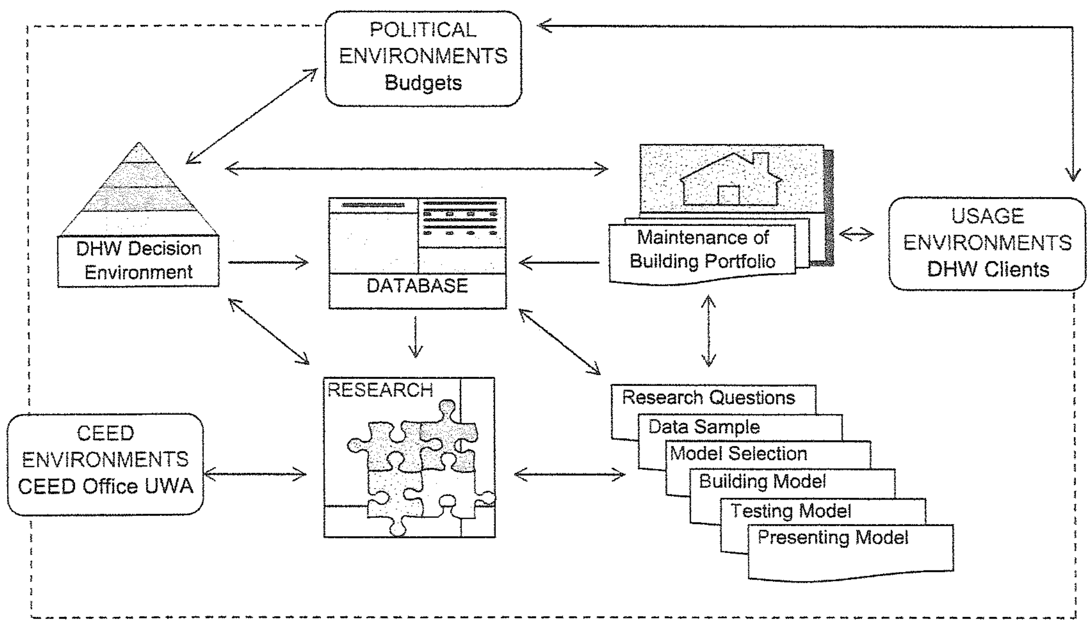
Figure 1

The Bromilow model was developed based on a 30 years old building at the University of Melbourne in 1987. Since then, any test of the theory has not been found by the author of this paper. The aim of this research is to establish a building maintenance life cycle model for DHW by utilising the data of maintenance costs collected by DHW, then to compare and contrast the results with the Bromilow model.

3.0 Research Development

3.1 Scope of the Research

Figure 2, describes the related parties, resources needed, procedures undertaken and interrelations among the elements for this research.

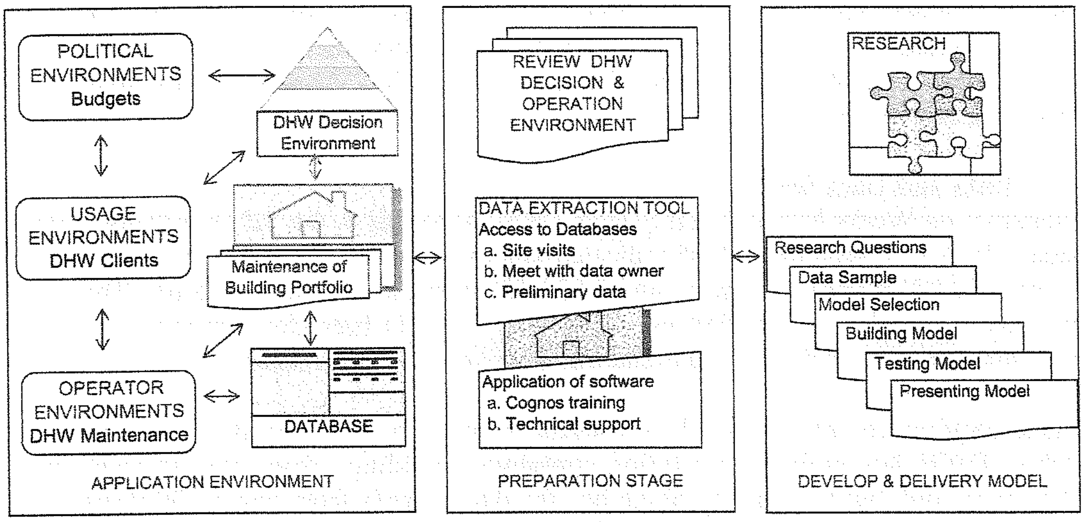


Scope of the Project Presented as a Diagram

Figure 2

3.2 Methodology of the Research

Figure 3, summarises the methodology for the research in three phases of development.



