FACILITY MANAGEMENT MODEL FOR MAINTENANCE AND REPAIR FOR OFFICE BUILDINGS

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ABSTRACT

FACILITY MANAGEMENT MODEL FOR MAINTENANCE AND REPAIR FOR OFFICE BUILDINGS

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For any building, deterioration depends on adequate design, qualified contractors, quality of materials, its operation and maintenance program, and environmental conditions. Any gap in these factors or uncorrected utilization will have an immediate effect on the degree and speed of building deterioration.

The process of deterioration in both the physical and functional condition of a facility is complex, and is indicated by wear and aging due to usage, degradation of equipment and construction material due to the environment, and the interaction of these mechanisms

The building Operation and Maintenance (O&M) phase is usually the longest and most costly phase of building's lifecycle, mostly its costs exceeding the total initial cost. Studying the costs of operation and maintenance and repair can have a significant effect on reducing total cost of ownership. One of the most important facility management functions is operation and maintenance. The O&M function has Maintenance and Repair (M&R) as the most important sub-function.

Facility Management (FM) is pertained with integrated information handling devoting business development to buildings, spaces, their associated environments and business functions. Both new and existing office buildings should confirm to specific requirements. Facilities management mandates the

requirements for activities and their management within the facilities. It should therefore view facilities and their use throughout whole life cycles. As the coordination between users and management has become closer, the economical advantage to the organization using a facility has improved. Better coordination between design, construction, and usage of facilities should improve the Life-Cycle Cost (LCC). By the same vein, enormous of the information increases throughout the life cycle of the facilities, the assorting, dropping, transferring, and retrieving data and information becomes more difficult. The Information Technology (IT) software and tools facilitate these difficulties.

The purpose of this study is to develop a facility management model for maintenance and repair for office buildings. This Model is a flexible and allows building owners and managers to practice their experience and knowledge.

The proposed information model depends on the Object-Oriented Model Language, which integrates product and process information to describe the annual maintenance and repair expenses. The Model components consisting four modules: 1) Facility Management Framework; 2) Maintenance and Repair components; 3) Property Condition Assessment PCA; 4) Priority Rule; and Ten-Year AM&R strategic Plan as the outcome of this model. The four modules integrated together with a database which consisting the M&R components. To support and validate the proposed information model, a prototype model developed to implement a real case study. This prototype model will demonstrate the information model functions and applications.

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I dedicate my thesis to my wife Souad for her continuing love and support.

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LIST OF ACRONYMS

Most of the Acronyms or abbreviations used in this thesis are listed here.

AAM&RE	Allowable Annual M&R Expenses
AEC	Architecture, Engineering, and Construction
AHP	Analytical Hierarchy Process
AM&RE	Annual Maintenance and Repair Expenses
AM&RR	Annual Maintenance and Repair Ratio
ANSI	American National Standards Institute
AP	Application Protocol
ARM	Application Reference Model
BOMA	Building Owners and Managers Association
BPM	Building Product Model
BPR	Business Process Re-engineering
CAD	Computer-Aided Design/Drafting
CAFM	Computer-Aided Facilities Management
CASE	Computer Aided Systems Engineering
CDR	Control Data Repository
CIFM	Computer Integrated Facilities Management
CIS	Computer-based Information System
CMP	Corrective Maintenance Program
COM	Component Object Model
COMBINE	COmputer Models for the Building Industry in Europe
CORBA	Common Object Request Broker Architecture

DBMS	DataBase Management System
DBMS	Database Management System Software
DFD	Data Flow Diagram
EA	Economic Analysis
EER	Experience and Exchange Report
ER	Entity-Relationship
ERD	Entity-Relationship Diagram
EXPRESS	Textual conceptual schema language
EXPRESS-G	Graphical form of EXPRESS language
FM	Facility Management
FMS	Facility Management System
FTP	File Transfer Protocol
GDP	Gross Domestic Product
GIS	Geographic Information System
GUI	Graphical User Interface
HTML	HyperText Markup Language
HVAC	Heating, Ventilation and Air Conditioning
IAI	International Alliance for Interoperability
IBDS	Integrated Building Design System
ICAM	Integrated Computer Aided Manufacturing
ICON	Integration of COnstruction Information
IDEF0	ICAN Function Definition Model
IDM	Integrated Data Model

IIBDS	Intelligent Integrated Building Design System
IFC	Industry Foundation Classes
IFMA	International Facility Management Association
IR	Inflation Rate
IS	Information System
ISFM	Information System for FM
ISO	International Organization for Standard
IT	Information Technology
KBS	Neutral Building Product Model for Computer Integrated Construction
LAN	Local Area Network
LCC	Life Cycle Cost
MDP	Markov Decision Process
MIS	Management Information System
M&R	Maintenance and Repair
M&RE	Maintenance and Repair Expenses
NIAM	The Nijssen's Information Analysis Methodology
NPV	Net Present Value
O&M	Operation and Maintenance
O&MM	Operation and Maintenance Management
OOP	Object-Oriented Program
PAM&RE	Proposed Annual M&R Expenses
PC	Personal Computer

PCA	Property Condition Assessment
PCR	Property Condition Report
PDES	Product Data Exchange Specification
PMP	Preventive Maintenance Program
PrMP	Predictive Maintenance Program
RATAS	Rakennusten Tietokone Avusteinen Suunnittelu (Finnish for Computer-Aided Design of Buildings)
SADT	Structured Analysis and Design Technique
SDAI	Standard Data Access Interface
SQL	Structured Query Language
SSADM	Structured Systems Analysis and Design Methodology
STEP	Standard for the Exchange of Product model data
STRADIS	STRuctured Analysis, Design and Implementation of Information Systems
TAI	Total Annual Income
TCP/IP	Transmission Control Protocol/Internet Protocol
TQM	Total Quality Management
UI	User Interface
UML	Unified Modeling Language
U_oD	Universe of Discourse
WAN	Wide Area Network
WWW	World Wide Web

CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND

Today's buildings are the product of the dramatic growth of new and existing assets for living, learning and commercial purposes. Half of the current residential, commercial and educational facilities in use today developed after World War II [Kaiser 1999].

Both new and existing facilities should confirm to specific requirements. Facilities management mandates the requirements for activities and their management within the facilities. It should therefore view facilities and their use throughout whole life cycles. As the coordination between users and management has become closer, the economic advantage to the organization using a facility has improved. Better coordination between design, construction, and usage of facilities should improve the Life-Cycle Cost (LCC).

The costs related to facilities usage have come into focus during the last decade due to the increasing pressure to forecast efficiency and productivity. Facilities management has increasingly been taking a strategic approach to improve the productivity and efficiency of any facility [Svensson 1998].

The purpose of facility management (FM) is to add to a business process by continually improving the quality of the operating environment and customer service. FM is trying to meet future requirements by anticipating all of the effected elements such as changes, planning, services, and expenses. It is also concerned with the care of people, occupants, customers, and buildings [Alexander K. 1992, Majahalme 1995].

Project information always flows through three different phases. It begins in the design phase, flows to the construction phase and finally to the facility management phase. This last flow is more costly and time-consuming as feedback loops in the form of change orders during the construction phase or excessive maintenance work during the facility management phase [Mahmoud et al. 2002].

The efficiency and productivity of organizations can be enhanced with Information Technology (IT). IT may be used for the intelligent rationalization of methods and processes and for more effective decision-making. IT has become a strategic resource not only in design and construction, but also in FM and in almost all sorts of organizational work [Svensson 1998].

The management of facilities involves an interaction between the design and construction and then the usage of facilities, interactions made possible by information technology tools. If the relationships between these phases are set up according to standards and satisfy the Facility Management System (FMS) requirements, the efficiency and productivity of the facilities' activities will be at their optimum. On the other hand, the FMS includes a database, a knowledgebase, and existing user-specific facility management applications. Using a building's Life Cycle plan and various professional domains to facilitate the structuring, sharing and exchange of information will enable facility managers to operate facilities efficiently [Maria 2000].

1.2 FACILITY MANAGEMENT (FM) HISTORY

The first introduction of the term FM as a professional service may be traced back to the early 1900s when scientific management and its subsequent use in office administration were first introduced [Mole and Taylor 1992, Svensson 1998]. Svensson [1998] discovered textbook about office management that were written in the beginning of last century, included information on how to maximize the efficiency of buildings by laying out office buildings in a functional manner [Svensson 1998]. The Buildings Owners and Managers Association (BOMA) was the first association of its kind, established in 1907 in Chicago, USA. The BOMA is an organization for commercial real estate specialized in organizing, standardizing and disseminating data.

Companies and other organizations today must frequently adapt their operational environment to new requirements. This situation is a result of various changes in society, such as greater competition, the increasing use of IT, rising fuel costs, and meeting changing health and environmental standards. Hence, the management of buildings and their equipment must be more dynamic and flexible.

This area uses three important terms, which must be well defined in order to comprehend the relationships that government them. For example, their relationship with facilities managers and with the business processes. These terms are Facility, Building, and Space.

The International Organization for Standards (ISO) defines a **Facility** as "a physical structure or installation, including related site works, serving one or more main purposes" [ISO 1994], while the definition of a **Building** is as "a type of facility comprising partially or totally enclosed spaces and providing shelter", which is a subset of facilities. Finally, **Space** defined as "three dimensional spaces within and around buildings and other facilities, bounded actually or theoretically". A facilities manager has to provide the business process with the complete business premises, including operational facilities and an indoor climate that supports these facilities and the business process.

Svensson [1998] compares FM by sorting their shared attributes and he adopts the following definition: **Facility Management** is "the continuous management of the workplace and operating environment of the organization at all levels with the purpose of providing user satisfaction and value for money" [Svensson 1998].

There are many perspectives from which to view this definition, according to the subjects and activities that are involved in FM.

It is clear from the definition and the domain of FM that an information system for FM should contain all of an organization's information associated with its buildings, business, and environment. The form of the information varies according to its source. It may exist in the form of planning and design documents, in the form of drawings, specifications, and service documents, or in some other user documentation formats. On the other hand, the data gathering task regarding the various disciplines of information such as the costs for cleaning, maintenance and operation, repairs, and equipment replacement is very large but only a portion of this information is required.

1.3 INFORMATION TECHNOLOGY (IT) HISTORY

The use of Information Technology within FM, or Computer-Aided Facility Management (CAFM) has had a varied history over the last few decades. Teicholz and Takehiko [1994] explained IT development throughout three different phases in depth. This section provides a short explanation of these three phases [Teicholz and Takehiko 1994]: **Phase 1**, pre-1985, the attributes of this phase represented the minimal use of any sort of technology by facilities departments; **Phase 2**, 1985-1990. During this phase, the attributes were clearer and enhanced by the widespread use of personal computers (PCs); and **Phase 3**, post-1990, the attributes of this phase, continuing to this day, are more open and more flexible in terms of integration, more independent, more powerful, faster, while PCs have become less expensive. and has been termed the Information Integration Phase.

Information Technology (IT) has become the principal process for any changes in the construction industry worldwide. Vast numbers of studies during the last two decades have redefined the way IT is integrated in the construction industry and have also focused on how IT methods can fundamentally change business processes in the future [Walker and Betts 1997].

IT supports business processes in many different ways, such as with improved communications among all the business discipliner, which in turn supports decision-making and promotes better service to clients. A high level of communication expected among people involved in developing new IT systems and those working to improve business processes. This type of communication is often achieved through models. Information models should be clear, easy to use, and independent. The business processes must be very clearly described so that the IT system can be designed to support it [Svensson 1998].

Recently, it has become normal practice for several groups of facility management and software programmers to work together to solve a particular problem, such as Operation and Maintenance (O&M). For example, Operation and Maintenance can be divided into subsections, such as Maintenance and Repair, which includes elevator, HVAC, electrical, structural/roof, plumbing, fire and life safety and other building maintenance and supplies. These subsections will then be divided into further small subsections for better control and efficiency. Solving problems leads to an increased need for data integration and additional quality control and assurance procedures associated with the integrity, flow, and accuracy of data. Satisfying these factors from the management level will allow a Computer Added Facility Management (CAFM) system to be used for corporate strategic business processes.

Facility managers need to evaluate how data can be used, how it will be archived, and how it will be updated as they are designing and implementing IT systems. IT implementation needs to be managed so that the new technology is integrated with the existing technology and administrative procedures [Teicholz and Takehiko 1994].

Bos (1994) and Svensson (1998) state five important advantages gained from using efficient facilities management information systems:

- Better support of primary organization;

- An increase of the life expectancy and value of a building;
- Optimization of the appliances of management;
- Optimization of maintenance activities involved in planning; and
- Improved quality of the individual working environment

1.4 PROBLEM STATEMENT

The deterioration and aging of existing facilities is a major problem in the operation, maintenance, and repair of facilities. The minimum ratio of value of construction works linked to the Canadian Gross Domestic Product GDP during the period 1991 - 2010 is 15%, the maximum is 20%, and the average is 17.4% throughout these 20 years. Bjork [1997] shows that Canada spent $ 52 billion on building construction and repairs, while the amount spent on maintenance and repairs to buildings was $ 8.5 billion [Bjork 1997]. In the United States the number is 10-times higher. Another study shows that the cost to operate, maintain, and repair a facility varies between 60-85% of its total ownership cost [Bjork 1997].

Hens, one of the important building components in a facility management is the operation, maintenance, and repair of facilities, which has become increasingly important for many countries and regions [Ying Nan et al. 2011]. This needs planning and correct timing of work to reduce the adverse affect of differed maintenance and repair which lead to accelerated deterioration and restoration costs of the structure building [M. Grussing and L. Marrano 2007]. On the other hand, Maintenance and repair of buildings are very expensive items that required large investment which are not always available to the building owners or managers, making it necessary to determine what maintenance actions to perform, and when, in order to ensure a well-functioning system with a reasonable cost [Stephen et al. 2010]. The building operation and maintenance phase is usually the longest and most costly phase of building's lifecycle, ultimately exceeding the total cost of initial design and construction. Targeting these operation and maintenance costs and the cumulative containment and renewal costs can have a significant effect on reducing total cost of ownership [M. Grussing and L. Marrano 2007].

Buildings are comprised of systems and components, crossing civil, mechanical, and electrical construction disciplines. Each component works interdependently with other components to support the functions of an efficiently operating building. As a physical asset, these components age and deterioration over time are ultimately adversely affecting performance and reliability of the building [M. Grussing and L. Marrano 2007].

I. Flores-Colen discusses the importance of 17 criteria that can help the priority choice in decision-making of maintenance and repair actions for facilities after Property Condition Assessment PCA. 30 experts assessed the 17 criteria in a survey using a questionnaire. He explains the difficulties facing the methodologies concerning the choice of the decision of criteria, which many include economic, functional, contextual, environmental, psychological, aesthetic, and cultural aspects. Accordingly, he proposes the priority rating scales and subclasses of each criterion, in order to help maintenance and repair decision-making for property after PCA [I. Flores-Colen et al. 2010].

According to the above brief, facility management decision making for maintenance and repair is a complex of four components. The first component is the facility management data model, which is the most important component that has the ability and flexibility to add or remove any further model without any rational effect. The second component is the PCA, which is delivered by consultant or inspector. The third component is the maintenance and repair components. The fourth component is the priority implementation of maintenance and repair components and when, which is depending on many criteria. The 10-year maintenance and repair strategic plan is the outcome of the integration of the four components and is the aim of this research. The 10-year strategic plan will regulate the availability of limited fund for maintenance and repair which is a major challenge for the decision makers. Maximizing the benefits of the limited funds is the goal of this research and the users.

The motivation of this study is to explain facility management model for maintenance and repair procedures that are developed for office buildings. The data model aims to represent the maintenance and repair components for a building in a 10-year strategic plan to facilitate, manage, and control the annual limited funds.

The development data model process should improved by: 1) rational decision support systems which meet the decision makers’ requirements; 2) the ability to add the experts' knowledge; and 3) the flexibility to modify the default elements of the model in the decision making process.

1.5 RESEARCH OBJECTIVES

The primary objective of this research is to develop an integration methodology for facility management to assist in managing annual maintenance and repair expenses. The methodology should support building owners and decision makers in assess property conditions and in selecting optimal maintenance and repair strategies while taking available funds into consideration.

The secondary objective of this research is to develop a prototype model, as proof of concept and for validation of the methodology.

The following sub-objectives need to be met in order to achieve the above objectives:

- Determine FM functions and information flows;
- Identify the key information elements associated with maintenance and repair;
- Identify the key deterioration elements associated with maintenance and repair;
- Develop a framework to store, manage, and retrieve the information; and
- Develop an organized data structure for evaluation purposes.

Operation and maintenance (O&M) of a building system is one of FM functions. Maintenance and repair is an O&M sub-function, and is the focus of this research. The dynamic nature of a facility to be reflected via an O&M function is divided into processes and sub-processes.

1.6 RESEARCH METHODOLOGY

The research objective is to develop a methodology for facility management model for maintenance and repair for office buildings. The following steps will follow to achieve the research objective:

1. Study previous and current research works in the same area intensively. Review the current research in the maintenance and repair of facilities, firms related with database of maintenance and repair components, and property assessment condition.
2. Study the previous research recommendations and utilize them in the research objective in order to realize them.
3. Analyze and understand the previous work's problem by studying all elements that had impact on the research objective.
4. Identify solution requirements or expectations: Annual Maintenance and Repair Ratio (AM&RR) base the core of the solution to any five or 10-year maintenance program based on property condition assessment. A comprehensive and integrated facility management model for maintenance and repair components is the solution and expectation.
5. Design and implement the solution: a set of processes should be considered in the design of the research objective. The trusty benchmarks, approved property assessment condition, and reality design method that simulate and evaluate the behavior of the maintenance and repair components during the life span of facility.
6. Develop a ten years strategic plan for maintenance and repair components

7. Develop a computerized prototype facility management model for maintenance and repair according to the developed research methodology.

1.7 THESIS STRUCTURE

Chapter -1- Introduction: This chapter describes the general meaning of Facility Management (FM) and Information Technology (IT). It also gives the definitions of Facility, Building, Space, and Facility Management (FM). The history of IT during the last century is explained and the objectives of this study are clearly defined.

Chapter- 2 - Facility Management Domain (Part I of the Literature Review): This chapter explains the construction industry in Canada from 1980 until 2002. It shows the relationship between the Gross Domestic Product **(GDP)** and expenditure on construction. It also defines and explains Life Cycle Costing **(LCC)** for different buildings along 40 year-spans. The Facility Management function and its elements are well-defined with illustrative figures. The scope of Maintenance and Repair **(M&R)** is explained along with all the related terms.

Chapter-3- Information Technology Domain (Part II of the Literature Review): This chapter focuses on IT Life-Cycle information through the various project stages, including the exchange of information and its flow for the benefit of Operation and Maintenance Management (O&MM) during the usage stage. It explains the different types of Information Models that have used FM. The improvements of the various IT tools and techniques are also noted. The standardizations and specifications represented by the IAI (IFC) and ISO-STEP for the development and compatibility of IT systems within FM are depicted. Finally, 19 models developed between 1991 and 2011 are highlighted, including their objectives, model types, architectures, and significant observations.

Chapter - 4- Deterioration: This chapter explains the deterioration of buildings during the usage stage, which is the main stage in a building's life cycle. The condition performance curves for buildings during their service life contain the most important modeling data, and can be used to develop a probability-based Markov Chain framework for repairing deterioration. Actual data collected on building conditions through annual assessments. The principles of deterioration, Markov Chain application, and their integration with the goal of modifying a comprehensive approach are explained in detail.

Chapter - 5 - Model Development Methodology: This chapter describes the methodology of the research, identifying the main problems for FM and decomposing the O&M into its sub-functions. An information model to overcome the identification problems for M&R is proposed.

Chapter – 6 – Developing a Facility Management Model for Maintenance and Repair (FMMMR): This chapter explains the development of an information model and a prototype model by incorporating all of the requirements from the information technology tools and the facility management applications to solve the problems identified in previous chapters.

Chapter – 7 – A Prototype Model and Case Study: A case study is applied, using the prototype model to examine the proposed Project Information Model. Oracle 8i and developer 6 will be used to structure the information model.

