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BUILDING RESEARCH NOTE

BUILDING MAINTENANCE DATA: SOURCES AND DEFICIENCIES

by

F. Steel

ANALYZED

Division of Building Research, National Research Council of Canada

Ottawa, January 1985

NATIONAL RESEARCH COUNCIL OF CANADA

DIVISION OF BUILDING RESEARCH

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ABSTRACT

Without better records about the costs of maintenance, operation and use of buildings, the proper mix of input resources that will give the best long-term value for money spent cannot be determined. This report identifies sources of existing information and potential sources of needed information.

INTRODUCTION

Information on how to organize and carry out the maintenance of buildings and building systems is plentiful. Typical expenditures incurred in operating and maintaining buildings, which would be useful for comparison purposes, are not so well documented. Very little information exists about the effectiveness of building maintenance or the consequences of a lack of maintenance. Results of studies by the Division of Building Research (DBR) in these areas are presented.

LITERATURE SOURCES

A literature search revealed that many sources and types of information on building maintenance are available.

Residential Buildings

As might be expected, the repair and maintenance of houses is well covered in books (1,2,3), popular magazines and manufacturers' promotional literature. Technical information on restoration or rehabilitation is often applicable. Other sources (4,5) cover technical as well as management, social and economic aspects of rehabilitating residential buildings.

Maintenance Management

There is a greater need among owners, operators and managers of larger or commercial buildings for recommendations about technical, administrative and management aspects of building maintenance and operation (6,7,8,9). Detailed information on methods and requirements of maintaining specific equipment can be obtained from manufacturers. Designers and contractors often provide instructions about the expected performance and correct operation of building systems. Owners and managers also rely on trade magazines (10,11) for product information, technical articles, management suggestions and marketing trends.

Industrial Maintenance

Information intended for maintenance and engineering personnel of manufacturing and industrial plants may also be useful to those who manage and operate buildings (6,7,12,13,14,15). These sources often discuss such subjects as service life; service frequency; cost effectiveness of maintenance programs for manufacturing equipment; and effective use of resources.

Service Life

Results of a survey about the service life expected from mechanical equipment and components used in building systems is given in an ASHRAE handbook (16), but no range or cause of variation in the service life is given. These reported service lives usually differ from those used in calculating capital cost allowances for taxation purposes. Service life values based on experience are needed for long-range budgeting or for calculating life cycle costs when comparing different systems. The subject of life cycle costs is covered by ASHRAE (16) and others (17). Two of ASHRAE's technical committees, TC 1.7 Maintenance, Maintainability and Reliability, and TC 1.8 Owning and Operating Costs, conduct research into these areas and update the ASHRAE handbooks as new information becomes available.

Overseas Activity

Reports and periodicals from a number of sources in Europe provide information about procedures, costs, administration and management techniques related to operating, maintaining and repairing buildings. In the United Kingdom where the building stock is much older than that of North America and annual expenditures for maintenance and repair exceed expenditures for new construction, there is a large data base available to meet the demand for technical, financial (18) and management information. Sources include a series of Building Research Establishment Notes published by the Department of the Environment, numerous articles published by the Maintenance Information Service of the Chartered Institute of Building, R&D Bulletins and Papers by the Ministry of Public Building and Works, Technical Notes by Building Services Research and Information Association, periodicals (19,20,21) and books (22,23,24). CIB, the International Council of Building Research, Studies and Documentation, has established Working Commission W70, Maintenance and Modernization of Buildings, to collect and exchange information on research into, and experience with, maintaining and modernizing buildings in different countries. Meetings and seminars are held regularly and proceedings (5) are published.

COST DATA

There are few data about the costs of building maintenance and the effects of maintenance on the costs of operation and use of buildings.

University Buildings

The Council of Ontario Universities has a standard recording and reporting format by which operating data for university buildings in Ontario

are collected, analyzed and shared. Studies (25) in the United States about the repair, rehabilitation, renewal or renovation of university buildings estimate that 1-2% of their replacement costs should be budgeted annually to keep those assets in suitable condition to meet current needs and changing safety standards.

Research Buildings

DBR has studied the costs of operating the buildings on the NRC campus. A broad overview of these costs is available (26). A more detailed analysis (27) of six years of work order records provided this summary of results:

The average annual expenditure for building maintenance is \$5.79/m², or 0.46% of the estimated replacement cost of the buildings.

The annual labour requirement for maintenance, alterations and miscellaneous but excluding contract cleaning is 6 minutes/m².

The average of 25 breakdowns that occur each year represent about 2% of all jobs.

About 50% of all jobs are completed in 12 weeks or less and 95% in 50 weeks or less.