Methodology of the Project Presented as a Diagram

Figure 3

3.3 Building maintenance in Life Cycle Cost (LCC)

The Life Cycle Cost analysis is a method of evaluating a system or components of total cost by measuring initial and future costs. There has been a growing awareness of the concept of life cycle performance of physical assets as distinct from a preoccupation with their initial procurement. In Australia, work on life cycle cost performance theories commenced in the Commonwealth Scientific and Industrial Research Organization (CSIRO) Division of Building Research Group in 1980s. Partly as a result of these initiatives, the Report of the Commonwealth Tertiary Education Commission's (1986) Review of Efficiency and Effectiveness emphasized the need to review past policies and to move to life cycle cost techniques in managing university buildings. Bromilow and Pawsey (1987)'s 'Life Cycle Cost of University Buildings' is an outcome of those initiatives.

To review the nature and incidence of maintenance and other operations from records of what has been done to each building in the past, as a basis to predict future needs, seems be an obvious approach for building maintenance in life cycle cost. However, when attempts have been made to apply life cycle concepts, research has been hindered by the lack of both well accepted methodology and of reliable and adequate data.

4.0 Application LCC to the Building Maintenance of DHW

4.1 Maintenances in DHW

The Department of Housing and Works is an organisation responsible for all of the State Government's housing and works functions. The Maintenance and Minor Works Branch manages building maintenance and minor improvements for clients.

Data recording for building maintenance was only initiated fairly recently. In 1985, after the formation of the Building Management Authority, attempts were made to address the increased demands for more reliable building maintenance expenditure data. This lead to developing a mainframe system to record details of work performed in breakdown repairs, but without costs. From 1991 onward, mainframe systems became stable and were extensively used for works management and other activities. About July 1999, the Department purchased a Maintenance Management System (Mainsever). The main driver for the move to Mainsaver was as a risk management exercise in relation to the Y2K millennium issues relative to mainframes. The Mainsaver system is the current application system for DHW. A data warehouse was established to capture data from operational systems, both mainframe and Mainsaver. This data warehouse is the source of data used for this research.

4.2 Data and Data Sample

The statistics on Works Management System (WMS) records in the data warehouse from 1 January 1989 to 7 September 2005 indicated that there were 4,678 registered work sites with total of 2,937 clients/customers, and 2,528,825 client invoice table records. The cost of maintenance could be classified into four categories: 1) breakdown maintenance; 2) planned maintenance; 3) routine maintenance; 4) minor work maintenance.

The data required in order to apply life cycle costing for this research is not readily available. DWH has building portfolios containing buildings from new to over one hundred years old, but no building alone has the data records from new to 30 years old. The decision was made to identify a portfolio of buildings which have similar building form, have data records for the building population that have buildings aged from new to 50 years old. These data sets form a life cycle group with records of maintenance costs. Primary school buildings in the Metropolitan Area seemed an obvious choice, since there were more than 10 schools built each decade, and the building types and sizes were also similar. As indicated in Figure 4, 10 primary schools per sample batch per decade from 1950's onwards were selected. As planned, records from 1992 to 2006 reflect spending patterns over this fourteen years period for 40 year old buildings that were built in the 1950's, 30 year old building that were built in the 1960's and so on. Together these groups enabled the building of a LCC Model which captured spending patterns for building life cycles ranging from new to 50 years old. All historical costs of maintenance were converted to today's money by using the Building Cost Index (BCI) of DHW. The average cost per class room was set as a standard unit for analysis. Classroom data for schools is readily available.