Chapter – 8 – Conclusion, Contribution, and Recommendations: This chapter discusses the results obtained by applying the prototyping model. The chapter also explains the result of the experience gained from this study, and indicates some recommendations for future research and practical applications. Figure 1-1 illustrates the research structure.

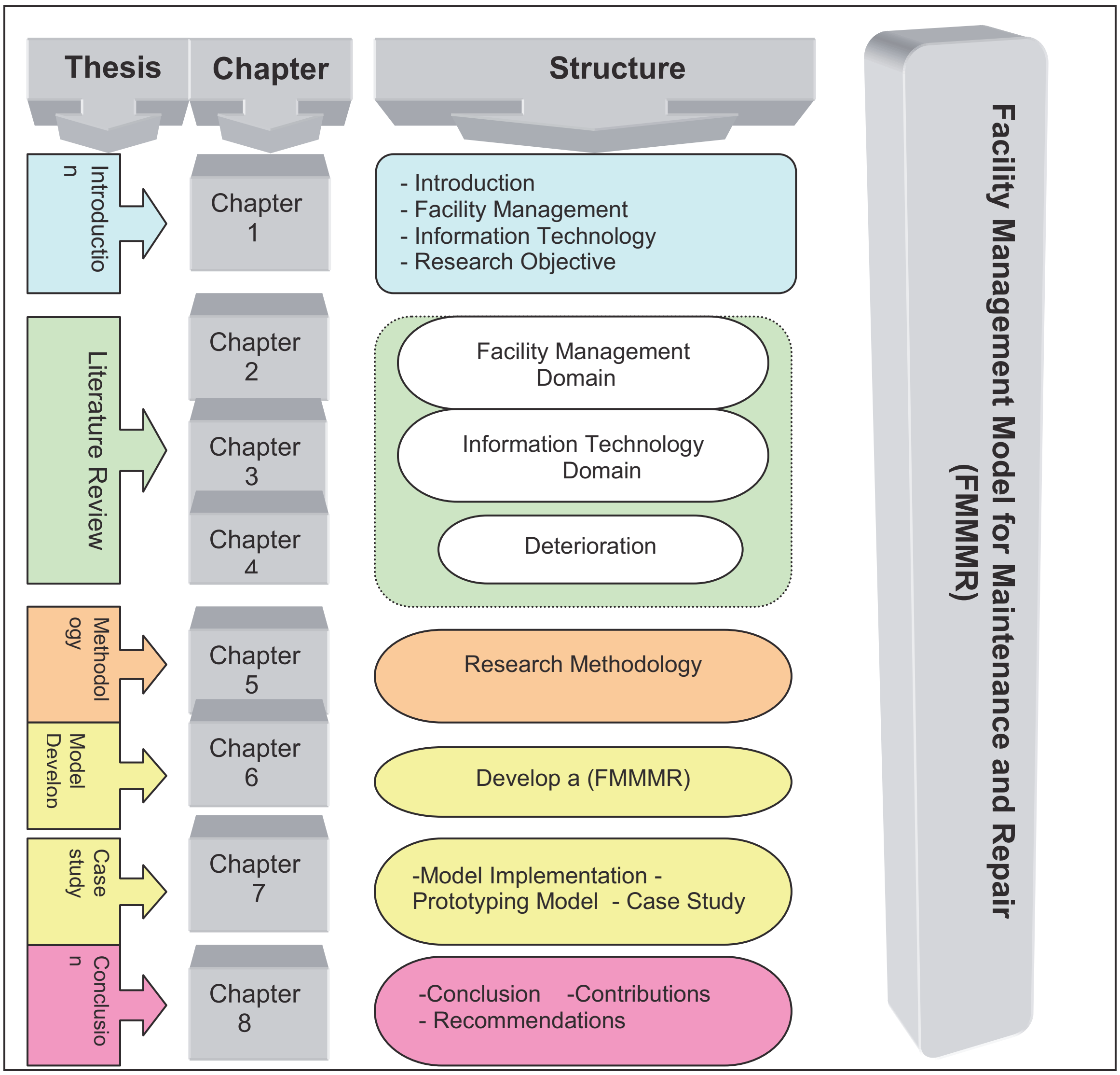


Figure 1-1 Thesis Structure

1.8 CONCLUSION

Chapter 1 briefly presents Facility Management (FM), Information Technology (IT), and the relationship between them -- the main domains of the research. Each is very broad, complicated, and is affected by different disciplines. A brief history, the characteristics and elements that are involved and the effects on each are also briefly explained.

The aims and goals of this research are very clearly presented. Research methodology briefly explained and followed by thesis structure.

CHAPTER TWO

LITERATURE REVIEW: FACILTY MANAGEMENT DOMAIN

This chapter examines the status of the construction industry in Canada from 1991 until 2010. It derives the relationship between Gross Domestic Product **(GDP)** and expenditures on construction work. In addition, it defines and explains the Life Cycle Costing **(LCC)** for different buildings over 40-year spans. The facility management functions and its elements are clearly explained with illustrated figures. Finally, the scope of Operation and Maintenance Management **(O&MM)** are explained in detail with all of the related terms.

2.1 CONSTRUCTION WORK AND GDP IN CANADA

The construction sector in most countries is a dynamic sector among other economic sectors. Construction work has an impact on many other sectors such as fishing; agricultural; highways and roads; religion; the public or semipublic sector, institutions, and so on Most of these sectors need buildings for office, warehouses, places of worship, small storage, or other premises.

The Canadian economy is always affected by the construction sector. It grows if the construction sector is healthy and has a positive economic value. Table 2-1 shows the relationship between the Canadian Gross Domestic Product (GDP) at market price and the expenditures for construction work during the period 1991 - 2010. It shows the ratio of the value of the construction works linked to the GDP. The minimum ratio is 15%, the maximum is 20%, and the average is 17.4% throughout these 20 years. Bjork [1997] showed that Canada spent $ 52 billion on building construction and repairs, while the amount spent on maintenance and repairs to buildings was $ 8.5 billion [Bjork 1997]. In the United States the number is 10-times higher. Another study shows that the cost to operate and maintain a facility varies between 60-85% of its total ownership cost [Bjork 1997]. The construction industry is a single important factor. Its needs are focused on various disciplines. In the mid of last century, many fields were developed to improve productivity and efficiency, such as cost and time control, planning and scheduling of design and construction phases.

Year	1991	1992	1993	1994	1995	1996	1997
GDP (M $)	685,367	700,480	727,184	770,873	810,426	836,864	882,733
Construction (M $)	114,148	111,272	111,269	123,321	121,592	129,351	154,737
Cons. %	17	16	15	16	15	15	18
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
GDP (M $)	914,973	982,441	1,076,577	1,108,048	1,152,905	1,213,175	1,290,906
Construction (M $)	161,790	171,431	181,748	189,978	196,585	208,090	229,755
Cons. %	18	17	17	17	17	17	18
Year	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	
GDP (M $)	1,373,845	1,450,405	1,529,589	1,599,608	1,527,258	1,624,608	
Construction (M $)	255,596	283,382	301,885	313,574	269,394	291,161	
Cons. %	19	20	20	20	18	18	

Table 2-1 The GDP and Construction Work in Canada “1991 - 2010” (Millions of dollars), Statistics Canada (CANSIM) Table 380-0017, http://estat.statcan.gc.ca/cgi-win/cnsmcgi.exe?Lang=E&EST-Fi=EStat/English/CII_1-eng.htm, accessed: June 16, 2011

2.2 LIFE CYCLE COST (LCC)

Stephen and Alphonse [1995] define **Life Cycle Costing (LCC)** as “an economic assessment of an item, area, system, or facility that considers all the significant costs of ownership over its economic life, expressed in terms of equivalent dollars” [Stephen and Alphonse [1995]. LCC is a technique that satisfies the requirements of owners for an adequate analysis of the total costs.

LCC has been used in many fields of construction. It uses an economic assessment of design alternatives by considering all of the income and expenditure over an economic life, expressed in equivalent dollar terms. The annual operation and maintenance costs can also be estimated by LCC for budgeting purposes. The consequences of decisions can also be assessed by LCC [Stephen and Alphonse [1995].

Flanagan and Ferry (1991) and Zhang (1999) divide the building life span for LCC analysis into eleven sections: Investment Conception; Feasibility Studies; Detailed Design; Design Review; Government Approval; Tendering & Quotations; Contract Management; Commissioning & Run-Up; Post-Completion Project Appraisal; Operation & Maintenance; and Demolition or Replacement.

Figure 2-1 illustrates the Operation & Maintenance (O&M), which is the 10^{th} section of this life cycle. O&M is actually the longest period for any facility among the other stages, and one that has the least uncertainty. The elements and functions of O&M of a facility, such as Maintenance and Repair (M&R), will be studied later in this chapter, and are within the aims and goals of this research.

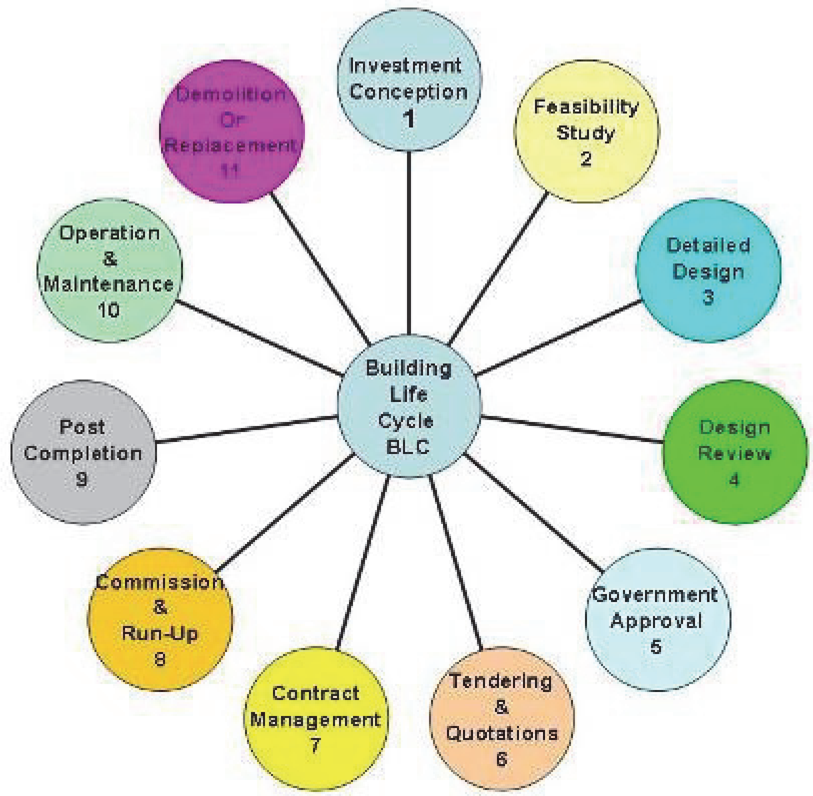


Figure 2-1 Building Life Cycle [Zhang 1999]

2.3 LCC STUDIES FOR DIFFERENT BUILDINGS

There have been few studies on the subject of LCC, compared to the other studies regarding the design and construction stages. Flanagan studied LCC for a few buildings during the 1980s is considered to be the 'Bible' for all facility management studies. BOMA gives a good view of different expenses for the Operation and Maintenance (O&M) stage, without relationship to the initial cost (Capital Cost) during the Design or Construction stages.

Flanagan [1989], in his book “Life Cycle Costing theory and practice”, divides the costs for the purpose of a building’s LCC into five cost categories: Capital Cost; Energy; Maintenance; Cleaning, and Rate [Zhang 1999]. The life span for the different buildings in this study was 40 years. The buildings included in this study were: a residential facility for seniors; a primary school; a secondary school; and office buildings.

Figures 2-2, 2-3, 2-4, and 2-5 depict the percentage of each cost category over the 40 years of the life span. In fact, the cleaning, energy consumption, rate (Bank profits), and maintenance and repair expenses are elements of operation and maintenance expenses. The following significant factors can be discovered by comparing the expenses of maintenance and operation against the capital cost: the operation & maintenance expenses among different buildings were: 58%; 55%; 56% and 58%, while the capital cost for the same buildings were 42%; 45%; 44%; and 42%. In addition, the following conclusions could be derived from (figures 2-2, 2-3, 2-4, 2-5):

- The O&M costs are the highest costs during the LCC of a building.
- The operation cost, which includes the energy and cleaning costs, are the highest costs over the LCC of a building (counted as part of O&M).
- The span time for the O&M stage is the longest span of all the stages.
- The O&M stage consists of different functions and sub-functions.

Consequently, the O&M stage is the most important stage of all the Life Cycle stages of any building. This implies that for cost-control, it is a risk-warning point uncertainty factors, annual expenses, healthy and worthy buildings all must concentrate on the O&M stage which is the essence of “Facility Management (FM)” and the goal of this study.

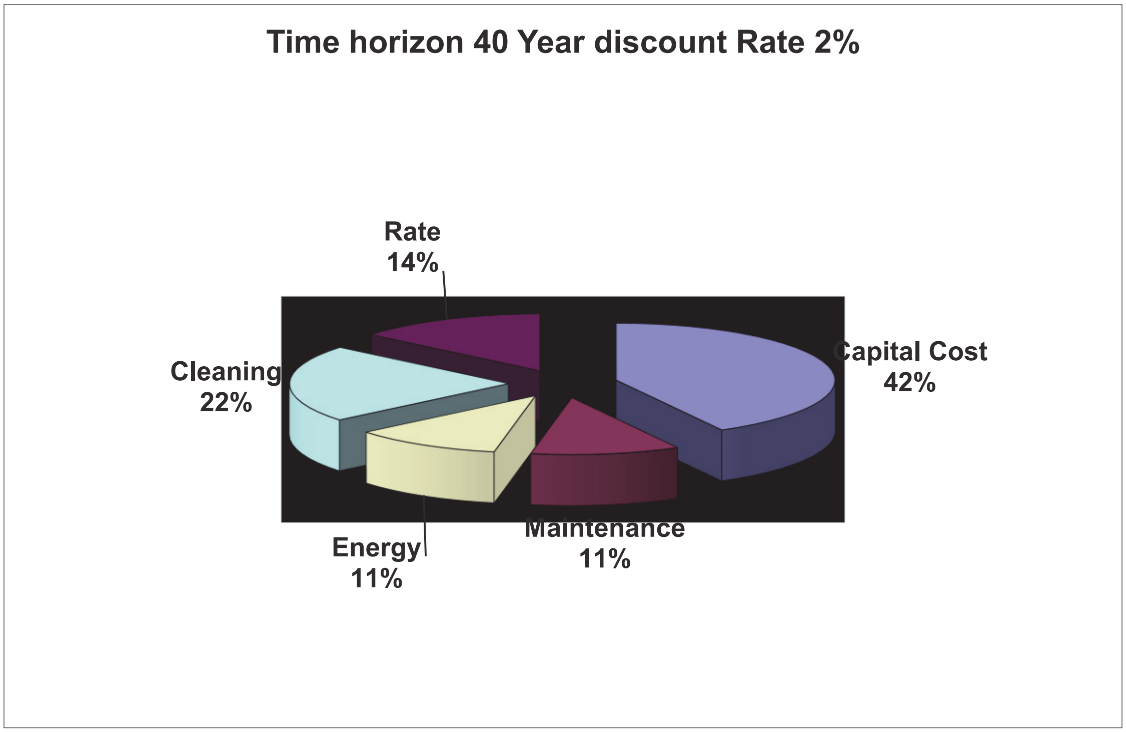


Figure 2-2 Senior citizens residence [Flanagan 1989]

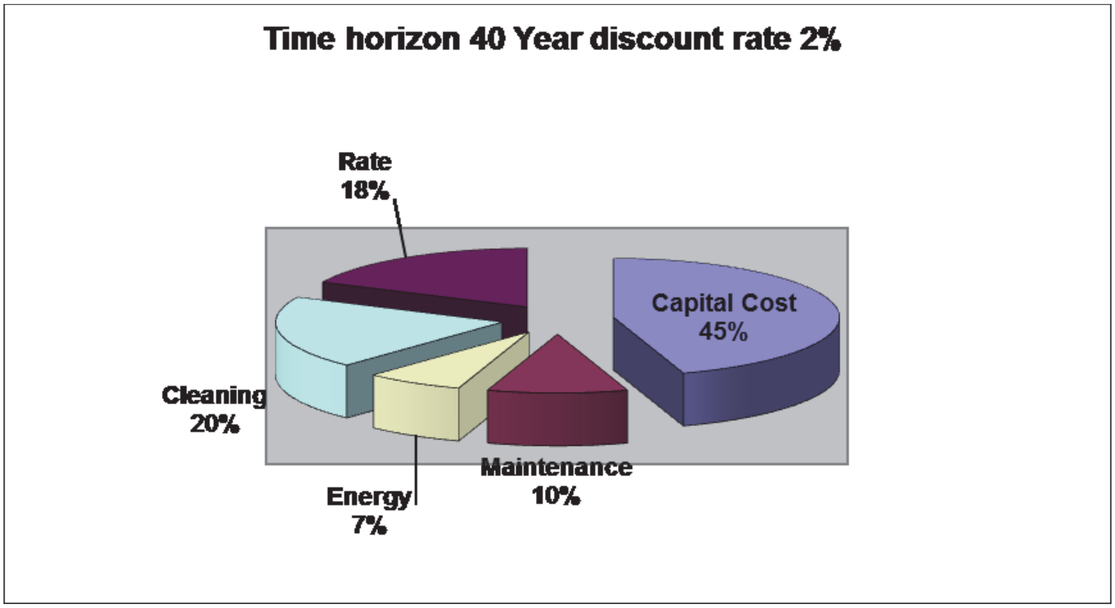


Figure 2-3 Primary schools [Flanagan 1989]

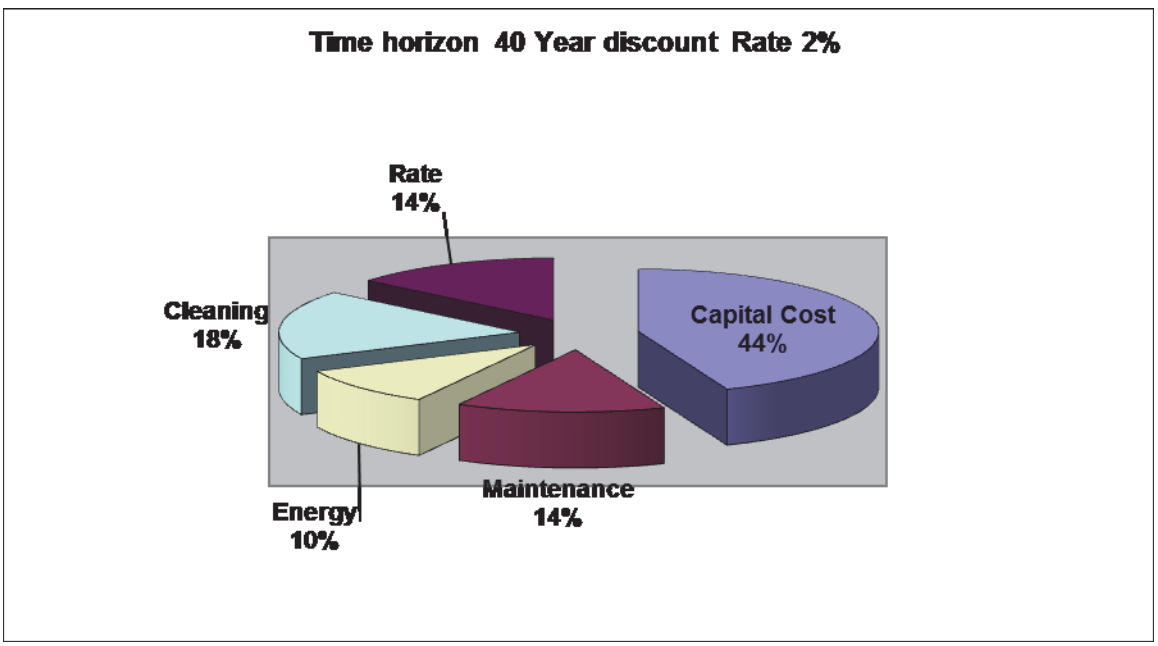


Figure 2-4 Secondary schools [Flanagan 1989]

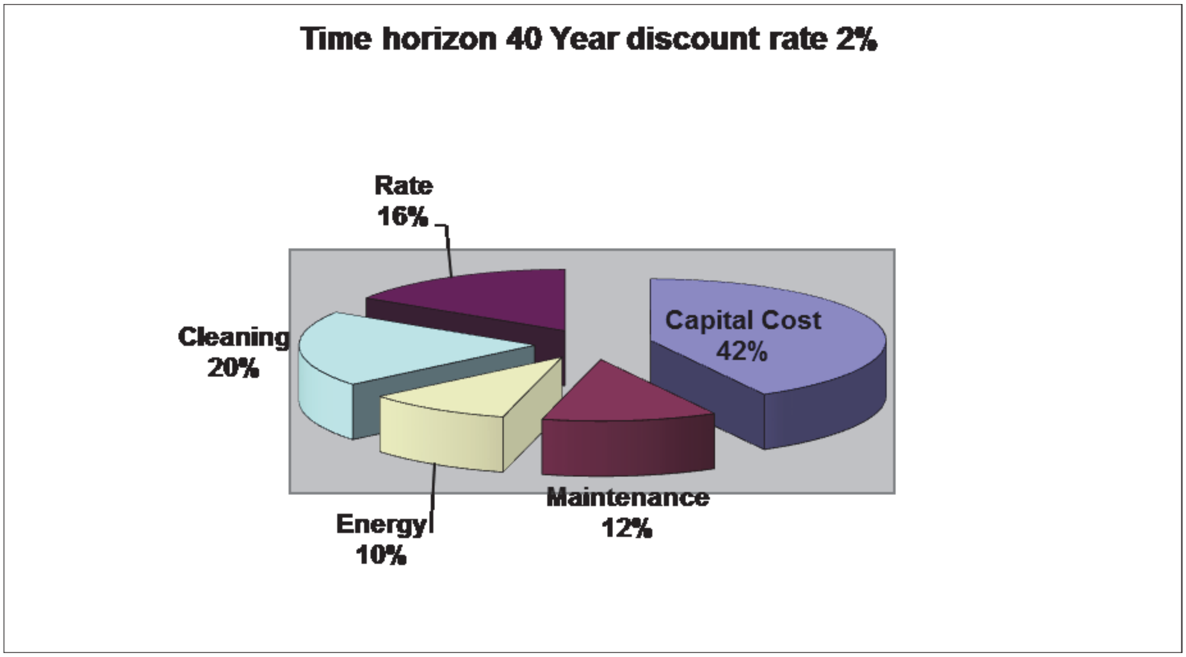


Figure 2-5 Office building [Flanagan 1989]

2.4 FACILITY MANAGEMENT FUNCTIONS

The significance of the (O&M) stage during the life cycle of any building was made very clear in the last section (2.3), and indicates the need to manage this stage in a cost efficient manner.