Work breakdown by type, amount of expenditure and labour content is:

Building maintenance	26%	31%
Building construction	11%	5%
Alterations for tenants	49%	43%
Maintenance for tenants	10%	15%
Other	4%	6%

Expenditure per unit area could not be proven to increase with the size or age of the buildings.

Office Buildings

Maintenance and other operating costs for private and government office buildings in North America are reported by BOMA (28). Operating costs, excluding financing and taxes, are about \$34/m² per year. These costs consist of maintenance and repairs, \$6.00/m²; utilities, \$9.50/m²; cleaning, \$8.50/m²; administration and miscellaneous, \$10.00/m². The present value of the series of these operating costs that would be incurred during the 60 years or more of service life expected from a building will be about \$700/m².

This compares with the design and construction costs of high-rise office buildings, currently about \$700/m². In comparison, the payroll burden is about \$800/m² per year and the present value of the series of payroll costs during the expected 60-year life of the building is about \$16 000/m², far in excess of the construction or operating costs. Thus it would appear to be potentially rewarding to search for and to exploit any improvements or changes in the design, construction, maintenance, operation or use of buildings that would increase employee productivity or lead to a better financial return on payroll expenditure. More information is needed

about the interaction between design, operation and use of buildings in order to minimize total expenditures and to maximize over the long term the value for those expenditures. Studies into these types of interaction are progressing in various organizations.

Cost Control

Studies by the Architecture and Building Sciences Division of Public Works Canada (PWC) found that commissioning of building systems following construction or alteration is often inadequate, resulting in systems that do not perform as intended, that are more expensive than necessary to operate, or that do not perform to meet the loads imposed by the use of the space. PWC found that systems in a five-year-old building consumed 20% more energy than if they had been commissioned as designed and had been operated as intended. This represents more than a 5% ($\$2/m^2$ per year) premium in operating costs. Quality control during construction, commissioning of the building after construction and training of those who operate the building would amount to less than 1% ($\$7/m^2$) of construction costs and would seem to offer a reasonable financial payback.

The operation of a building on startup cannot always be as economical as in later years. For instance, it has been found that extra ventilation to cope with the initially higher rates of outgassing of new materials, while more expensive, may be beneficial especially if it helps prevent 'sick building syndrome'.

After construction, additional costs of perhaps 1 to 2% ($\$10/m^2$) could rectify designs that did not accommodate the loads imposed by the actual method of use of the building. Potential savings of $\$1.50/m^2$ per year resulting from implementation of such 'hindsight designs' have been identified by PWC. This gives a longer but still reasonable payback period.

The multi- and trans-disciplinary study of the overall performance of buildings may provide one method to determine functional and operational improvements that could be made so that buildings could better satisfy user needs. PWC is currently developing such procedures and has conducted building performance studies in office buildings in Edmonton and Winnipeg. ASTM has recently formed a new committee E 06.25, Overall Performance of Buildings, to develop standard procedures to evaluate the performance of existing buildings and to evaluate the integrated performance of two or more building subsystems. Work was recently undertaken in New Zealand and Australia to establish techniques for the post-occupancy evaluation of buildings (29,30). These types of activities should identify benefits to be derived from improving the design, operation and use of buildings. They can identify changes or improvements to be made in standards for an office environment and their implementation should lead to better working conditions, thereby increasing productivity.

BUILDING MAINTENANCE AND NEW CONSTRUCTION

Recently the replacement value, in constant dollars, of the existing building stock in Canada was increasing by about 3% per year owing to new construction. In comparison, the annual expenditure for building

maintenance amounts to an estimated 0.5% of the replacement value of existing buildings, representing about 15% of the economic activity of new construction. Assuming an estimated replacement value of \$700 billion for the existing stock of Canadian buildings, annual expenditure on maintenance would be about \$3 billion.

The rate of loss of Canadian buildings is not known but could be determined (31) periodically from changes in property assessment records. Whether better building maintenance would reduce the rate of loss and reduce overall costs is not known because of a lack of information. However, the present economic climate with its attendant reduction in new construction has led to an increasing emphasis on renewal, rehabilitation and conversion of buildings. This shows that there must be some economic advantage to owners in prolonging the life of a building and reducing the loss rate. The extra expenditure for maintenance that can be justified economically to prolong the life of a building can be determined only as more information is gathered about the relative costs of maintaining buildings in good condition versus reducing maintenance but having to demolish and rebuild sooner.

SUMMARY

Methods have been developed to determine cost-effective maintenance policies and procedures in industry, where the economic motive has been strong. Similar procedures can be applied in developing technical, financial and management solutions for problems of maintaining buildings and building services. As building owners come to realize the economic benefits of better maintained and better operated buildings, more data will be made available so that the most cost-effective procedures can be determined.