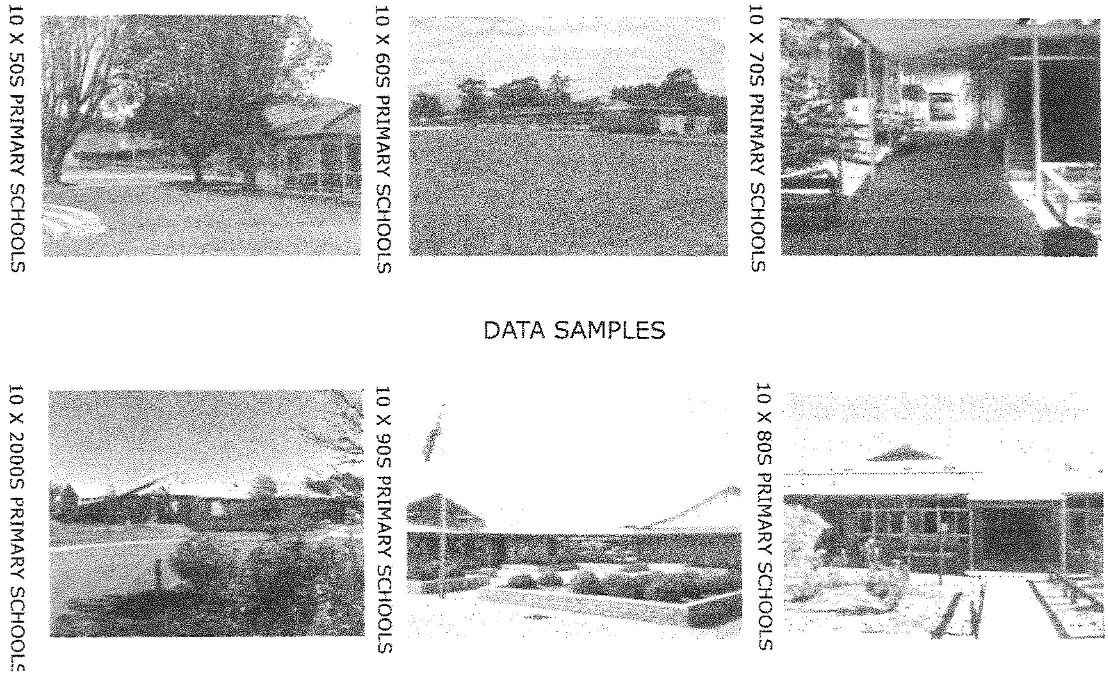


Figure 4

4.3 Data Processing

The data processing demonstrated in Figure 5 was designed to bring original costs of maintenance of sample schools firstly into four maintenance categories, which would be basis for researching elements of maintenance, then grouping and sorting the costs according to school, financial year, applying BCI to convert historical costs to current costs as of July 2006, and finally averaging the costs as per class room to standardize the measurements. Since the costs of maintenance in 1992/1993and 1993/1994 were under strict budget control or funding restrictions, it would not reflect the true maintenance needs, so data for those two years were not taken into account for the LCC model.

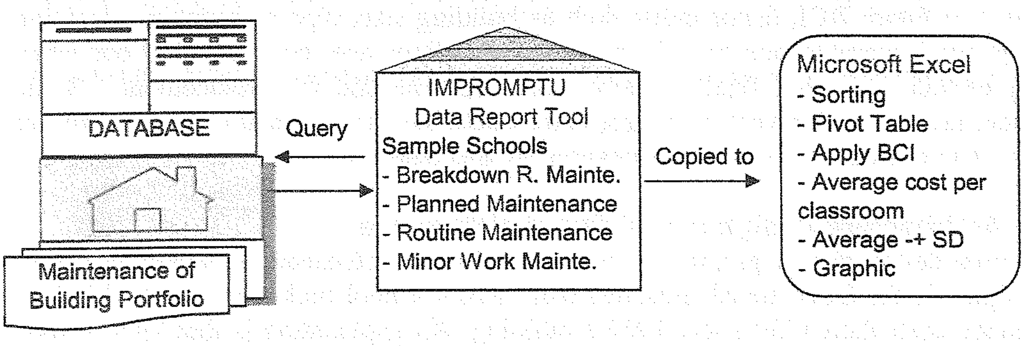


Figure 5

5.0 Model Development

Attempts were made to structure the maintenance cost information for schools in the LCC model according to the age of the building as described in Bromilow's model. In Figure 6, the diagram shows the spending pattern for each decade schools for the period of 1994/1995 to 2005/2006, a twelve years period. Figure 7 is a modified version of total maintenance spending pattern from new to 50 years old buildings. The scattered points represent average cost per classroom for sample schools. The trend line represents the trend of average cost per classroom of total maintenance after adjustment for BCI.