Traditionally, (FM) has been considered primarily to comprise facility maintenance and operation tasks [Maria 2000]. The FM mission is to improve and add value to a business by ensuring and improving the quality of all of the environment processes for the O&M of a facility.

The North American Facilities Management Domain Committee of the International Alliance for Interoperability (IAI) has developed a Facility Management Function hierarchy as a guideline for developing IAI Facility Management projects [Yu et al. 1999b].

Whitten et al., [2001] define a **Function** as "a set of related and on-going activities of the business. There is no start or end for a function; it continuously performs the work as needed". For example, the FM system includes the following functions (sub-systems): Operation & Maintenance Management (O&MM), Property Management, and Services. Each of these functions may consist of dozens or hundreds of discrete processes to support specific activities and tasks.

Figure 2-6 identifies the FM functions, here classified into three basic categories: (O&MM), Property Management, and Services [IFMA 1997 and Yu et al. 1999b]. O&MM is classified further into three related sub-categories: (1) Monitoring and Tracking, (2) Maintenance, Alteration, and Repair, and (3) Space Management. Moreover, the three sub-classifications are further divided to reflect more specific details. For example, Maintenance, Alteration, and Repair are divided into: Procurement and Installation, Preventive Maintenance, Project execution, and Problem Identification and Allocation [Yu et al. 1999b].

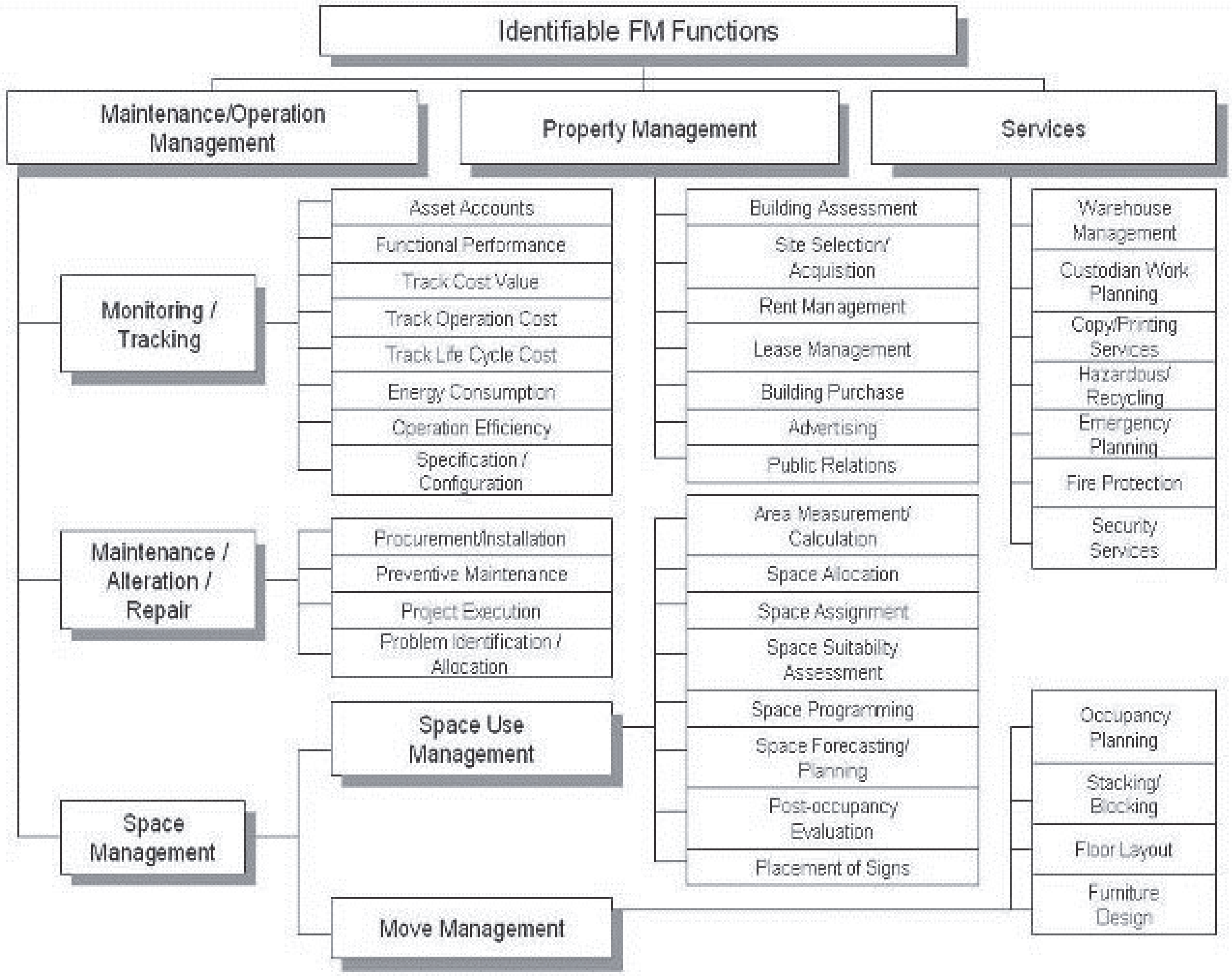


Figure 2-6, Facility Management Functions [Yu et al. 1999]

2.5 FACILITY MANAGEMENT ELEMENTS

The North American FM Domain Committee of the IAI developed the hierarchy of FM elements as shown in Figure 2-7. The FM elements are classified into Building Systems and Non-building Systems, while Human Resources are considered as a parallel element. Most of the FM elements are those of operation and maintenance that need to be taken care of environmentally during the facility life cycle. Maintenance and Repair (M&R) is a sub-function of O&M

which is the most strategic element in FM [Teicholz and Takehiko 1994; Maria 2000]. This research will focus on the M&R sub-function with respect to the facility management elements.

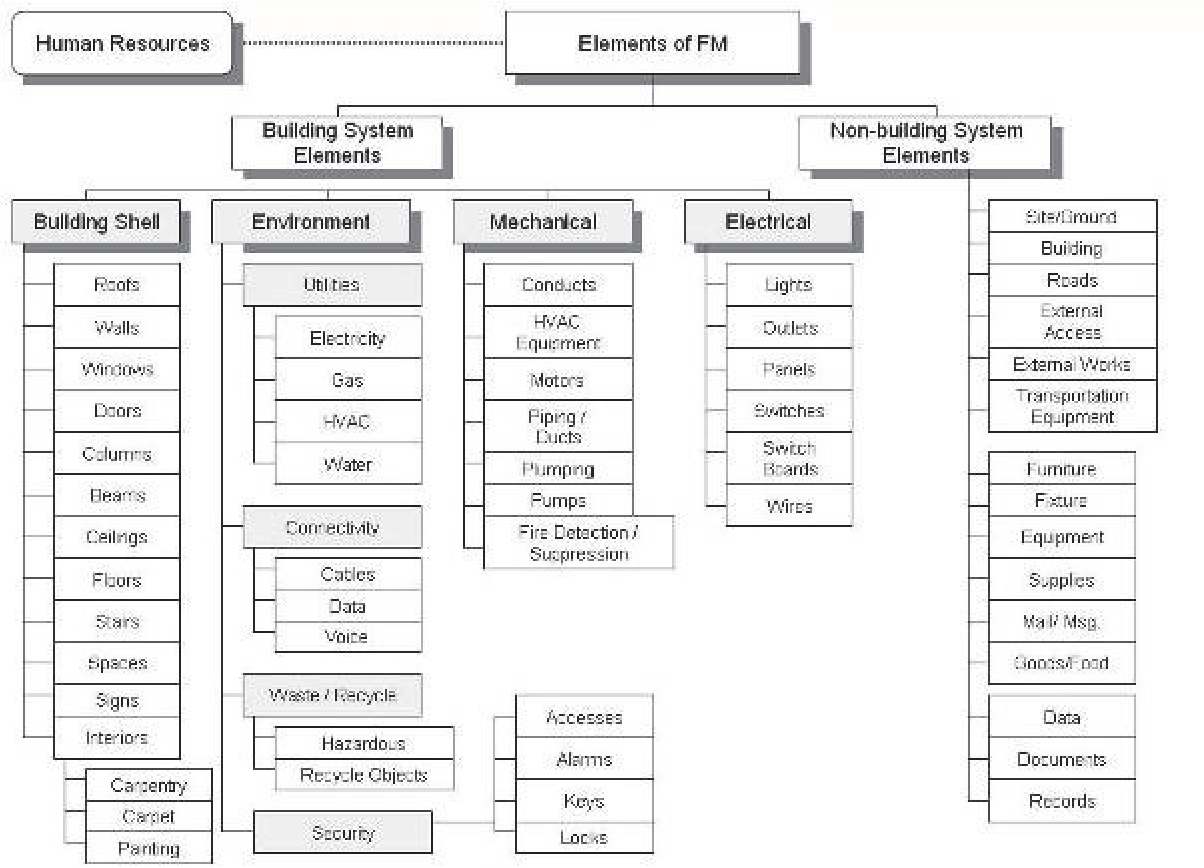


Figure 2-7, Facility Management Elements

2.6 SCOPE OF OPERATION AND MAINTENANCE MANAGEMENT (O&MM)

The building operations and maintenance stage is usually the longest and most stage of building's lifecycle, ultimately exceeding the total cost of initial design and construction. Targeting these operations and maintenance costs and the cumulative sustainment and renewal costs can have a significant effect on reducing total cost of ownership. This requires planning and correct timing of work, to reduce the adverse affect of differed maintenance and repair which lead to accelerated deterioration and restoration costs correcting distresses and maintaining a quality condition level through proactive facility management [M. Grussing and L. Marrano 2007].

Svensson [1993] defines the elements of O&MM as follows: **Operation** is “the effort required to supply the property with heating, water, and electricity and to maintain both the outside and inside of the building”. **Maintenance** is “the work needed to preserve the function of the building, the technical and aesthetical standard and the value of the building”. **Management** is “the organization and coordination of the activities of an enterprise in accordance with certain polices and in achievement of defined objectives”.

Maintenance actions during the O&M stage of the life cycle are particularly important to avoid any delay in facility use. The continuing efforts to find ways to improve staffing, operational efficiency and productivity are the other important elements. Good management practices have an effect similar to that of quality assurance during construction; to enhance the likelihood that performance will indeed conform to design intent. This responsibility for good practices rests primarily with the facility manager and maintenance staff. Training of maintenance staff, use of appropriate material, and the application of a new computerized facility management system will support condition monitoring, documentation management, reduce cost and time, and make it possible for maintenance scheduling to be linked with other building systems [Stephen and Alphonse 1995].

Facilities must accommodate anticipated new communication, building automation, and energy saving technologies. Consideration must be given to the changing patterns of space use.

The primary goal of O&MM is to keep the facility systems in the best possible condition at the lowest possible expense [Maria 2000].

The main objectives gained in daily activities by use of quality O&MM are:

- Reduced frequency of unscheduled breakdowns and of the downtime of critical equipment and systems, by using effective preventive maintenance programs;
- Enhanced maintenance efforts;
- Reduction of overall maintenance expenses;
- Rehabilitation of facility systems, by analyzing various strategies; and
- Control of the budget, by comparing the maintenance expenses and the expected equipment performance.

Three types of maintenance programs are implemented with any facility as follows:

- **Corrective Maintenance** is the oldest and most traditional method followed to correct defective items. It is the day-to-day repair or replacement of defective items.

- **Preventive Maintenance** is the planned and controlled program of continuous inspections and corrective actions taken to ensure peak efficiency and minimize deterioration. A successful preventive maintenance program requires constant performance reports that indicated the percentage of preventive work orders completed in the scheduled time frame.
- **Predictive Maintenance** is an approach developed during 1970s for maintenance work. All the economic studies for the facilities components are prepared and then, through these studies, the history of the facilities components and their expected times for replacement can be predicted [Flanagan and Ferry 1991]. Predictive maintenance relies strongly on the diagnosis of in-service performance and the decision criteria for choosing maintenance work. While the first aspect defines the actions recommended for a given condition state during the service life, the seconds lead to the effective carrying out of those actions [I. Flores-Colen et al. 2010].

It has become unusual to find an organization in a commercial building that is not using a computerized maintenance management system for the change management of facilities and services.

CHAPTER THREE

LITERATURE REVIEW: INFORMATION TECHNOLOGY DOMAIN

3.1 INTRODUCTION

This chapter focuses on impact the information technology on life-cycle information throughout project phases, with a focus on the exchange of information and its flow for the benefit of O&MM during the usage stage. In addition, this chapter examines four types of information models that are used for FM functions. The improvements in the different IT tools and techniques are also considered. The standardizations and specifications of the International Alliance for Interoperability (IAI), Industry Foundation Classes (IFC) and the International Organization for Standard-Standard for the Exchange of Product model data (ISO-STEP) are depicted for the development and integrating of IT systems within FM functions. Finally, nineteen different information models used over the last 21 years (1991-2011) are highlighted. The objectives, model types, model architecture, and important observations will be discussed in brief.

For decades, much of the efforts of the construction Information Technology (IT) research community have been concentrated on developing models for information exchange and sharing in building construction. These models have focused primarily on design and construction, whereas very little research has been done in the FM field [Bourdeau, et al. 1991; Wix and Ottosen 1999].

FM is a new field, which has an inter-relationship to the design, construction, and property disciplines. It is important to stress the inclusion of O&M, since this information is used during the FM stage, but that information is only generated during the design and construction stages [Bjork 1997].

Different types of information are used in various management stages, such as Administrative Information (AI), Financial Information (FI), and Technical Information (TI). Each of these is needed for a variety of tools and techniques. AI is needed for planning, organizing, guiding, coordinating and controlling the FM. FI is needed for planning and controlling the budget of the FM project, and TI is required to carry out the O&M [Svensson 1993].

Facility managers have had few tools to play with. Their options have been either to search the literature or intelligent computer software for help in estimating the decision-making process for the optimum timing and the best conditions under which to maintain, repair or replace aging and failing systems.

This study will help facility managers and owners in their future decision making by using an Integrated Information Technology System.

3.2 IMPORTANT TERMS AND DEFINITIONS

Björk [1997] defines **Information Technology (IT)** as **"**the use of electronic machines and programs for the processing, storage, transfer and presentation of information". Construction planning and scheduling, engineering drawings, bills of quantities, facility management, and other applications have all been using IT to implement project activities.

Data "is composed of known facts that can be recorded and that have implicit meaning" [Elmasri and Navathe 2000]. The names, telephone numbers, and addresses for the people we know are examples of data that we can record.

A **Database** “is a collection of related data” [Elmasri and Navathe 2000].

A **Database Management System (DBMS)** “is a collection of programs that enables users to create and maintain a database” [Elmasri and Navathe 2000]. A DBMS is a general base used by various software packages.

Information “is data that has been refined and organized by processing and purposeful intelligence” [Whitten et al. 2001].

The difference between data and information is that data is a by-product of doing business, while information is a resource created from the data to serve the business. [Whitten et al. 2001]

Prototyping “is a technique for quickly building a functioning, but incomplete model of the information system using rapid application tools” [Whitten et al. 2001]. Prototyping is an important research process and makes use of conceptualization. This research will develop a prototype FM model for maintenance and repair for office building.

3.3 INFORMATION LIFE CYCLE THROUGH PROJECT PHASES

To support effective FM much but not all of the project information generated from the early project stages will be useful for the later stages [Yu et al., 1999b]. This information could be drawings, pictures, charts, technical documents, specifications, bills of quantity, etc [Ruppel et al., 1994]. Each of these types of information represents very different points of view towards the end users. The end users are the building owners and facilities managers.

ISO/TC59 (1993) divides a project into three main stages: Realization, Use, and Demolition. The Realization stage is divided into three further stages: Initiation, Design and Construction [Bakkeren and Tolman 1995]. See figure 3-2.

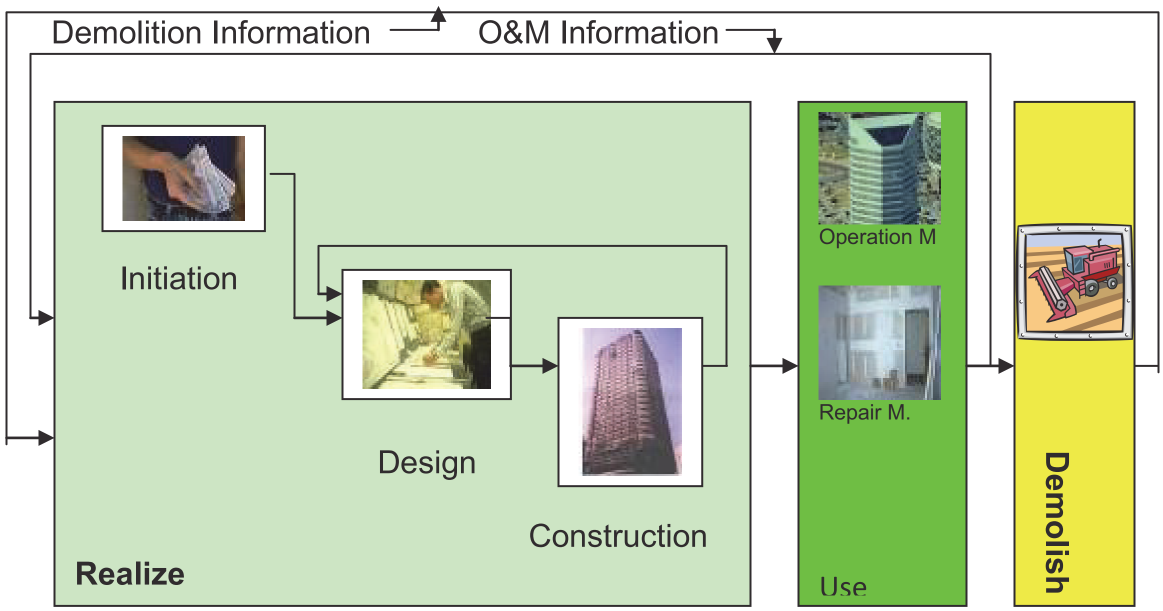


Figure 3-1 Facility phases and information exchange [Bakkeren and Tolman 1995]

Information exchanged among the main stages and between the sub-main stages is an attribute of the modern information system. The most important part in the information exchange is the backward exchange. The backward exchange contains the operation, maintenance and demolition requirements for the main stages, and at the same time it contains the design and construction requirements for the sub-main stages.