Information is available about how to maintain buildings and building systems. But now, information is needed about how much expenditure is reasonable, and how to determine whether it would be a good investment to spend more on maintenance.

REFERENCES

1. Bright, J.L., The Home Repair Book, J.G. Ferguson Publishing Co., Chicago, IL, 1977, 372 p.
2. Schwartz, R. and Cobb, H.H., The Complete Homeowner, Macmillan Co., New York, 1966, 434 p.
3. Seaquist, E.O., Diagnosing and Repairing House Structure Problems, McGraw-Hill, New York, 1980, 255 p.
4. Second Canadian Building Congress, "Rehabilitation of Buildings", Proceedings, National Research Council of Canada, Ottawa, Ont., 1980, 185 p.
5. The 9th CIB Congress, Stockholm, "To Build and Take Care of What We Have Built With Limited Resources", Volume 1a, "Renewal, Rehabilitation and Maintenance", The National Swedish Institute for Building Research, Gavle, Sweden, 1983, 488 p.

6. Morrow, L.C., Maintenance Engineering Handbook, 3rd ed., McGraw-Hill, New York, 1977, 1650 p.
7. Sack, T.F., A Complete Guide to Building and Plant Maintenance, Prentice-Hall, Englewood Cliffs, NJ, 1965, 512 p.
8. March, C.A., Building Operation and Maintenance, McGraw-Hill, New York, 1950, 384 p.
9. Shear, Mel A., Handbook of Building Maintenance Management, Reston Publishing Co. Inc., Reston, VA, 1983, 612 p.
10. Building Operating Management, Milwaukee, WI, Trade Press Publishing Co., periodical.
11. Buildings (The Facilities Construction and Management Magazine), Stamats Communications Inc., Cedar Rapids, IA, periodical.
12. Plant Management and Engineering, Maclean-Hunter, Toronto, periodical.
13. Plant Engineering, Technical Publishing Co., Barrington, IL, periodical.
14. Petroleum Mechanical Engineering Workshop and Conference, Proceedings, New York, ASME, annual conference.
15. AIPE International Plant Engineering Conference, Proceedings, Cincinnati, OH, American Institute of Plant Engineers, 1976.
16. ASHRAE Handbook, 1980 Systems Volume, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA, p. 45.1-45.6.
17. Value Engineering, Journal of the Society of American Value Engineers, Beverly Hills, CA.
18. Building Maintenance Cost Information Service, BMCIS Building Maintenance Price Book, 2nd ed., Kingston upon Thames, Surrey, U.K., 1981, 160 p.
19. Building Services, Journal of the Chartered Institution of Building Services, Building Services Publications, London.
20. Building Technology and Management, Journal of the Chartered Institute of Building, Hartley Publishing Co., London.
21. Maintenance Management International (formerly Terotechnica), Elsevier Scientific Publishing Co., Amsterdam, periodical.
22. Seeley, I.H., Building Maintenance, Macmillan Press, London, 1976, 362 p.
23. The National Building Maintenance Conference, "The Management of the Building", Dept. of the Environment, London, 1980.

24. Lee, R., Building Maintenance Management, 2nd ed., Granada (London, Toronto), 1981, 360 p.
25. "Building Renewal and Formula Funding", Journal of the Council of Educational Facilities Planners, International, Vol. 22, No. 1, Jan-Feb., 1984.
26. Steel, F., "Building Maintenance Profile for National Research Council, Montreal Road Campus, Ottawa". National Research Council of Canada, Division of Building Research, Building Practice Note No. 45, Ottawa, Ont., 1983, 8 p.
27. Steel, F., "Expenditure for the Operation and Maintenance of Buildings". National Research Council of Canada, Division of Building Research, Building Research Note No. 224, Ottawa, Ont., 1985, 15 p.
28. BOMA Experience Exchange Report, Building Owners and Managers Association Int., annual, Washington, DC.
29. Daish, J., et al., Bibliography on Post-Occupancy Evaluation of Buildings, School of Architecture, Victoria University of Wellington, Wellington, N.Z., 1980, 31 p.
30. Hornsby, C.P., A Post-Occupancy Evaluation of the New Auditorium Reception Building at EBS, Experimental Building Station, Department of Transport and Construction, Chatswood, Aust., 1982, 42 p.
31. Steel, F., "An Inventory of Canadian Building Stock, 1980". National Research Council of Canada, Division of Building Research, Building Research Note No. 200, Ottawa, Ont., 1983, 13 p.