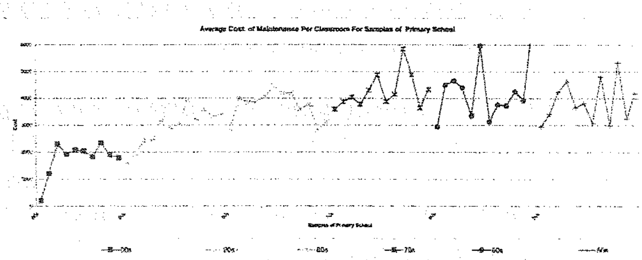


Figure 6

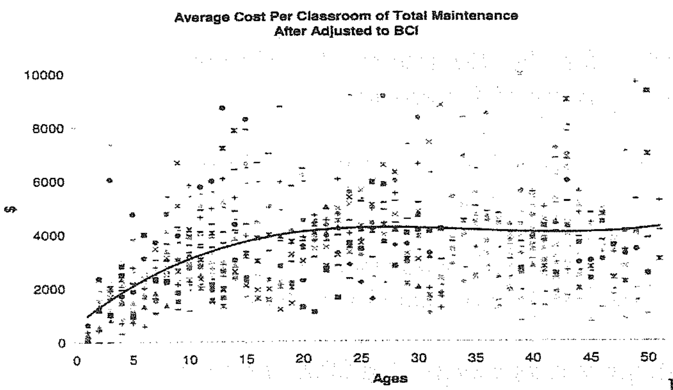


Figure 7

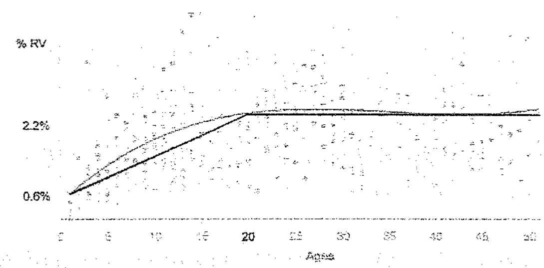


Figure 8 Predictive building LCC model

6.0 Overview of results and conclusions

The current replacement value of a classroom, built as part of a new school is approximately $180,000, determined by dividing the number of classrooms into the tender price for the school. From Figure 7, the LCC trend line commence to attract maintenance costs of about $1000 per classroom or approximately 0.6% of RV, and levelling out about $4000 per classroom, which is about 2.2% of RV, after only 20 years (Figure 8). This model shows a similar pattern with Bromilow model, but about 10 years early to level out, and 20% and 10% respectively above the estimation generated from the Bromilow model (Figure 1).

This predictive model (Figure 8) is based on the actual maintenance spending of 60 sample primary schools as in July 2006. The current maintenance levels of those building condition are acceptable. However, the predictive model or figures presented in this paper are subject to future BCI, factor index such as building size, type or economic location etc. In general, maintenance costs increased as buildings age, costs levelled out when reaching certain ages, and finally, major costs were needed for replacement. Some researchers argued that preventive maintenance could save money and extend the life of the assets, and this trend is generally supported by this research.

7.0 Architecture Design in building maintenance

Architectural design plays a part in the cost of building maintenance. As shown in Figure 6 and Figure 7, the LCC model indicates that 1970's school buildings attracted higher maintenance costs than 1950's and 1960's building. An explanation is that 1970's style school buildings were designed as a response to a booming economy and fast growing population, as low cost schools. They were smaller overall than earlier schools with low ceiling heights, flat roofs and fibro cement wall cladding. They suffered from poor ventilation which required engineering systems to overcome. In recent times these schools have been extensively evaporatively cooled to overcome this defect. They attracted higher cost for the damage cause by overflow from rain, plugged downpipes, and other related causes. 1950's and 1960's school building were constructed from the brick walls and tile roofs with steeper slope, wide eaves, more durable design, which costs less to maintain. The 1980's and 1990's schools reflect a return, in a modern guise, to traditional school construction.

8.0 Implication for further studies

Attempts have been made to test the model with other portfolio data, such as high schools or police stations; and then to predict future five years costs with BCI according to age of the buildings. This work was not able to be completed due to insufficient time for this current project.

9.0 References

Barrett, S. (2005) Strategic Maintenance Plan for the Department for Community Development for 2005/2006, *DHW, West Australia Government.*

Bromilow, F. J. & Pawsey, M. R. (1987) Life Cycle Cost of University Buildings, *Construction Management and Economics*, Vol 5, S3-S22.

Department of Treasury and Finance (2005) Strategic Asset Management Framework for Western Australian Public Sector Agencies, *West Australia Government.*

Gartner, J. (2007) DHW Maintenance and Minor Works Review Jan 2007. *Department Housing and Works, Western Australia Government,* Release 1.3 pp.16-21.

Ryan, J. D. Strategic Maintenance Planning for Public Building, a Portfolio Approach, *Department of Contract & Management Services, West Australia Government.*