A large amount of information is transferred from one stage to another, while a certain amount of controlled information will be lost through this transfer process.

Figure 3-3 illustrates the information transferred and lost through the different stages of the project information flow.

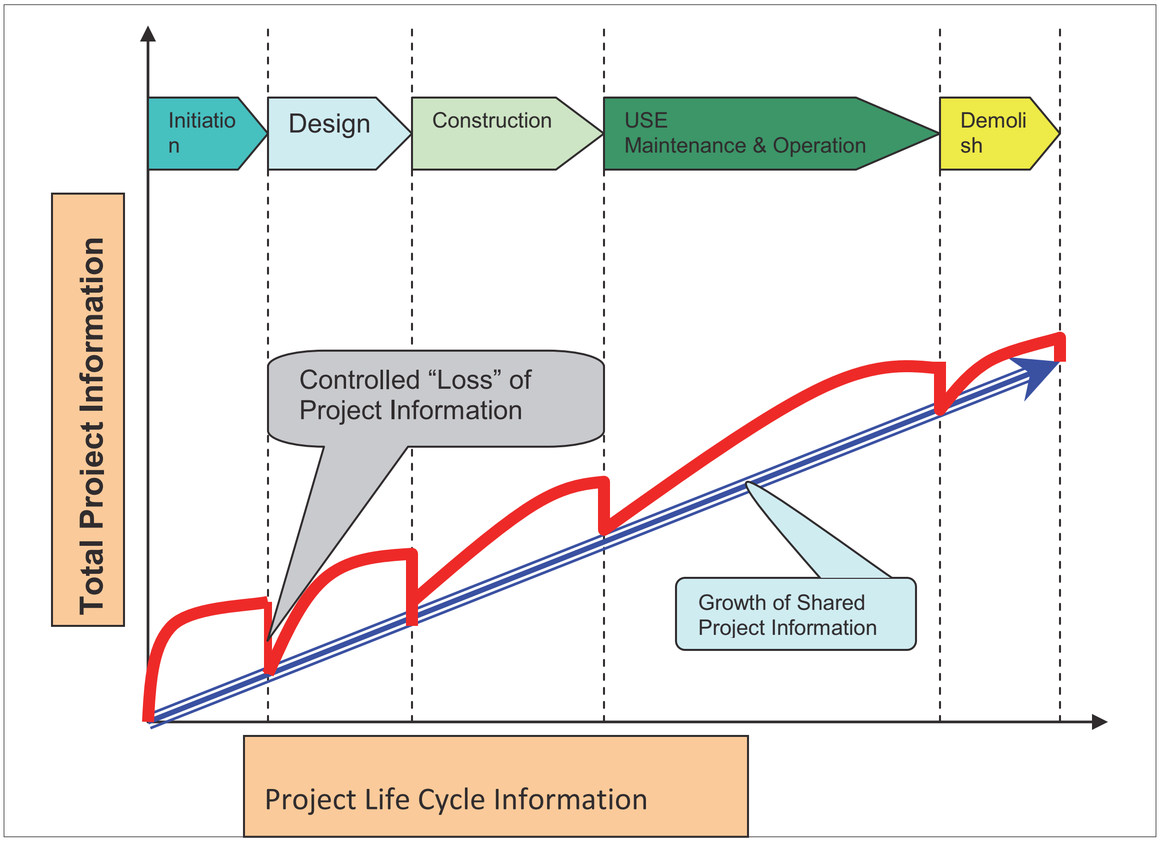


Figure 3-2 AEC/FM Project Information Life Cycle [Yu et al. 1999b]

3.4 MODEL REQUIREMENTS

Information models for AEC/FM should be able to meet all requirements of the users that work in facility management. In other words, the model must be easy to handle and operate efficiently, which means they must meet many different requirements [Peters and Udo 1995, Ojwaka 1999]. A brief list of the requirements would include:

- Handling multimedia data with different possible views;
- Support collaborative group work;

- Support of the property requirements to enable the delivery of the defined services;
- Integration of existing IT-tools;
- Comprehensive coverage of all stages in a building's life cycle;
- Standardization and specification of data exchange and management;
- Avoiding redundant information; and
- Being flexible enough to follow the developments in both FM and IT tools.

3.5 TYPES OF INFORMATION MODELS

A **Model** is "a representation of reality. Models can be built for proposed systems or for existing systems. Both are needed as a way to document business requirements or to better understand those systems" [Whitten et al. 2001].

A model should be able to be updated regularly to include new topics or new information. This updating feature allows a user to go through the model in a step-by-step manner and so should be user-friendly.

Information models should include all the facts regarding products and processes that are needed to construct the systems they model [Michael and Hamid 1994].

3.5.1 DATA MODEL

Recently, integrated database models have been used widely as the most effective method to integrate computer programs in the life cycle of a building [Andrej and Danije 2002].

A Data Model "is a technique for organizing and documenting a system's data". Data modeling is sometimes called database modeling or information modeling, because a data model is eventually implemented as a database. An example of a simple data model, known as an Entity-Relationship Diagram (ERD) represented in figure 3-4.

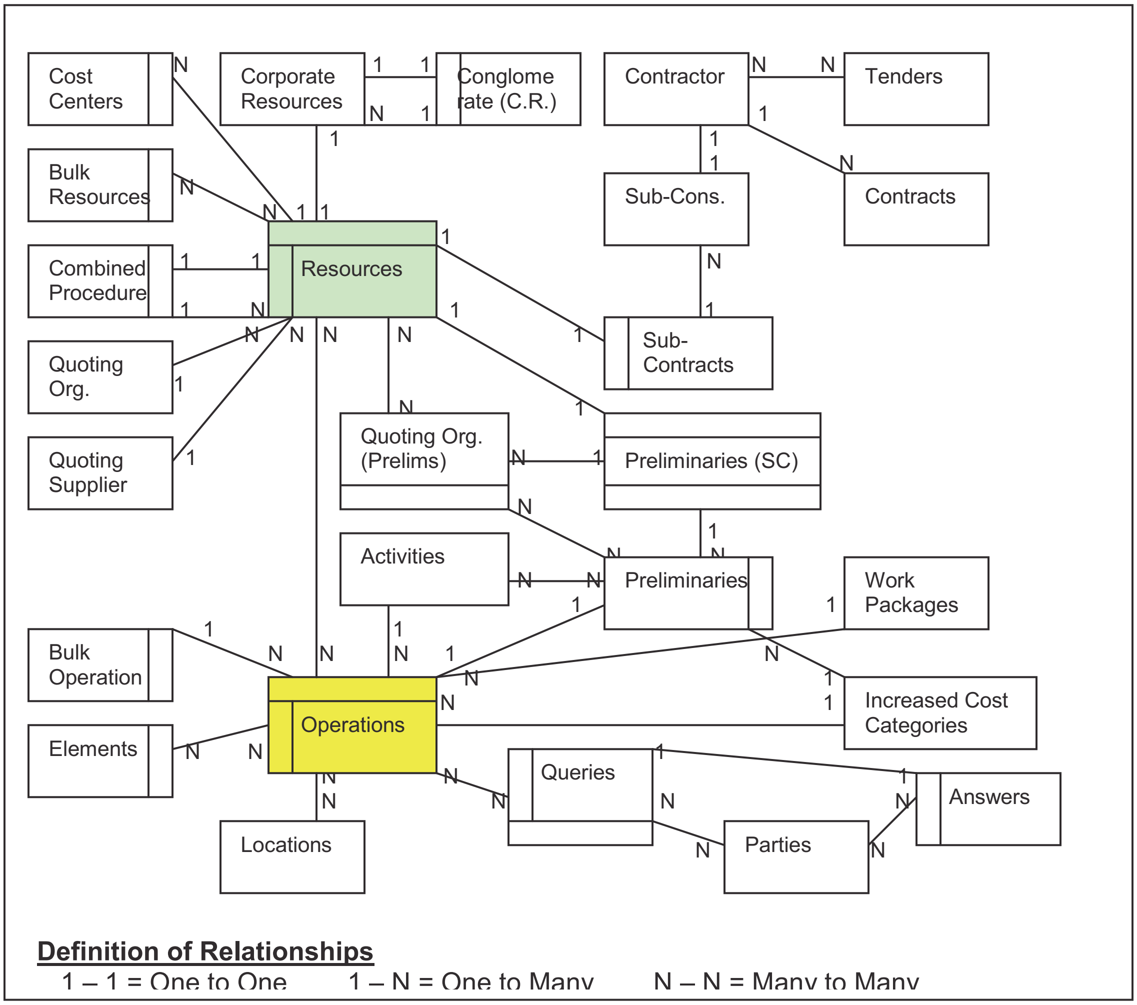


Figure 3-3 Conceptual Data Map (Entity Relationship Diagram) [Martin 1993]

A data model describes the structural and behavioral properties of the system [Britts, 1994] and [Svensson 1998].

3.5.2 PRODUCT MODEL

A **Product Model** "is a conceptual structure used to organize the project participants". An information model can be built effectively by describing the engineering characteristics and supporting the communication between computer-aided activities by storing all the information that needs to be exchanged about a product throughout its life cycle. Because of its potential and characteristics, many researchers have adopted the building as a product concept to sustain the exchange of sharing data. Researchers have defined a product model in different styles.

The International Organization for Standardization [ISO] defined a **Product Model** (in 1989) as “the totality of data elements, which completely defines a product for all applications over its expected life cycle. Product data includes the geometry, topology, tolerance, relationship attributes and features necessary to completely define a component part or an assembly of parts for the purpose of design, analysis, manufacture, test inspection, and product support” [Maria 2000].

3.5.3 PROCESS MODEL

A **Process Model** “is a technique for organizing and documenting the structure and flow of data through a system’s processes and/or polices, and the procedures to be implemented by a system’s processes. Logical process models are used to document an information system’s process focus from the perspective of the system owners and users [Whitten et al. 2001].

3.5.4 PROJECT MODEL

A **Project Model** “is a system that provides an integration of the products, processes, and organizational aspects for an Architecture, Engineering, and

Construction (AEC) project to provide richer semantics for project management" [Stumpf et al. 1996].

A project model contains the relationships between information about real-life objects in a project and those real-life objects themselves. The conceptual model will provide structuring to store and organize the information about the real-life objects [Luiten, et al. 1993].

Figure 3-5 illustrates an example of a simple project model. The figure includes the Textual conceptual schema language-Graphical (EXPRESS-G) diagram that shows the relationships between real-life objects, information, conceptual models, and modeling languages

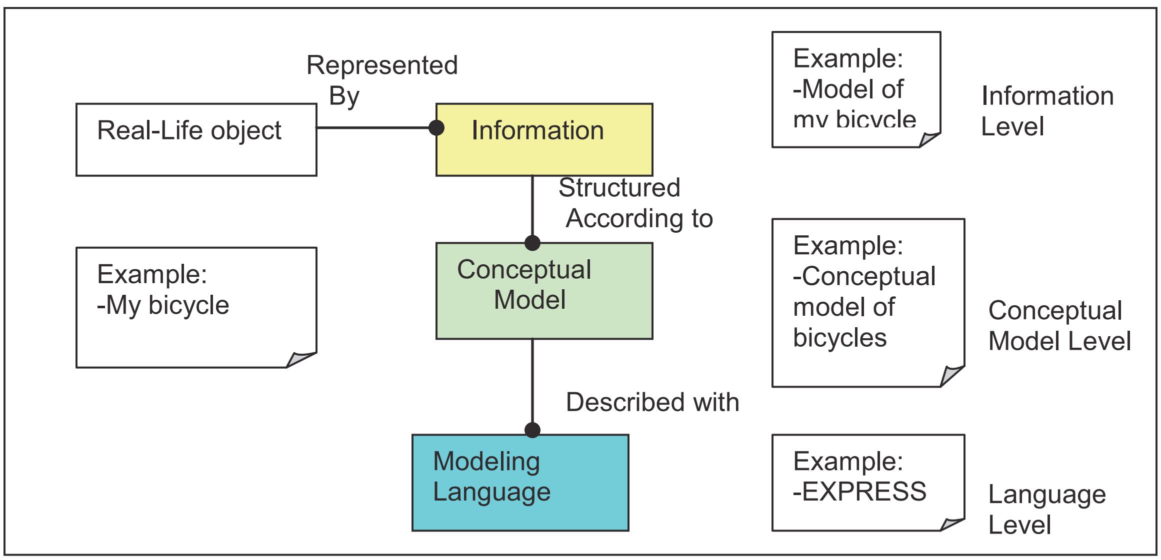


Figure 3-4, Simple Project Model with three levels of abstraction [Luiten, et al. 1993]

.3.6 STANDARDIZATION AND SPECIFICATIONS

Today's formalization and standardization of data exchange protocols between various project roles and applications in the building industries should provide better communication and support to business activities. Improved communication will increase quality and productivity, and reduce costs, delays, and contractual disputes [Mahmoud et al. 2002].

Building owners and managers have been facing two major problems, and they need to solve them in an information model that can support the technical processes. The first is managing the interaction between the processes, which takes place in the course of projects and in independent processes of a project's work. The second problem lies in the interaction between the technical processes and the business activities processes. Most of the information models supporting project works need to be expanded with respect to the technical processes [Wolfgang et al. 2000].

A standard information model always contains several modules, which support different tasks. For example, a Generic FM Process Model consists of: a Core Process, a FM Configuration Process, a FM Execution Process, and a FM Control Process [Svensson 1998]. However, international developments in standardization and specification are advancing rapidly and are leading to emerging solutions for product definition, product data communications, enterprise integration and co-operation [Debras et al.1998]. In fact, two major efforts in developing standards for building data representation and exchange are ISO-10303, referred to as STEP, and IAI/BuildingSmart International. The main concepts of IAI and STEP and the most important elements and applications are presented next.

3.6.1 IAI & IFC – SCOPE AND ARCHITECTURE

In 1994, a group of U.S. companies that were auto-CAD users and developers started an organization whose goal was to discover, standardize and promote the strategic importance of integration methods. This organization later became the IAI (International Alliance for Interoperability) [Svensson 1998], and in 2008 it became BuildingSmart International, with several regional chapters. Membership In BuildingSmart International is open to a range of companies in the industry, especially in the fields of Architecture, Engineering, Construction and Facility Management (AEC/FM). Membership types include information providers, universities and research organizations, clients, vendors, consultants, contractors, and product manufacturers. BuildingSmart International develops and publishes a common semantic definition of building product models called Industry Foundation Classes or IFC. These allow for system interoperability among industry processes in Architecture, Engineering, Construction/Facility Management (AEC/FM) by making it possible for the computer applications used by all project participants to share and exchange project information [Debras et. al.1998, Froese et al. 1998, Svensson 1998, and Yu et al. 1999b].

IFC function as a universal language to improve the communication, productivity, delivery time, project cost, building elements, geometry, material properties, schedules, document organization, and quality throughout the design, construction, operation and maintenance life cycle of building project objects, and represents the information requirements common to all industry processes [IAI 1996]. In the simplest form of interoperability, the IFC project model is communicated from one software package to another in a data file (e.g. using ISO 10303 part 21 for material). Upon receipt of the data file, the software will re-create the project model for further processing. The IFC data model also enables a centralized database.

BuildingSmart International has a strong relationship with ISO Standard 10303: STEP in the form of a memorandum of understanding. Many of BuildingSmart International members are also members of STEP. ISO has adopted the BuildingSmart International mechanism for drafting building construction domain standards.

3.6.2 ISO 10303 – SCOPE AND ARCHITECTURE

ISO is the International Organization for Standardization.

ISO 10303 is the Industrial Automation Systems and Integration-Product Data Representation and Exchange, known officially as the STEP [ISO 1996c].

STEP is the acronym for the "STandard for the Exchange of Product model data" This standardization is a worldwide effort to develop mechanisms for the exchange of product model data. STEP was developed by ISO TC 184/SC4 in collaboration with a number of universities and industry associations worldwide.

ISO 10303 is an International Standard for computer-sensible representation and exchange of product data. The objective is to provide a mechanism capable of describing product data, independent of any particular system. The nature of this description makes it suitable not only for file exchange, but also as a basis for implementation and sharing product databases and for archiving purposes [ISO 1993].

ISO 10303 consists of a series of parts covering different fields such as buildings, manufacturing, plant and automotive design and construction. For example, ISO 10303 APP 225 represents a specification that will focus on building and construction data exchange requirements. Its title is “Building Elements Using Explicit Shape Representation” and it will support the exchange of 3D building models. As the title indicates, 3D building model are represented as assemblies of building elements (e.g., beams, columns) along with explicit (e.g., non-parametric) and some additional information such as material properties, building elements classification or element versions [ISO 1996a]. It allows different implementation technologies to be used for storing, accessing, transferring, and archiving product data. The ISO 10303-225 was developed by the German national project headed by W. Hans and became an International Standard (IS) in 1997.

Building elements are those physical objects that a building is composed of, such as structural elements, enclosing and separation elements, service elements, fixtures and equipments and spaces.

ISO 10303 – 225 is designed to transfer the necessary data to maximize the advantages of spatial building models. Such advantages include [ISO 1996a]:

- Enabling concurrent engineering and design leading to shorter time;
- Avoiding repeated data input and related mistakes;
- Reducing rework and design control checks;
- Increasing productivity through quicker, error-free information exchange and communication; and

- Allowing for easier design modifications

Along the same lines as the ISO-225, STEP delivers more Application Protocols (AP), which is a subset of generic tools, and STEP supports the elaboration of sector-specific conceptual models. Some examples of APs include [ISO 1996a], [ISO 1996b], [Debras et al.1998, Maria 2000]:

3.7 CURRENT INFORMATION MODELS APPLIED IN FMS

This section reviews 19 of the major research projects of the past 21 years (1991-2011). These projects focus on FM Information Integration Approach. The projects' outlines will briefly mention the objectives, model approach, model architecture, and important observations as follows:

1. **Facility Programming Product Model (FPPM), [Perkinson et al. 1992]**

   Objectives: The FPPM model aims to establish a framework in which to assist decision-making and evaluate performance during the life cycle of building projects.

   Model Approach: The FPPM represents a conceptual framework to store, manage, and retrieve FM information.

   Model Architecture: Contains two different elements or "Cells". The first contains the address elements (e.g., level, information, system, and graphic links) and the second cell contains the utility elements.

   Important observations: 1) The FPPM was developed for the public sector user. 2) This model has four priority levels, which decide the type of utility elements.

2. **Integrating Database and Geometric Modeling Technologies to Manage Facility Information, [Zamanian and Steven 1993]**

   Objectives: The project developed a computer–based model to manage and exchange information for constructed facilities.

   Model approach: A database model system with an object–oriented system was developed to manage structured non-spatial information. **Model architecture:** The conceptual schema is supported by two paradigms: 1) the formal representation paradigm, and 2) the implementation paradigm

   Important observations: 1) The model is on a platform level. 2) The model relates only to the spatial and non-spatial information. 3) O&M management is not included in this model. 4) A prototype implementation model was developed.

3. **Application of Product Model Theory in Facilities Management, [Mottonen 1995]**

   Objectives: To improve the information flow from the design and construction stages to the usage stage of the project.

   Model approach: Applied the product model approach of the earlier RATAS projects to the O&MM of buildings

   Model architecture: Represented by covering the maintenance of the property, the maintenance functions, and the documents used by functions that described the maintenance objects

Important observations: Did not place any emphasis on renovation or financial and administrative information.

4. **Software Analysis of a Flexible Object-Oriented Facility Management System (FMIS), [Bos 1994]**

   Objectives: Focuses on the fundamental logistical requirements for FM decision-making information and for maintenance and space planning. It is based on the earlier model by De Waard, 1992 with the application of the COMBINE project.

   Model approach and architecture: The architecture contains: 1) an Operating and Maintenance System formed by object models (e.g., space, furniture, appliances, etc) and by functional models describing the activities involved in different decision-making processes (e.g., determine the total cost of paint works); and 2) the existing FM computer application.

   Important observations: 1) it has the capability to manage FM activities, and 2) flexibility is the most critical system requirement.

5. **Information System for Facility Management (ISFM), [Majahalme 1995]**

   Objectives: To develop a framework for future IT applications within the FM domain. The procedure starts with the information analysis method, from core business idea to implementing an IT system.

   Model Approach: ISFM is a conceptual model to support computer-based information systems for FM.

Model architecture: ISFM contains four sub-models: Business Activities for facility management (BAfm); Management Activities for facility management (MAfm); Concept for facility management (Cfm); and Document System for facility management (DSfm).

Important observations: 1) ISFM has the capability to provide an analysis method for FM information. 2) The model has been tested by five prototype applications. 3) The four sub-models are generally applicable. 4) It is not capable of identifying the specific information required by different FM functions.

6. **An Integrated Facilities Management Information System based on STEP (IFMIS): A Generic Product Data Model, [Cheng et al. 1996]**

Objectives: Two main objectives: 1) the centralization of information; and 2) The availability of the exchange of product information based on an open and configurable mechanism.

Model approach: The IFMIS model is a generic product system, conforming to STEP standards.

Model architecture: The architecture contains the following: 1) a Control Data Repository (CDR) based on the developed product model and which can be populated via an enhanced CAD System. Because there is an association between the objects in the drawings and the object data within the CDR, the system integrates the CAD System and the asset/maintenance/energy applications through a central database; and 2) an Exchange Control Mechanism (ECM).

Important observations: 1) The model suggests STEP-conforming system architecture; and 2) A generic product data model must be specified to support the data shared by the three integrated systems.

7. **Integrated Facility Management Information, a Process and Product Model Approach, KBS Model, [Svensson 1998]**

Objectives: To support FM functions, such as O&M management, tenancy agreement management, and indoor-climate calculation processes.

Model approach: The KBS model conforms to the STEP standards for both process and product models.

Model architecture: The model consists of the following components: 1) KBS-Core, designed to handle the specific entities through its relationships with the other parts systems, and established to define the KBS model structure; 2) Four sub-models represented by: a) Catalogue_Of_Technical_System (e.g., structural, HVAC, transport, etc), b) Catalogue_Of_Spatial_System, c) Catalogue_Of_Construction_Parts (e.g., Frame, Plate, Opening, Installation elements, etc), and d) Work_Section_Sub-model.

Important observations: 1) The KBS model is validated by implementing three prototypes, whose scopes are defined by identifying a range of supported FM functions, and 2) The technical system structures information around three main concepts: technical_system, space_room, and tenant.

8. **Product Modeling: Helping Life Cycle Analysis of Roofing Systems, [Vanier 1998]**

Objectives: The model identifies the need for data integration and for information applications (e.g., CAD Systems, financial, maintenance, and inventory database). This model predicts the service life of roofing systems, benefitting facility owners.

Model approach: This Roofing Maintenance model was developed according to STEP and IAI standards to support software systems and to address the needs of asset managers.

Model architecture: The object entities for the roofing maintenance product model were developed using the following steps: 1) Using existing data from STEP/IAI/KBS conceptual models; 2) Model existing application data requirements (MicroROOFER, Digital images, .bmp data); 3) Model risk analysis requirements for Markovian chain and multi-objective optimization; and 4) Enhancing the model by using the Kosoval (1998) roofing thesaurus.

Important observations: 1) The model is conceptual regarding storing data for building inspections; and 2) It has been used by many entities for general guidance, is useful not only for roofing maintenance product models but also for other maintenance management domains.

9. **Development Framework for Data Models for Computer-Integrated Facilities Management (CIFM) [Yu et al. 1999b]**

Objectives: Aims to develop an information framework to facilitate and share integration strategies among FM computer applications throughout a facility's life cycle.

Model approach: Is built according to the IFC (IAI) as a mechanism to capture building project information from design to commissioning.

Model architecture: The main components of the CIFM model are: a system core represented by: A) an FM Object Repository, and B) Facility Management Classes (FMC), comprised of a set of modules. The core contains the information used by FM applications.

Important observations: 1) The Object Repository represents a database that includes FM object information. 2) The IFC-FMC mapping engine is a mechanism to map IFC objects into FMC objects and also to enable the acquisition of captured information during the design/construction building phases.

10. The Development of Industry Foundation Classes for Facilities Management [Wix and Ottosen 1999]

Objectives: The model represents a general maintenance process developed to define the object requirements and interfaces for sharing maintenance information [Wix et al. 1999].

Model approach: The project developed a process model according to IAI standards and utilizing IFC to support the maintenance processes.

Model architecture: The model depends on the IAI engineering maintenance project [IAI 1998] to identify the key processes: Identify

Assets, Plan Maintenance, Do Maintenance, Record Account, Use Maintenance, Libraries, Purchase Equipments for Maintenance, and Account for Maintenance Cost and Associated Concepts (e.g., assets, work orders). The project developed a high level of IAI project planning to enable a series of maintenance processes to be identified for initial work.

Important observations: 1) the information flow in the model is on a general level. 2) The model needs more details and classification.

11. An Information Model to Support Maintenance and Operation Management of Building Mechanical Systems [Maria 2000]

Objectives: Developed to represent, storage, process, and retrieve information focusing on equipment maintenance management

Model approach: The framework is a process model conforming to the IAI/IFC approach and the use of object-oriented modeling language.

Model architecture: The framework consists of two main management activities; Manage Assets, and Manage Resources, in addition to the Emergency Operations, Control Quality, Control Productivity, and Control Safety. Each of these processes contains many sub-processes.

Important observations: 1) The model focuses on details for the maintenance of building Mechanical Systems; 2) A prototype implementation model is developed to validate the proposed information model

12. Development of a Decision Support System (DSS) for Building Maintenance Management [Langevine et al. 2002]

Objectives: This project represents the work in progress (completed in 2006, item 14 from this list) on the development of a Decision Support System for Building Maintenance Management. The budget is an important factor that impacts Maintenance Management in different ways and DSS will assist in prioritizing maintenance expenditure and in forecasting maintenance budgets.

Model approach: The conceptual design of the DSS consists of: 1) A deterioration model that uses the probabilistic Markovian model to determine the performance rate for any component of a building; 2) A life cycle cost analysis module; 3) A neural network module; and 4) An Analytical Hierarchy Process (AHP) module to assess the relative importance of the maintenance budgets for each facility under construction

Important observations: 1) the DSS model is still in process; 2) The objective explains its ability to assist asset managers in formulating their maintenance and repair budgets

13. Computerized Maintenance Management System (CRMS) for Low-Slope Roofs

(CRMS) [Morcous, and Rivard 2002]

Objectives: CRMS provides an evaluation that assists asset managers in making cost-effective maintenance decision for roof components. The building envelope life cycle asset management is a part of the new CRMS, called CBRoof [Morcous and Rivard 2002].

Model approach: A conceptual model, developed using the Object-Oriented language C^{++} , Microsoft Foundation Classes (MFC), and the Object-Oriented Database Management Systems (OODBMS) objective store 6.0 [Morcous and Rvard 2002] .

Model architecture: The CBRoof model consists of three main modules: 1) The "Case-Based Reasoner" Module contains a retriever algorithm; 2) The Client Database Module supports the representation of roof data and roof knowledge. The "Roof Knowledge" Module stores the knowledge required for case retrieval and the "Roof Data" Module stores the different types of roof data for roof components collected by roof engineers and technicians; and 3) The "Case library" contains all roof cases.

Important observations: 1) CBRoof is a part of the Building Engineering Life Cycle Asset Maintenance (BELCAM) research project. 2) The CBRoof model was developed for Low-Slope roofs and the service life prediction of roof components. 3) The project is in process and aims to use a large database of roof condition history in the near future. 4) A prototype model not mentioned.

14. A Decision Support system (DSS) for the Maintenance Management of Buildings [Langevine 2006]

Objectives: This DSS was developed to assist asset managers in the public sector to monitor and forecast the deterioration of buildings, as well as to determine maintenance standards and strategies that are appropriate to specific funding levels, and to allocate funds for competing building maintenance needs.

Model approach: This DSS is a conceptual schematic design and integrated framework developed for the maintenance management of buildings. The UNIFORMAT II classifications for building elements, the Analytical Hierarchy Process (AHP) methodology, and SQL server are the main elements.

Model architecture: Consists of five main modules: 1) Develops a conceptual and integrated framework; 2) Develops a uniform condition assessment procedure; 3) Develops relative weights for the building components to facilitate proper delineation of the building inventory; 4) Develops a system to monitor the performance of building assets; and 5) Develops a prototype model.

Important observations: 1) This DSS was developed for public sector buildings; 2) A life case study is applied and demonstrated; 3) This DSS is generic and not limited by the complexity, scale, size, or type of building; and 4) DSS evaluates maintenance strategies, determine budget levels, and allocate funds between competing asset maintenance needs.

15. A Forecasting Model for Maintenance and Repair Costs for Office Buildings [Yiqun Liu 2006]

Objectives: The main objective of this research is to develop a forecasting model of Maintenance and Repair (M/R) costs for office buildings.

Model approach: It is a process model developed to forecast M/R costs to aid owners and facility managers in evaluating and budgeting for office building M/R costs.

Model architecture: 1) Develops a procedure to process the collected data and its treatment; 2) The Analytical Hierarchy Process (AHP) methodology is used to determine the M/R cost coefficient; 3) Develops a forecasting method for total M/R costs of office buildings for their life cycle; and 4) Develops a prototype model.

Important observations: 1) This model was developed for office buildings; 2) Life cycle cost techniques are used to forecast the total M/R costs; 3) Model is limited to M/R elements; 4) Uses a BOMA database for M/R costs by accessing EER reports; and 5) A case study was applied and evaluated.

16. **Building Component Lifecycle Repair/Replacement Model for Institutional Facility management [M. Grussing and L. Marrano 2007]**

Objectives: It is a data model developed to reduce lifecycle cost for ownership for building facilities using a computational component repair/replacement simulation model.

Model approach: A parametric model of component repair cost is used to quickly estimate the corrective repair cost as a percentage of the total replacement cost based on the condition index value. The parametric cost model assumes that when the condition index is near 100, repair cost is minimal. Likewise, when the condition index is at or below the failure threshold (CI = 40), the cost to repair is equal to the replacement cost since repair is not longer an economically viable option.

Model architecture: The model is constructed by creating an inventory of components that comprise the building. The building component inventory divides the facility first into major building systems, and then into individual components that make up those systems according to ASTM Uniformity II hierarchy (ASTM E 1557-02).

Important observations: 1) This model was developed for facility management; 2) Life cycle cost techniques are used to forecast the total R/R costs; 3) Model is limited to R/R components; 4) Uses ASTM E 1557-02 hierarchy for building component inventory; and 5) A case study was applied and evaluated.

17. **Evaluation Methods for Building Product Models: Measuring the Performance of Building Commissioning Data Model [M. Tanyel and Omer 2007]**

Objectives: it is to describe evaluation procedures and metrics for the validation of a data model that is developed for building commissioning.

Model approach: Capturing the domain knowledge and supporting interoperability are the two premises of building product model development efforts in the AEC industry. A data model describes the characteristics of the domain artifacts as well as how these artifacts are related to each other.

Model architecture: The Building Commissioning (BC) data model is developed in four versions. Every version is compared to a new set of data that comes from a commissioning case and the data model is update according to the comparison results. The comparisons are done by matching data entries in the commissioning documents, in to the attributes of the BC data model.

Important observations: 1) This model was developed for measuring the performance of building commissioning; 2) The model established according to three BC characteristics: the scope; the ability to support BC functions; and the flexibility; 3) The prototype model consists three parts: Latest version of BC model as an EXPRESS file; manages data input/out put and interoperability; and the applications stores the BC data administers every change on the project repository; and 4) A case study was applied and evaluated by using a prototype model.

18. Discussion of Criteria for Prioritization of Predictive Maintenance of Building Facades: Survey of 30 Experts [I. Flores-Colen et al. 2010]

Objectives: It is a research discusses a set of 17 criteria to help the maintenance choice for building facades, from three viewpoints: physical performance; risk; and costs.

Model approach: A set of 17 criteria were selected by the researcher based on their experience and on a thorough literature review. Then, a survey using a questionnaire for the importance of these 17 criteria was assessed by 30 experts. The final step is to propose, based on previous experts' answers, priority rating scales and subclasses of each criterion, in order to help the maintenance decision-making for facades after in-service inspections.

Model architecture: This research does not have a computerize model

Important observations: 1) The researcher does not develop a model for facility management; 2) The research was a discussion for a set of 17 criteria to help the decision-making for propitiation of predictive maintenance after in-service inspection; and 3) The results obtained from a survey of 30 experts on building pathology, performance, and maintenance.

19. Inspection, Condition Assessment, and Management Decisions for Commercial Roof Systems [Donald et al. 2010].

Objectives: It is a model to consider the relationships among inspection condition assessment, leaks, and costs for low slop roof systems. The model analyze a visual inspection method and consider the use of inspection data, leaks, age, and costs as inputs to roof replacement decision making and argue that all sources of information is beneficial.

Model approach: The model depends on the visual roof inspection. In addition, depends on a survey of occupants and records of maintenance and repair activities. Furthermore roof-condition-assessment rating schema and Markov model of deterioration are presented. Final section discuses implications for roof replacement decision making.

Model architecture: This research does not mention any type of model architecture.

Important observations: 1) This model was developed for inspection, condition assessment, and management decisions for roof system maintenance; 2) This model uses Markov model for deterioration; 3) Model is limited to M/R of low slop roof systems; and 5) A case study was applied and evaluated.

3.8 LIMITATION OF AVAILABLE MODELS

Throughout the literature review (chapters 2&3), it is clear that the FM functions and their elements, and the modern IT tools and their strategies, are focused on improving the Information Models. Therefore, all of the FM functions and IT tools and techniques have been employed to achieve the best productivity, efficiency, and reductions in the cost and time of the building operations and maintenance during the usage stage by involving and exchanging all the required information during the previous stages (design and construction).

The 19 information models represented in section (3.7) and developed over almost 21 years have the following summary characteristics:

- 6 Generic information models focusing on maintenance works;
- 7 Detailed information models focusing on maintenance decision- making;
- 3 Detailed information models focusing on maintenance of low-slope Roofs
- A detailed information model focusing on the maintenance of the spatial and non-spatial information;

- A detailed information model focusing on the maintenance of the mechanical system; and
- A detailed information model focusing on the maintenance and repair costs of office buildings.

The following points illustrate the limitations analysis of the previous 19 research and indicate current understanding the problem of FM models:

1. As outlined, M&R is the most important function in FM and thus justifies our focus on it.
2. M&R is the reaction to deterioration acts to maintain a building in the required range of its life span.
3. The M&R budgeted cost is always the most-affected factor in the annual operation and maintenance expenses, yet it has not been very well estimated nor included in an accurate, reputable method.
4. The various types of maintenance programs (daily, preventive, and predictive) have been mixed together and not scheduled in a comprehensive plan.
5. Interval Facility Evaluation for 10-year plans is not yet familiar to facility owners or managers.
6. A database for M&R expenses should be taken from a trusty benchmark such as the BOMA, which has more than 100 years of experience in this field. In the previous research only one study was based on BOMA data.

7. Forecasting annual M&R expenses for the medium term 10 years is an important solution and would be a valuable tool for professional planning with an acceptable annual budget for building owners and managers.

Scheduling the various types of maintenance programs according to the forecasting of annual M&R expenses for ten years is also an important function within facility management

However, many of the available office buildings have been adopted facility management models to find the optimal method to minimize the expected expenditure while keeping the element out of the risk of failure. The availability budget for maintenance and repair is an essential factor governing the decision making process. Sound decision making should take into account indirect cost components such as user delays, and the economic, social and environmental impacts associated with M&R [Saleh 2008].

3.9 CONCLUSIONS ON FM AND IT

Chapter one and two illustrate project life cycle, cost life cycle, facility management functions and elements, information life cycle, facility management model requirements, facility management models, standardizations, 19 current facility management models, and the limitation of available models. All these subjects are related and very important to this research to learn from the previous work and experience to overcome the limitations of the available office buildings management models by integrating the trusty data in the decision making process.

CHAPTER FOUR

DETERIORATION

4.1 INTRODUCTION

The cost of operation, maintenance and repair of buildings has been increasing, as illustrated in chapter 2. Most building owners and managers are aware of these costs. Governments are also spending more money on the O&M and repair of their buildings than ever before.

To estimate the expected costs of building O&M and repair over the next decades the rate of deterioration must be determined. Extrapolation of the ongoing observed deterioration gives a reliable indicator of future deterioration. Building maintenance is viewed by most organizations as a cost burden and so requests for action, identified via an assessment of the building condition, invariably exceed the funds available [Sherwin, 2000]. Even with a solid financial situation, organizations demonstrate a reluctance to spend in order to preserve the condition of their assets [Chew et al., 2004]. Thus, buildings fail to maintain their optimum operating capacity and functional performance, which ultimately leads to a spiral of decline and disrepair [Arditi and Nawakorawit 2002]. An obsolescence gap develops wherein a building is unable to meet all the demands placed on it.

A combination of the physical deterioration processes and the available performance data provides a more reliable prediction of future deterioration.

Deterioration rate and building performance are bi-converse indicators. Increasing the rate of deterioration will reduce the building performance and vice versa. Because the deterioration process possesses the following properties (1) the deterioration level gets worse during the time where the repairing is not carried out; (2) the uncertainty of the deterioration process increases with time; and (3) the worse an observed state is, the more likely deterioration proceeds [Mitsuru et al. 2008].

4.2 BUILDING PERFORMANCE

BS 5240 defines "**Building Performance**" as the behavior of a product in use. It denotes the physical performance characteristics of a building as a whole and of its parts [James, 1996].

Traditionally, the term "Building Performance" has been used in the context of noise control, fire safety, thermal efficiency, and internal air quality **[**James, 1996]. Each of these criteria has an important role and deals with a specific function. The total performance of a building is a result of the integrated individual performance of each criterion.

Buildings are comprised of systems and components, crossing civil, mechanical, and electrical construction disciplines. Each component works interdependently with other components to support the functions of an efficiently operating building. As a physical asset, these components age and deterioration over time are ultimately adversely affecting performance and reliability of the building [M. Grussing and L. Marrano 2007].

A set of reliable performance prediction and optimization models is needed at the core of any property maintenance management system. These are usually based on current and expected future property conditions. Current conditions are measured, and consequently their accuracy depends on the measurement methods, skills, and technology. Future conditions, on the other hand, are predicted using a deterioration models. Maintenance decisions are thus made based on the predictions made by the deterioration models [Ying Nan et al. 2011]. I. Flores-Colen listed various criteria of technical (Physical) performance perspective for maintenance decision making: (1) type of constructive solution; (2) Sensitivity of the component within the building system; (3) magnitude of the environmental degradation agents; (4) magnitude of the human degradation agents; (5) preventive maintenance program; (6) buildings age; (7) remaining service live; and (8) date of the last intervention [I. Flores-Colen et al. 2010].

To assess how well a building is behaving overall and in the long term, a more reliable approach is needed. Figure 4-1 depicts the degree of predictability of the total building performance relation to its number of elements.

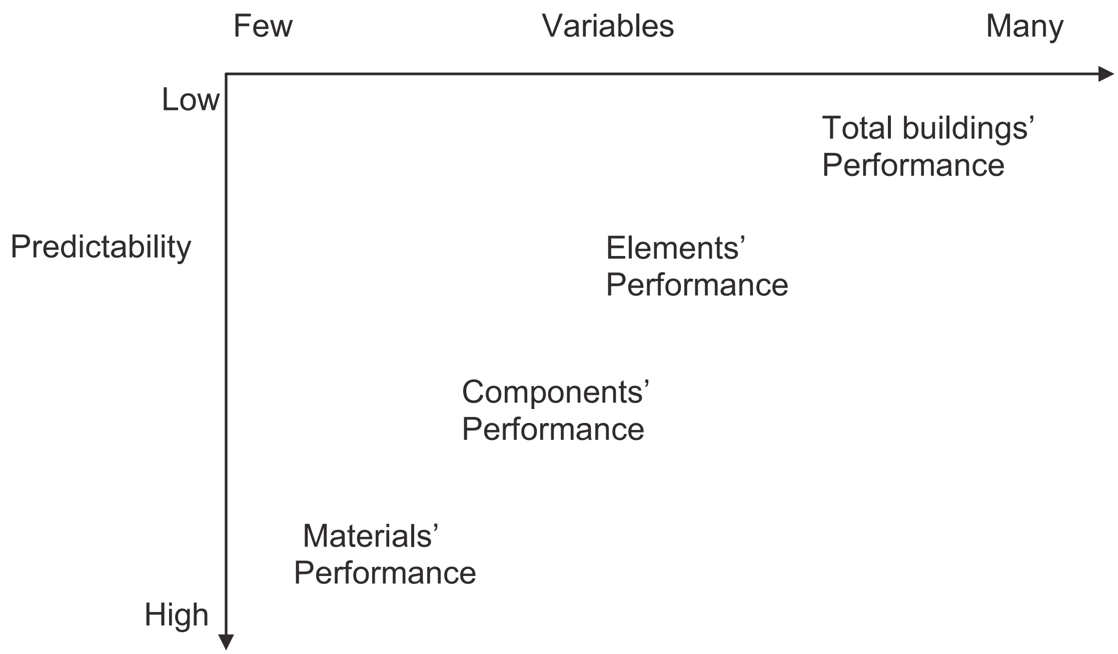


Figure 4-1 Degrees of performance predictability Source: [James, 1996]

External building performance and internal building performance are both important to measure the total building performance. External building performance is the comparison between a building's performance and other references such as Means, BOMA, IFMA, and internal building performance is that of the building assessed on its own without direct reference to other properties. These performance levels are necessary to determine how well a building is serving the needs of end users and to identify any major defects in overall performance.

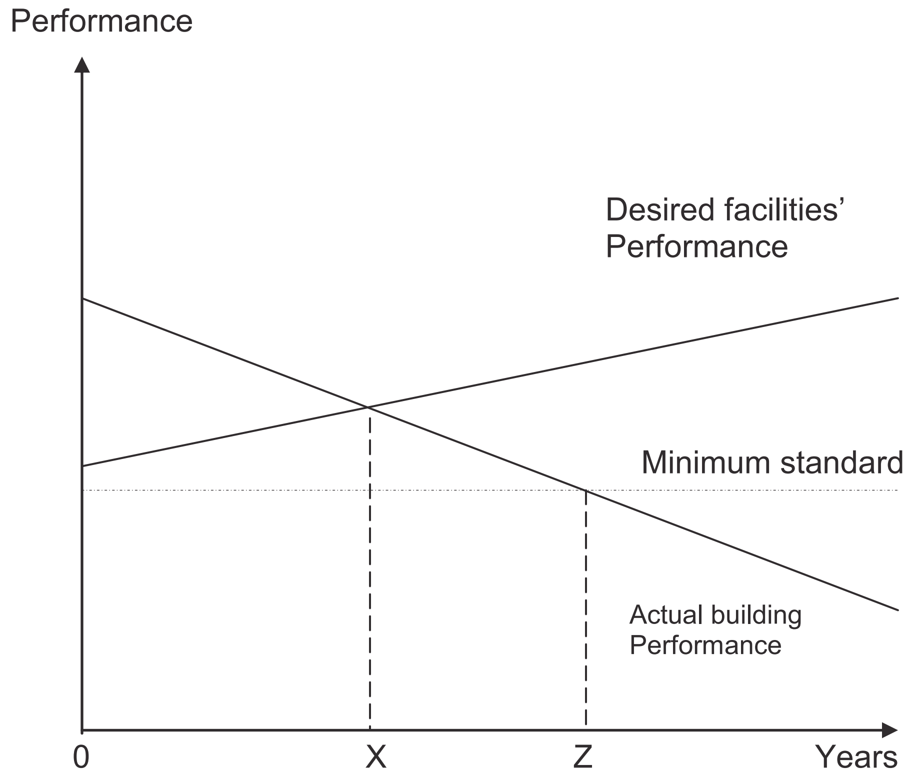


Figure 4-2 The relationship between total building performance and facilities' performance Source: James, 1996

4.3 DETERIORATION

For any building, deterioration depends on adequate design, qualified contractors, quality of materials, its operation and maintenance program, and environmental conditions. Any gap in these factors or uncorrected utilization will have an immediate effect on the degree and speed of building deterioration.

The process of deterioration in both the physical and functional condition of a facility is complex, and is indicated by wear and aging due to usage, degradation of equipment and construction material due to the environment, and the interaction of these mechanisms. Therefore, a Deterioration Model is an integral and important part of infrastructure management. Maintenance and rehabilitation decision-making is based on current and future conditions [Langevine 2006]. Caulking material will deteriorate faster in a humid and low-temperature region than in a dry and moderate temperature zone. Window and wall materials will deteriorate faster when the caulking is undergoing deterioration. Figure 4-3 shows the deterioration process [Langevine 2006]. Periodic repair or replacement of the various deteriorated components is needed to restore condition and performance capabilities for the component and the building as a whole [M. Grussing and L. Marrano 2007].

Measuring building performance is crucial to the overall performance concept since measurement is vital to our objective understanding of things and processes. Facilities management requires another indicator in addition to building performance to evaluate the results of building performance measurement. This indicator has been termed “Benchmark”, and benchmarking became one of the main buzz-words in facilities management in the 1990s [James, 1996].

4.4 BUILDING PERFORMANCE BENCHMARKS

Building performance benchmarks are divided into two primary categories according to their type, Quantitative and Qualitative benchmarks. Quantitative benchmarks are related to the cost and have immediate significance, such as [James, 1996]:

- Average annual maintenance costs per employee;

- Cleaning costs per sq. meter;
- Heating costs in kwh/m^2 per annum; and
- Building performance and cost-in-use data.

Qualitative Benchmarks, however, are not related to the cost, but are essentially indicative of strategic or long-term use, such as [James, 1996]:

- Building quality assessment (BQA) rating;
- Post-Occupancy Evaluation (POE) feedback; and
- Property Efficiency Evaluation (PEE) rating.

In addition to the above building performance benchmarks, additional categories are increasingly being applied in facilities management, but they are not related to this study (for example, “Spatial Efficiency Benchmark” [James, 1996]).

Facilities managers should thus consider building performance as a potential “Success Factor”, whether or not it is a "critical success factor" in benchmarking terms [James, 1996].

Building performance has great potential as a valuable tool for decision makers at both strategic and operational levels. Some of the key outcomes of building performance evaluation include the [James, 1996]:

- Evaluate a building in a wider perspective at micro and macro levels;
- Highlight the a building’s performance lacunae;
- Schedule priorities of maintenance works;
- Provide initiation warnings of identified problems; and
- Assist in managing the cash flow of the maintenance and other aspects.

4.5 MAINTENANCE MANAGEMENT APPROACH

The scope of operation and maintenance management (O&MM) was explained very well in terms of the maintenance definition, objectives gained from (O&MM), Maintenance Programs, Corrective Maintenance, Preventive and Predictive Maintenance, Computer systems for the Maintenance Management, and Work Control systems in Chapter 2, Facility Management Domain, and item 2.6. In addition, this chapter's items 4.1 Introduction and 4.2 Building Performance Benchmarks, also explain the terms Deterioration, Performance, and Benchmarks. All these subjects are related to each other and are integrated in the Functions of Facility Management. Any type of maintenance program needs to initiate performance indicators, which are the results of observations. A performance observation is conducted because there is a need, due to building deterioration or, on other words, in a building's performance.

British Standards have defined **maintenance** as "a combination of any actions required to retain an item in, or restore it to, an acceptable condition as their start point" (BSI, 1993) [Keith and Mark, 2007].

The existence of obsolescence was also recognized by the Chartered Institute of Building, which proposed an alternative definition of maintenance and refurbishment as "work undertaken in order to keep, restore, or improve every facility, its services and surroundings to a currently acceptable standard and to sustain the utility and value of the facility" (1990). In this definition, maintenance and refurbishment is explicitly linked to improving the value of the built asset.

Keith and Mark [2007] explains Jones's model figure 4-3, repeated maintenance cycles (a to d) occur until the point at which a building fails to satisfy the occupier's demands and a major refurbishment is required. Even after refurbishment some residual obsolescence remains and this grows over repeated refurbishment cycles until the obsolescence gap is too great for an organization to bear. At this point, the organization either re-locates; the building is demolished and re-built; or the building is refurbished beyond its original purpose and a change of use occurs.

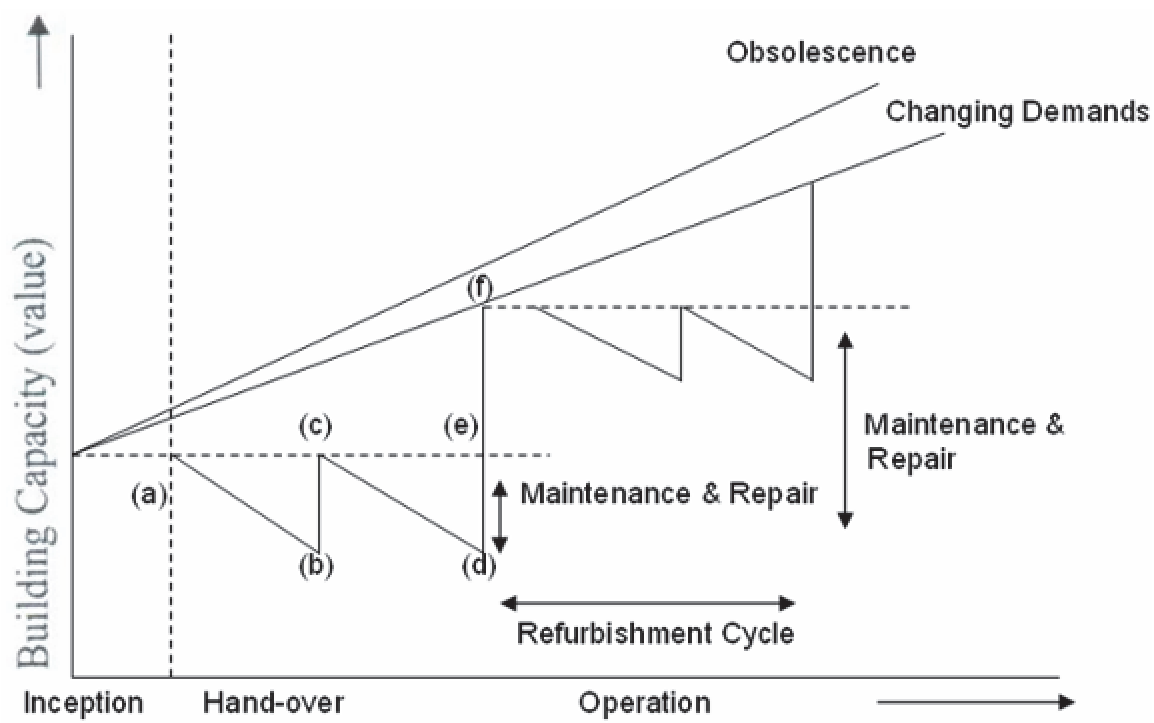


Figure 4-3 Model of the maintenance - refurbishment life cycle

Source: [Keith and Mark, 2007]

A number of researchers have attempted to develop models that link maintenance decisions to building performance. Vanier (1998) suggested that if the requirements (performance) of a building could be defined in terms of the functional requirements of its users, these would provide a series of standards (benchmarks) against which performance indicators could be compared and maintenance interventions considered. Mohamed and Horner (2003) developed an alternative performance approach to strategic maintenance management through the application of the principles of integrated logistic support the identification and selection of built asset maintenance actions. Mohamed and Horner (2003) argued that by integrating the physical and functional models of a building together and applying Failure Mode Effects Analysis and Reliability Central Maintenance principles, a more cost-effective approach to building maintenance could be achieved. However, whilst all the above seek to base performance issues at the centre of the maintenance decision-making process, they still consider performance as primarily the physical ability of the system (or its components) to meet physical criteria.

On the other hand, current building maintenance strategies, whether based on planned or unplanned maintenance, are most likely to be budget-driven. This means that maintenance is not carried out according to actual need, but dictated by financial priorities decided at the time or during the previous 12 months. Although theoretically the budget should be built up as a result of estimated needs, it is almost invariably based on previous years' figures, modified for changes in the number of buildings, specially-agreed programmers of planned maintenance and inflation forecasts [Horner et al, 1997]. Three methods are currently used for constructing a budget for estate-based management organizations:

1. Basing this year's budget on last year's expenditure with an allowance for inflation.
2. Using the Department of Environment (DoE) or other formula for calculating the maintenance element of the estate budget.
3. Using a stock condition survey to quantify the size and type of the maintenance task. This is the method used in this research; more details will be explained in the following sections.

4.6 Deterioration model in stochastic and deterministic methods

Life-cycle cost analysis is an essential approach to differentiating alternative rehabilitation strategies for steel bridge paint systems, for example. An economic analysis (EA), a deterministic method, and the Markov decision process (MDP), a stochastic method, were used to carry out the life-cycle cost analysis.

The EA and the MDP were used to analyze and differentiate among the proposed rehabilitation scenarios. The results of the EA were different than those of the MDP for the two data sets.

A major problem becomes apparent upon careful examination of the data that feed either model. The cost and performance data are highly variable, and considerable doubt exists about the validity of comparisons among different sources. The reasons for these problems are many, for instance, the cost components are seldom available in adequate detail and format.

4.6.1 STOCHASTIC METHOD

Many researchers used the Markov chain decision process to conduct life-cycle cost analysis for maintenance or repair [Zayed et al. 2002]. A major goal of

Zayed's study was to develop economic models that can be used to provide a rational framework for the evaluation of alternatives in the paint maintenance of steel bridges [Zayed et al. 2002]. The study "Statewide Performance Function for Steel Bridge Protection Systems" is the redemption of the stochastic and deterministic methods on the relationship between the rate of bridge paint condition change and time, known as the Performance Function. The study reviews aspects of the rehabilitation and the processes, assesses to the degree possible the state of the art, arrives at conclusions, and makes recommendations where applicable. Performance functions for steel bridge paint used in the Indiana Dept. of Transportation **(INDOT)** structures were developed using two methods and which were then compared by analyzing and studying the results. The Deterministic Model (a regression model) is a well-established statistical technique. A probabilistic model developed with Markove chain was used to reflect the stochastic nature of bridge paint conditions at a given age. These models were developed for life-cycle cost analysis and their input data provided, based on data and experience from the study of bridge paint maintenance. Because the results of the Stochastic and Deterministic Methods were quite different, an analysis was conducted to determine why.

4.6.2 DETERMINISTIC METHOD

Life-cycle cost analysis is an essential approach to differentiating alternative rehabilitation strategies for any facility, for example. An economic analysis (EA), which known by Deterministic Method (DM) throughout implementing Net Present Value equation (NPV) for building life cycle cost is the most used in the

M&R strategy plans. Economic analysis (EA) is the closes to the accurate results to the forecasting the maintenance and repair expenses as approved by Zayed's studies [Zayed et al. 2002]. In addition, section (4.5) Maintenance Management Approach outlined three methods currently used to determine annual cost estimation of maintenance and repair for estate-based management organizations. All are deterministic methods, used widely, efficiently, with sound results.

Mitsuru states that estimations using the MDP become difficult as the rank of the transition probability matrix increases rapidly along with small increments in the number of state variables and policies, which is called "the curse of dimensionality" [Mitsuru et al. 2008].

Therefore, this research will use the EA in the ten-year strategic plan by using a stock condition survey method (property assessment condition) to quantify the size and type of the maintenance task.

4.7 CONCLUSION

In this chapter, Total Building Performance is a result of the integrated individual performance of each criterion. Deterioration of any building depends on adequate design, a qualified contractor, material quality, operation and maintenance program, and environmental conditions. Building Performance Benchmarks are divided into two main categories according to type, Quantitative Benchmarks and Qualitative Benchmarks. A performance diagnostic is conducted because there is a need, due to building deterioration or a lack in a building's performance. A number of authors have attempted to develop models that link maintenance decisions to building performance. On the other hand, current building maintenance strategies, whether based on planned or unplanned maintenance, are most likely to be budget-driven. The EA and the MDP were used to analyze and differentiate among the proposed rehabilitation scenarios. The results of the EA were different from those of the MDP for the two data sets. Models were developed for life-cycle cost analysis and their input data provided, based on data and experience from the study of bridge paint maintenance. The results were analyzed to determine the reason for the conflict and to select the superior method illustrated bellow [Zayed et al. 2002]:

- The EA uses deterministic values of cost and time, while the MDP uses probabilistic time and deterministic costs;
- The optimal scenario, from the EA prospective, is the one that has lowest central cost value (mean), while the MDP provides only the set of decision that are optimal without mentioning their cost values;
- The cost and performance data are highly variable and considerable doubt exists about the validity of comparisons among different sources; and
- The reasons for these problems are many, for instance, the cost components are seldom available in adequate detail and format.

Accordingly the outcomes of the comparisons are listed bellows:

- A major problem becomes apparent upon a careful examination of the data that feed either model;
- Another major factor in the variability of the cost data is the presence of hidden costs;

- The EA provide its superiority over MDP using INDOT data; and
- The EA method’s advantages (simple to use, understand, and applied widely) are offset by the MDP’s ability to incorporate the inherent statistic nature of the phenomenon being modeled.

CHAPTER FIVE

MODEL DEVELOPMENT METHODOLOGY

5.1 INTRODUCTION

The introduction and literature review (Chapters 1, 2, 3, and 4) have clearly demonstrated that the integration between IT domains and FM functions is an important area for future development work as well as the research objectives.

Recently, the demands for purchasing business software applications have been increasing, especially for supporting business functions such as FM.

Today's IT vendors have become more than just players in the information systems game; they are partners of the businesses that purchase their products and services. This situation shows the need for an explicit and integrated generic research program.

At the same time, the facility management models and reports on annual maintenance and repair that are available demonstrate that office buildings are deteriorating and require immediate action. Building owners and managers desperately need facility management models for maintenance and repair management to assist them in managing deteriorating properties. This gap reflects the immediate need for research to develop a reliable model in the domains of facility management and annual maintenance and repair to assist building owners and managers to solve the complex problems associated with facility management.

The model methodology proposed here is developed according to a BOMA EER report, previous research in the same field, Property Condition Assessment (PCA), and information collected during interviews with building owners. A Facility Management Model for Maintenance and Repair (FMMMR) would include the following:

1. It would allow building owners and managers to practice their experience and judgment in the decision making process.
2. It should be flexible to add accumulation of several years of experience and knowledge of FM database.
3. It would improve the performance of a building infrastructure, reducing, and controlling the time for maintenance and repair achievable and easy to manage.

This chapter discusses the methodology of developing an integrated conceptual facility management model for annual maintenance and repair expenses for office buildings, following a system analysis approach. The system analysis approach has five main steps: identifying the problem, analyzing and understanding the problem, identifying solution requirements or expectations, designing and implementing the solution, and evaluating the results.

5.2 SYSTEM ANALYSIS APPROACH

5.2.1 IDENTIFY THE PROBLEM

As outlined in the literature review, 19 information models for the FM were reviewed along with all of their characteristics. Further to the statistical notice that was mentioned in section 3.7 of Chapter 3, the following shortcomings have been observed:

1. Facility owners and managers have an urgent need for a comprehensive information model for managing facility management functions.
2. Most information models do not follow a system analysis approach, which is a road map to identify and solve a problem and the typical FM functions. FMMMR follows system analysis approach.
3. Most information models are either built in the FM platform or are supported by the restricted portions of maintenance work in FM functions, including the spatial and non-spatial, the mechanical system, and the maintenance of the roof low-slope. Developing a FM general platform with a specific concern, such as an M&R module is a requirement of the industry not being addressed by current information models.
4. Most information models are inefficient for FM applications. The FM information is mostly available in the wrong format or in the wrong place. Retrieving or reformatting the wrong information is a costly waste. [Whitten et al. 2001] manifests the resources of this inefficiency as follows:
    - ➢ Either too little or too much information
    - ➢ Incomplete and inconsistent information
    - ➢ Obsolete or inaccurate Information
    - ➢ Redundant information
    - ➢ Information that is not relevant to the task at hand

5. There is a lack of integration between information technologies and FM functions. Any solution should consider the most important factors that affect the entire information model. This lack of integration can arise in different ways and from different resources. Sections 3.4 and 3.5 explain the system requirements and type of information models.
6. A wide range of functions are included in FM. The IAI and the IFC delineate the functions and elements of FM as indicated in sections 2.4 and 2.5 of chapter 2. Maintenance and Repair Management (M&RM) is one of the FM functions that receive the least attention in current FM fields, while it is the most important component for the life cycle of a facility.
7. Two studies out of the 19 evaluated had focused on the maintenance function and developed an information model.
   - "A Forecasting Model for Maintenance and Repair costs for Office Building" [Yiqun Lui 2006] ; and
   - "A Decision Support System for the Maintenance Management of Buildings" [Langevine 2006]

Both of these studied maintenance and/or repair cost forecasting in isolation, by different methods and not within a platform model for facility management. Building owners are always trying to reduce Maintenance and Repair Expenses (M&RE) within their available budget based on annual building income. Operation expenses, local and federal taxes, fees, fixed expenses, and other categories are all very important for a building, and the M&RE should be at the same level of importance. The ratio of M&RE to the total annual income is an important and sensitive issue for building owners. This ratio should be studied with a high level of accuracy, supported by trusty benchmarks for the total income and total expenses. Building evaluation (assessment) and forecasting annual M&R expenses for five or ten years is not a function of either model, indicating a lack of information in this field. Forecasting the annual M&R expenses for five or ten years by using different types of maintenance programs (corrective, preventive, and predictive maintenance) is a typical solution and building owners and managers prefer having this option.

5.2.2 ANALYZE AND UNDERSTAND THE PROBLEM

This is the second step of the system development methodology. The following points illustrate the analysis of the previous research and indicate the current understanding the problem of FM models:

1. As outlined, M&R is the most important function in FM and thus justifies our focus on it.
2. M&R is the reaction to deterioration acts to maintain a building in the required range of its life span.
3. The M&R budgeted cost is always the most-affected factor in the annual operation and maintenance expenses, yet it has not been very well estimated nor included in an accurate, reputable method.
4. The various types of maintenance programs (daily, preventive, and predictive) have been mixed together and not scheduled in a comprehensive plan.

5. Interval Facility Evaluation for 10-year plans is not yet familiar to facility owners or managers.
6. A database for M&R expenses should be taken from a trusty benchmark such as the BOMA, which has more than 100 years of experience in this field. In the previous research only one study was based on BOMA data.
7. Forecasting annual M&R expenses for the medium term 10 years is an important solution and would be a valuable tool for professional planning with an acceptable annual budget for building owners and managers.
8. Scheduling the various types of maintenance programs according to the forecasting of annual M&R expenses for ten years is also an important function within facility management.

5.2.3 IDENTIFY SOLUTION REQUIREMENTS OR EXPECTATIONS

Annual maintenance and repair expenses as a portion of total annual income, known as the Annual Maintenance and Repair Ratio (AM&RR), are at the core of any solution to implementing a 10-year maintenance program based on property condition assessment. A comprehensive and integrated facility management model for maintenance and repair components makes this possible. The requirements of this model are:

1. Trusted benchmark data for Total Annual Income (TAI), total expenses, fixed expenses, Maintenance and Repair Expenses (M&RE), federal and local taxes, etc. The BOMA can provide this benchmarks data for

different Canadian cities thanks to their Experience and Exchange Report (EER) for any year;

2. A building Property Condition Assessment (PCA), to forecast the M&R components for 10 years planning. Any consultant or specialist in the building inspection business could be a resource for this requirement. This research depends on the Inspec-sol Property Condition Report (PCR), which is in accord with the ASTM E 2018-01 standardization. Inspec-sol is a firm specializing in this type of PCA in Montreal;
3. The inflation rate is very important for forecasting M&R expenses. Statistics Canada is the best resource for this information;
4. Determining the relationship between the Annual M&R Expenses (AM&RE) and the Total Annual Income (TAI), by using the BOMA database;
5. Finding the Allowable Annual M&R Expenses (AAM&RE), using the total annual income of selected building and referring to the AM&RR;
6. Forecasting the Allowable Annual M&R Expenses (AAM&RE) for ten years or less by using Net Present Value (NPV) formula;
7. Setting a priority rule for the M&R components according to their positions in the building, cost estimate, M&R-type program and the allowable funds;
8. Identification of the two types of M&R programs (Preventive Maintenance Program (PMP), and Predictive Maintenance Program (PrMP)); and

9. The generation of required reports.

5.2.4 DESIGN AND IMPLEMENT THE SOLUTION

A Facility Management Model for Maintenance and Repair (FMMMR) is the solution that will meet all of the stated requirements. The design process of FMMMR is as follows:

1. Design and implement a database warehouse for the M&R Expense components from a BOMA EER report. See more details in chapter 6;
2. Establish the Annual Maintenance and Repair Expenses (AM&RE) references for all of the M&R components. See more details in chapter 6;
3. Calculate the Annual Maintenance and Repair Expenses Ratio (AM&RR) by dividing the AM&RE by the Total Annual Income (TAI). See more details in chapter 6;
4. Determine the average Inflation Rate (IR) or by R^2 method for 20 years by using the Statistics Canada database. See Appendix C;
5. Input the selected building information:
    a. Building criteria and information
    b. The Property Condition Report (PCR). See more details in chapter 6; and
    c. The Total Annual Income (TAI). See more details in chapter 6;
6. Retrieve summary building information;

7. Determine the Allowable Annual Maintenance and Repair Expense (AAM&RE) for selected building (case study) based on their TAI and AM&RR. See more details in chapter 6;
8. Forecast ten years or less for AAM&RE using the net present value formula;
10. Determine the maintenance program type (Preventive Maintenance Program (PMP), or Predictive Maintenance Program (PrMP));
9. Assign the Proposed Annual M&R Expenses (PAM&RE) for each M&R component according to the priority rule and so that the PAM&RE does not exceed the AAM&RE for an assigned year; and
10. Generate reports. See chapter 7 for more details.

5.2.5 EVALUATE AND VALIDATE THE MODEL

As facility management models become more common, more attention is being paid to the question of how to evaluate and validate these models. Researchers and developers have utilized a variety of techniques including field tests and expert reviews, but there is no clear consensus on which methods are appropriate in which circumstances [M. Tanyel and Omer 2007].

Ying Nan states the same evaluation and validation correctness conditions; currently there is no specific testing methodology that can be easily applied to determine the correctness of the models for facility management. Furthermore, no algorithm has been developed to determine which techniques or procedures are more useful. Moreover, every new simulation project presents a new and unique challenge [Ying Nan et al. 2011].

The scope of evaluation is to verify that the information covered in the data model is capable of representing the attributes of a real time building commissioning case. During the commissioning process, a huge amount of information is produced. Much of this information is kept in commissioning reports of real projects [M. Tanyel and Omer 2007]. By another words, the evaluation is the ensuring that the software of the facility management model and its implementation are correct.

Interoperability demonstrations are done after the model is developed. These evaluations are summative; they focus on what has actually accomplished and evaluate the impact of the model in terms of interoperability and business use case value. Interoperability demonstrations are either done with a piece of prototype software or commercial software tool that utilizes the developed model [M. Tanyel and Omer 2007].

Evaluation is concerned with doing things right, and validation is concerned whether with doing the right things, so the validation is the process of determining whether a simulation model is an accurate representation of the system for the particular objective of the study. Accordingly, the purpose of the evaluation and validation is to assess a model that is accurate when used to predict the performance of the real-world system that it represents [Ying Nan et al. 2011].

After the above introduction to the evaluation and validation of the facility management model, two main methods are utilized for validation building product models: expert assessment focusing on the content of the model and interoperability demonstration focusing on the ability of the model to support the functionality in the business use case. The experts are formed as a group that has experience in AEC industry, information modeling and software development. Expert assessment is a formative approach and utilized during the development phase. It examines how the model is improving and may lead to changes in the way the model is structured and carried out [M. Tanyel and Omer 2007].

Chapter six, seven and eight evaluate and validate the development FMMMR model, the implementation of the prototype’s case, and the improving the comments on the necessary points and future recommendations.

Following the steps as indicated can optimize the objectives of this research. The research methodology and the structure of this research were explained in sections 1.5 and 1.6 of chapter 1, which also concisely presents the methodology.

5.3 CONCLUSION

Building owners and managers desperately need facility management models for maintenance and repair management to assist them in managing deteriorating properties. This situation reflects the immediate need for research to develop a reliable model in the domains of facility management and annual maintenance and repair to assist building owners and managers to solve the complex problems associated with facility management.

This chapter presented the methodology of developing an integrated conceptual facility management model for annual maintenance and repair expenses for office buildings, following a system analysis approach. The system analysis approach has five main steps: identifying the problem, analyzing and understanding the problem, identifying solution requirements or expectations, designing and implementing the solution, and evaluating the results.

CHAPTER SIX

PROCEDURES TO DEVELOP FMMMR

6.1 INTRODUCTION

Chapter 6 concentrates on the design stages process to develop FMMMR. Starting with the references to building a database warehouse, BOMA EER report for maintenance and repair components, Canadian cities recorded with BOMA EER, the maintenance and repair ratio (MRR), followed by property condition assessment, cost estimate for the M&R components, Study the methods to determine accurate inflation rate, and finally all the previous resources of database warehouse ended by 10-year strategic plan, which is the primary goal of this research and the building owner and manager. Practical example illustrates in this chapter to approve the relationships between the resources and shows the flow process step by step. This practical example depends on the case study and will validate the prototype software.

6.2 DATABASE DEVELOPMENT PROCESS

As outlined in Chapter 5, the database warehouse and references of FMMMR are totally depending on the Building Owners and Managers Association (BOMA) reports, Experience Exchange Reports (EERs) and Property Condition Assessment (PCA) produced by any assessment firm or observer (Inspector).

6.2.1 BUILDING OWNERS AND MANAGERS ASSOCIATION (BOMA INTERNATIONAL)

The BOMA, founded in 1907, is a professional organization for commercial real estate and is the oldest and largest in its field. Its membership includes building owners, managers, developers, leasing professionals, medical office building managers, corporate facility managers, and asset managers. It publishes “The BOMA Magazine” [BOMA, 2010].

BOMA’s North American membership represents a combined total of more than nine billion square feet (850 million m^2) of downtown and suburban commercial properties and facilities in North America [BOMA, 2010].

BOMA International communicates the issues, trends, statistics and news of the commercial real estate industry to its members via several publications. These include the BOMA Magazine, the official publication of BOMA International, and the Experience Exchange Report, a compilation of income and expense data for office buildings across North America reporting on over 1 billion square feet of office space and the industry benchmark for more than a decade. They also publish several “how-to” guidebooks with, for example, information on measuring floor area [BOMA, 2010].

6.2.1.1 EXPERIENCE EXCHANGE REPORT (EER)

The EERs, produced by the BOMA, provide readers with a diverse collection of data analyses ranging from national cross-tabulations and special building data tabulations to city analyses for over 250 cities in North America. For each metropolitan area, the data is further broken down into location (downtown or suburban), submarket (where data permits) and size analyses. While the data in size analyses eliminate the possible income and expense variations due to size, the size parameter greatly reduces the number of data points presented in the tables. To examine a large sample data set one can use the “all downtown” or “all suburban” tables. A good rule of thumb for obtaining more reliable information is to use tables with at least 25 buildings; if the number is much less, than 25 then the data must be used with caution [BOMA EER 1999].

EERs are the most comprehensive resource for financial performance information on private and public office buildings in North America. It is the only research product on the market that features analytical studies of national trends and market level reports. The 2010 EER tracks income and operating expenses from 4,549 buildings across North America, including office rents, retail and other income, telecom and wire access income, real estate taxes, energy and other utility costs, repair and maintenance, cleaning, administrative costs, security, roads and grounds, and more. The EE Report is used by property owners, property managers, brokers, asset managers, investors, appraisers, service providers, engineers, consultants, economists, and for research and analysis [BOMA EER 1999].

Each EER has four tables; each table has two related sections [BOMA EER 1999]:

1. General building information and its criteria; and

2. Table details

The tittles of the four tables are: (see Appendix 1 for a particular city)

1. Occupancy Summary

2. Income and Expense Overview

3 Income and Expense Summary

4 Income and Expense Details

Important components of an EER are specifying in Appendix A.

6.2.1.2 Maintenance and Repair Components:

Maintenance and Repair (M&R) expense is an important category of total operation expense. It covers the total expenses of a building for repair and maintenance work to operate that building in a proper condition and to offer the best quality and environmentally-sound services to the end users. M&R expenses contain 12 subcategories; Payroll, Elevator, HVAC, Electrical, Structural/Roofing, Plumbing, Fire/Life safety, General Building Interior, General Building Exterior, Parking Lot, Miscellaneous/Other. A building's location (downtown or suburban), height, total area, and a building's age are also factors that affect the total amount of maintenance and repair. BOMA EER reports consider all of these elements to calculate the total annual maintenance and repair expense per square foot for a given market. Annual Maintenance and Repair Expense (AM&RE) is the main subject of this research -- the FMMMR will calculate, forecast, schedule, and plan different types of maintenance and repair for a given office building after studying its categories and Total Annual Income.

6.2.1.3 Canadian EER 2010

As outlined above, the EER has four tables, and each table has two related sections. The first section is the building information criteria and the second is the table itself. When any change is made in the building information criteria, such as Market (city), Location (Downtown, Suburban), Building Size, Building Height or Building Age, the information in the table will change accordingly. The Canadian EER 2010 shows 236 buildings from 12 Markets (cities), but only 145 buildings can be accessed through the database. Table 6.1 illustrates the Canadian cities, the number of buildings, and the province.

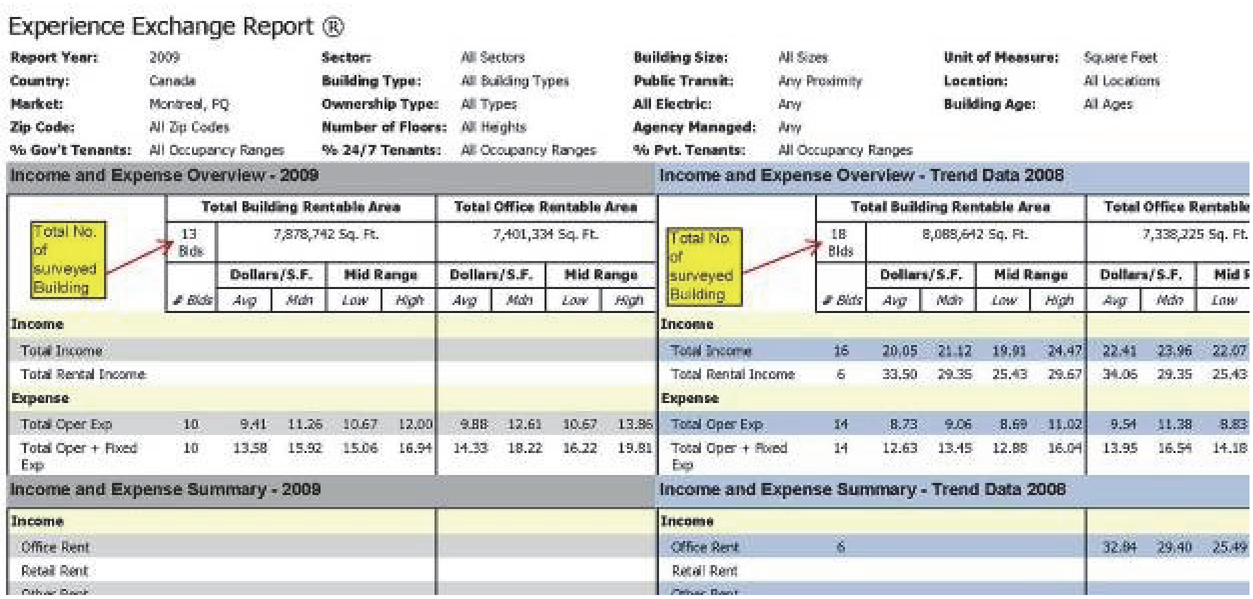
S. No	Province	**Market (City)**	Gov. Blds	Private Blds	Total Blds
1	Alberta (AB)	**Edmonton**			
2	British Columbia (BC)	**Vancouver**	8	2	10
3	Manitoba (MB)	**Brandon**	5		5
4	New Brunswick (NB)	**Frederiction**	6	1	7
5		**Saint John**	3		3
6	New Foundland and Labrador	**St. John's**	10	1	11
7	Nova Scotia (NS)	**Halifax**	15	2	17
8	Northwest Territori (NWT)	**Yellow Knife**			
9	Ontario (ON)	**Kingston**	5		5
10		**Ottawa**	36	8	44
11		**Sudbury**	8	1	9
12	Prince Edward Island (PEI)	**Charlottetown**			
13	Quebec (PQ)	**Montreal**	8	5	13
14		**Quebec**	12		12
15		**Rimouski**	8	1	9
16	Saskatchewan (SK)	**Regina**			
17	Yukon Territori (YT)	**Whitehorse**			
	Total		124	21	145
18	All Canada	**All Markets**	190	46	236
	Difference		66	25	91

Table 6-1 Canadian EER 2010 analyses

6.2.1.4 Canadian EER 2010 Comments

The following comments are necessary to better understand the Canadian EER 2010.

1. EER 2010 provides annual reports for two years by selecting “Include Trend Data” to “Yes” option. Chart Performance Trends allows performances to be tracked year-over-year within a given market or nationally. Figure 6.1 shows two charts: for year 2009 and year 2008.



Experience Exchange Report ®

Report Year:	2009	**Sector:**	All Sectors	**Building Size:**	All Sizes	**Unit of Measure:**	Square Feet
Country:	Canada	**Building Type:**	All Building Types	**Public Transit:**	Any Proximity	**Location:**	All Locations
Market:	Montreal, PQ	**Ownership Type:**	All Types	**All Electric:**	Any	**Building Age:**	All Ages
Zip Code:	All Zip Codes	**Number of Floors:**	All Heights	**Agency Managed:**	Any		
% Gov't Tenants:	All Occupancy Ranges	**% 24/7 Tenants:**	All Occupancy Ranges	**% Pvt. Tenants:**	All Occupancy Ranges		

Income and Expense Overview - 2009

Total No. of surveyed Building	Total Building Rentable Area					Total Office Rentable Area			
	13 Blds	7,878,742 Sq. Ft.				7,401,334 Sq. Ft.			
		Dollars/S.F.		Mid Range		Dollars/S.F.		Mid Range	
	# Blds	Avg	Mdn	Low	High	Avg	Mdn	Low	High
Income									
Total Income									
Total Rental Income									
Expense									
Total Oper Exp	10	9.41	11.26	10.67	12.00	9.88	12.61	10.67	13.86
Total Oper + Fixed Exp	10	13.58	15.92	15.06	16.94	14.33	18.22	16.22	19.81

Income and Expense Summary - 2009

Income		
Office Rent		
Retail Rent		

Income and Expense Overview - Trend Data 2008

Total No. of surveyed Building	Total Building Rentable Area					Total Office Rentable		
	18 Blds	8,088,642 Sq. Ft.				7,338,225 Sq. Ft.		
		Dollars/S.F.		Mid Range		Dollars/S.F.		Mid R
	# Blds	Avg	Mdn	Low	High	Avg	Mdn	Low
Income								
Total Income	16	20.05	21.12	19.91	24.47	22.41	23.96	22.07
Total Rental Income	6	33.50	29.35	25.43	29.67	34.06	29.35	25.43
Expense								
Total Oper Exp	14	8.73	9.06	8.69	11.02	9.54	11.38	8.83
Total Oper + Fixed Exp	14	12.63	13.45	12.88	16.04	13.95	16.54	14.18

Income and Expense Summary - Trend Data 2008

Income				
Office Rent	6	32.84	29.40	25.49
Retail Rent				

Figure 6-1 Chart Performance Trends for year 2009 and 2008

2. In the EER table, “Income and Expense Overview” the term “#Blds” indicates the number of buildings covered by the survey. The EER 2010 for all

Canadian markets (cities) covered 236 buildings. See figure 6.2 for 2008 and 2009.

Experience Exchange Report ®

Report Year:	2009	**Sector:**	All Sectors	**Building Size:**	All Sizes	**Unit of Measure:**	Square Feet
Country:	Canada	**Building Type:**	All Building Types	**Public Transit:**	Any Proximity	**Location:**	All Locations
Market:	All Markets	**Ownership Type:**	All Types	**All Electric:**	Any	**Building Age:**	All Ages
Zip Code:	All Zip Codes	**Number of Floors:**	All Heights	**Agency Managed:**	Any		
% Gov't Tenants:	All Occupancy Ranges	**% 24/7 Tenants:**	All Occupancy Ranges	**% Pvt. Tenants:**	All Occupancy Ranges		

Income and Expense Overview - 2009

	Total Building Rentable Area					Total Office Rentable Area			
	236 Blds	34,283,038 Sq. Ft.				31,578,073 Sq. Ft.			
		Dollars/S.F.		Mid Range		Dollars/S.F.		Mid Range	
	# Blds	Avg	Mdn	Low	High	Avg	Mdn	Low	High
Income									
Total Rental Income	23	28.49	17.32	9.83	30.62	28.96	17.40	9.83	31.22
Total Income	23	30.45	17.54	9.97	32.54	30.95	17.62	9.97	33.33
Expense									
Total Oper Exp	178	9.74	10.73	8.59	12.85	10.51	12.15	9.48	14.79
Total Oper + Fixed Exp	199	13.83	14.57	11.79	17.42	14.97	16.22	12.99	19.87
Income and Expense Summary - 2009									
Income									
Office Rent	24					27.71	13.01	10.65	29.87

Income and Expense Overview - Trend Data 2008

	Total Building Rentable Area					Total Office Rentable Area			
	240 Blds	32,257,376 Sq. Ft.				29,276,235 Sq. Ft.			
		Dollars/S.F.		Mid Range		Dollars/S.F.		Mid Range	
	# Blds	Avg	Mdn	Low	High	Avg	Mdn	Low	High
Income									
Total Income	198	21.24	19.61	15.84	23.85	23.79	22.24	18.71	26.82
Total Rental Income	18	22.98	20.10	10.33	29.35	23.93	20.10	10.33	29.35
Expense									
Total Oper Exp	180	9.06	10.07	8.30	12.46	9.97	11.68	8.99	14.70
Total Oper + Fixed Exp	192	13.14	13.78	11.64	16.47	14.50	15.78	12.75	19.07
Income and Expense Summary - Trend Data 2008									
Income									
Office Rent	19					23.19	19.19	10.33	29.40

Figure 6-2 EER-Canadian, for all markets and selected for all criteria, for year 2009 and year 2008.

3. Since not all building owners or managers file their information so that the EER survey cannot properly process it (if they file at all), the "# Blds" indicates only the number of buildings that provided the given data. In the second table, Total Income indicates that 23 of 236 buildings provided the amount of the total annual income information. The "# Blds" as the raw data of "Total Operation and Fixed expenses" is 199 of the 236 buildings.

4. Online subscribers of the BOMA EER 2010 report can access this report for all Canadian and US markets with or without "Chart Performance Trends". EER 2010 requires a minimum of five buildings to generate a report. For example: by selecting Montreal for :"Market", Private for "Sector", and Suburban for "Location" the result of running the program is 2 of 13 buildings

and will not generate a report. The 13 buildings indicated the total number of buildings that participated in the 2009 survey from all three criteria. See table 6-1

5. Table 6-1 Canadian EER 2010 Analysis indicates the number of buildings for Government and Private sectors for each Canadian market (City).

6. The number of Canadian Markets and buildings for EER 2010 are less than the previous year, EER 2009, and are decreasing in scale. EER 2002 shows about 28 Markets participated in the survey, while EER 2010 shows only 12 Canadian markets participated.

7. The largest city in Canada is Toronto, which did not participate in EER 2010. This was a surprise to the BOMA committee and to the researchers. This indicates the unhealthy condition for the Canadian market's participation in general and Toronto in particular for real state statistics and benchmark performances.

8. Saint John's in New Brunswick participated with only three buildings. Accordingly, the EER 2010 cannot generate any statistical or performance reports for that city.

9. The number of private buildings for any Canadian market in the EER 2010 is less than five, and so EER 2010 cannot generate reports for those markets. Only Montreal and Ottawa have submitted data for five or more private buildings. Montreal has five and Ottawa eight private buildings in EER 2010.

No additional reports can be generated for either Montréal or Ottawa if the selection goes any deeper for the location, size, or age, for lack of a large enough database.

10. The EER 2010 can generate a solid report when the criteria selections are set for 'all'. The report will show the Total Income and Total Expense data in the overview or in the detailed tables.

11. EER 2010 does not generate income data for most Canadian markets. This is also the case for the Montreal, private sector.

12. In general, EER 2009 (data collected in the year 2008) reported income data under the selection for all criteria.

13. EER 2009, showing trend data from 2008 for Montreal under the selection for all criteria is the most important resource for this FMMMR research.

14. An EER report has two information columns. The first is the "Total Building Rentable Area" and the second is the "Total Office Rentable Area". FMMMR research depends on the first column data of Income and Expense.

15. Total Rental Income for Montreal –Trend Data 2008- under selection "all" for all criteria is 33.5 $/SQFT for six buildings. The Average, Median, Low, and high values are 33.5 $/SQFT, 29.35 $/SQFT, 25.43 $/SQFT, and 29.67 $/SQFT, respectively.

16. Table 6.2 shows the data for Montreal from the Trend Data 2008 table that will be used for the FMMMR.

City	Total Rental Income ($/sqf)					Total Oper Exp ($/sqf)					Maint & Rep Exp ($/sqf)				
	#Blds	Avg	Mdn	Low	High	#Blds	Avg	Mdn	Low	High	#Blds	Avg	Mdn	Low	High
Montreal	6	33.50	29.35	25.43	29.67	14	8.73	9.06	8.69	11.02	10	2.43	3.09	2.31	3.47

Table 6-2 EER 2009 Data for Montreal City

17. The median values for "Total Rental Income", Total Operation Expense", and "Maintenance & Repair Expense" for Montreal (Trend data from 2008) are 29.35, 9.06, and 3.09 $/SQFT respectively. See table 6-2

18. Sometimes, the "Income and Expense Summary Table" does not include the summary of Maintenance and Repair Expense. The summation is performed wherever it was missing. Table 6-3 explains the values of Avg or Mdn TAI and AM&RE for any Canadian city with the "#Blds" for that value. Any value for Avg or Mdn of AM&RE without the number of "#Blds" that it is referring to get their value directly from the "Income and Expense Summary Table".

6.2.1.5 Total Annual Income (TAI) and Annual Maintenance and Repair Expenses (AM&RE) for Canadian Cities according to the EER 2009 Report.

Table 6-3 shows the values of the Total Annual Income (TAI) and Annual Maintenance and Repair Expenses (AM&RE) for each city and in different categories (All, Government, and Private). These two items are the benchmarks for any future studies and will serve as references in the database. All calculations and operations in this research will depend on the average of TAI and AM&RE. In this table Montreal has two different types of data with a number of buildings. The first is for Montreal (All) and the second is for Montreal (Gov). The number of buildings that provided the information for TAI in (All) is six and ten for AM&RE, while in the (Gov) category these numbers are 13 and 6, respectively. The data in the Montreal (All) column is closer to 'reality', because it has more buildings in the expenses report and lower numbers in the income report, and so this is the data that will apply in this research. All values of TAI and AM&RE are calculated at 100% of Office Occupancy and the area of a building includes common areas and general upkeep as per BOMA EER 2009 report's catalogue. Therefore, the values of TAI and AM&RE can be used immediately without any further treatment.

City	Office Occupancy (%)	Total Annual Incom (TAI) $/SQFT			Annual Maintenance & Repair Expenses (AM&RE) $/SQFT		
		#Blds	Avg	Mdn	#Blds	Avg	Mdn
Vancouver	96.63	10	27.68	24.03	10	2.18	2.48
Brandon	94.55	5	17.23	16.99		2.35	2.47
Fredericton	95.24		17.27	17.18		2.74	3.34
St. John's	99.88	11	22.67	20.46	5	3.39	3.55
Halifax	96.71	18	21.37	18.33		5.44	6.00
Kingston	90.95		0			3.20	4.41
Ottaw (All)	97.79	36	23.1	21.63	20	2.99	3.11
Ottawa (Gov)	98.03	30	24.33	21.72	14	2.99	3.11
Ottawa (Priv)	95.24	6	12.39	10.19	6	3.01	2.95
Sudbury	96.37	7	19.30	14.45	5	2.97	3.89
Montreal (All)	95.75	6	33.50	29.35	10	2.43	3.09
Montreal (Gov)	97.6	13	22.05	21.37	6	2.99	3.34
Quebec	97.97	12	19.90	19.67		5.35	5.06
Rimouski	89.83	8	18.38	25.02		4.79	5.51
All Cities	94.6	18	22.98	20.10	122	2.55	2.92

Table 6-3 Total Annual Income and Annual Maintenance & Repair Expense for Canadian Cities according to EER 2009

6.2.1.6 Annual Maintenance and Repair Ratio (AM&RR)

The averages of the Total Annual Income TAI and of the Annual Maintenance and Repair Expenses AM&RE are recorded in table 6-3, according to the BOMA EER 2009 Report. The next step is to find the relationship between these two most important elements (TAI and AM&RE). This relationship is known as the Annual Maintenance and Repair Ratio (AM&RR), and is the weight of the value of the AM&RE to the value of the TAI for each property, according to its categories. The potential importance of the Annual Maintenance and Repair Ratio (AM&RR) is because it can become a benchmark to determine and forecast the future annual maintenance and repair expenses for any property according to its actual total annual income. We can consider AM&RR as a reference and benchmark for further economic and engineering studies such as Annual Maintenance and Repair Expenses because it is the result of a process that include data and elements from independent sources for over a hundred years. Table 6-4 shows the value of the AM&RR for each type of property in each Canadian city.

City	Office Occupancy (%)	Total Annual Incom (TAI) $/SQFT			Annual Maintenance & Repair Expenses (AM&RE) $/SQFT			AM&RR
		#Blds	Avg	Mdn	#Blds	Avg	Mdn	Avg
Vancouver	96.63	10	27.68	24.03	10	2.18	2.48	0.08
Brandon	94.55	5	17.23	16.99		2.35	2.47	0.14
Fredericton	95.24		17.27	17.18		2.74	3.34	0.16
St. John's	99.88	11	22.67	20.46	5	3.39	3.55	0.15
Halifax	96.71	18	21.37	18.33		5.44	6.00	0.25
Kingston	90.95		0			3.20	4.41	NA
Ottawa (All)	97.79	36	23.1	21.63	20	2.99	3.11	0.13
Ottawa (Gov)	98.03	30	24.33	21.72	14	2.99	3.11	0.12
Ottawa (Priv)	95.24	6	12.39	10.19	6	3.01	2.95	0.24
Sudbury	96.37	7	19.30	14.45	5	2.97	3.89	0.15
Montreal (All)	95.75	6	33.50	29.35	10	2.43	3.09	0.07
Montreal (Gov)	97.6	13	22.05	21.37	6	2.99	3.34	0.14
Quebec	97.97	12	19.90	19.67		5.35	5.06	0.27
Rimouski	89.83	8	18.38	25.02		4.79	5.51	0.26
All Cities	94.6	18	22.98	20.10	122	2.55	2.92	0.11

Table 6-4 Annual Maintenance and Repair Ratio (AM&RR %)

6.2.1.7 The relationship between AM&RR and Building's Location, Size, Age, and Height

Table 6-4 explains relationship between three items TAI, AM&RE and AM&RR. The measuring unit for both TAI and AM&RE is $/SQFT. BOMA EER, online provides tables for any market (city) by location, size, age, and height individually, if there are at least five buildings in each category provided complete information as mentioned in 6.2.1.4 Canadian EER 2010 Comments. AM&RR is the ratio between two components TAI and AM&RE. It is so easy to determine AM&RR if BOMA EER provided values for TAI and AM&RE for any category of location, size, age, and height for the same market and for more than five buildings. Recently, most Canadian cities provided building information to BOMA EER survey with less than five buildings to any category which make impossible to determining AM&RR. On the other hand, the AM&RR for “All” is included the impact value of location, size, age, and height on both TAI and AM&RE and by indirect on AM&RR, which is the average impact of all categories. FMMMR is database model depends on the data provided by the source, which is BOMA EER as one of the main providers. FMMMR will provides details value for AM&RR if the source provided details values for TAI and AM&RE as illustrated in table 6-4 for Ottawa and Montreal markets (all, government, and private). Accordingly, the results of AM&RR and other subsequences results such as strategic plan for 10 years will be more accurate when BOMA EER provides a wide range of building information with full data of location, size, age, and height.

6.2.2 Property Condition Assessment (PCA)

Ying defined the Property Condition Assessment as measuring and evaluating the state properties of a constructed facility and relating these to the performance parameters [Ying Nan et al. 2011].

The second Component of the FMMMR is the Property Condition Assessment (PCA). The purpose of this model, the FMMMR, is to define good office buildings and customary practice for conducting baseline property condition assessments of any improvement on a parcel of commercial real estate by performing a walk-through survey and conducting research, as outlined within this PCA [ASTM E2018 – 01]. Facility can be known with certainty or physical deficiencies only when in inspection, which is assumed to reveal the true condition without any measurement error, takes place. When a condition state is observed by inspection at a certain time, two kinds of actions can be available. One is repairing the facility, and the other is performing a new inspection after some time interval in order to minimize the life cycle cost of the facility [Mitsuru et al. 2008]. The term physical deficiencies includes the presence of conspicuous defects or material, arising from deferred maintenance of a subject property's material system, components, or equipment as observed during the field observer's walk-through survey. According to this definition, deficiencies that may be remedied with routine maintenance, miscellaneous minor repair, normal operating maintenance, etc. should be excluded.

The walk-through survey is the procedure to identify the state of a subject property's material and its physical deficiencies and to recommend various systems, components, and equipment that should be observed and evaluated to determine the extent of physical deficiencies. Prior to the walk-through survey, the observer or consultant should identify any physical deficiencies. Records, documents, owner or building manager interviews are used to specifically identify, or assist in the identification of physical deficiencies, as well as to be informed of preceding or ongoing efforts to investigate or remediate the physical deficiencies, or a combination thereof. The consultant or the observer should at least review the basic building certificates of occupancy, outstanding and recorded building code violations, and recorded material fire code violations. In addition, the owner or building manager should submit the following documents for review by the consultant or observer:

1. Previous building condition report or any appraisals;
2. Guarantee information (roofs, boilers, chillers, cooling towers, etc);
3. Records of building systems and materials' age;
4. Historical costs incurred for repairs, improvements, recurring replacements, etc.;
5. Pending preventive maintenance and proposed repairs;
6. Records indicating building occupancy and turnover percentages; and
7. Drawings and specifications.

6.2.2.1 Property Condition Report (PCR)

ASTM E2018 – 01 defines a Property Conditions Assessment and is the process by which a person or entity observes a property, interviews sources, and reviews available documentation for the purpose of developing an opinion and preparing a PCR of a commercial real estate property's current physical condition.

ASTM E2018 – 01 also defines the Property Condition Report: a written report, prepared in accordance with the recommendations contained in this guide (PCA), that outlines the consultant's observations and opinions as to the subject property's condition, and their assessment of the probable costs to remedy any observed material physical deficiencies. In fact, the product that results from completing a PCA in accordance with the PCA guide is a PCR. The PCR incorporates the information obtained during the walk-through survey, from the document review and interviews sections of this guide, and includes recommendations of probable costs for the suggested remedies of the identified physical deficiencies.

The objective of the inspection survey is to incorporate a visual comprehension of the subject property so as to obtain information on material systems and components for the purpose of providing a brief description. This would include identifying physical deficiencies to the extent that they are observable, and obtaining the information needed to address such issues in the PCR as outlined in the ASTM E2018 – 01. Inspections can help plan maintenance activities, such as replacing damaged roof flashing and inform major decisions such as roof replacement [Donald et al. 2010]. These activities and more are the major components of the 10 – year strategic plan of FMMMR.

During the walk-through survey the field observer records his/her observations as to the subject property's readily accessible and easily visible building components, equipment, and systems. This observer must have acquired detailed, specialized knowledge and experience in the design, evaluation, operation, repair, or installation of the same components, equipment and systems. The field observer should document his/her observations and records with photographs. The photographs should include, as a minimum: front and typical elevations and exteriors, site work, parking areas, roofing, structural systems, conveyance systems, life safety systems, representative interiors, and any special or unusual conditions.

6.2.2.2 Walk-Through Survey

Mitsuru listed two dimensions to the observation decision: (1) when to inspect to facility and (2) how to inspect it (which technology to use). The first decision is related to the presence of forecasting uncertainty, and the second is with that of measurement uncertainty. Formulating the optimal timing problem of both inspection and M&R activities with forecasting uncertainties are the objectives of the building owners or managers [Mitsuru et al. 2008].

ASTM E 2018 – 01 lists a set of observations during a site visit that a field observer should record: the general physical condition of the subject property, the material systems and components, and any material physical deficiencies or unusual features or inadequacies observed or reported, by conducting specific or representative observations, as appropriate. ASTM E 2018 – 01 divides the subject ‘property’ into the following subsections:

1. **Site:** The observer should investigate the general topography and problematic features, storm water collection and drainage system, paving material and curbing system, number and type of parking spots, sidewalks, landscaping (material and system), and type and provider of the material utilities (water, electricity, natural gas, etc.).

2. **Structural Frame and Building Envelope:** The observer should identify any problematic features related to the building material, the type of structure (including substructure) and the superstructure and building envelope system (facades or curtain wall system, glazing system, exterior sealants, exterior balconies, doors, stairways, parapets, balconies, etc.).

3. **Roofing:** The observer should take note of any problematic features related to the roofing system material, including parapets, balconies, slope, drainage, etc., including the age of the material and of roofing system, roof warranty, and any evidence of roof leaks and repair.

4. **Plumbing:** Identify and observe the material and systems of the plumbing systems (sanitary, storm, and water supply).

5. **Heating:** Report any problematic features related to the heat generation and distribution system, identify the type of maintenance, indicate the

maintenance contract validity, verify if equipment must be replaced or upgraded, note any unusual shutdowns, and determine the repair time lag.

6. **Air Conditioning and Ventilation:** The observer should report any problematic features related to the air conditioning and ventilation systems, including cooling towers, chillers, package units, split systems, air handlers, thermal storage equipment, age of material and equipment, past material component upgrades/replacements, type of maintenance and its level, verify the state of the maintenance contract, note any unusual shutdowns, and determine the repair time lag.

7. **Electrical:** Identify the electrical service provided and report on the state of the electrical distribution system (panels, transformers, meters, emergency generators, general lighting systems, etc.), indicate general electrical items (type of wiring, energy management systems, emergency power, lighting power, etc.), and any special or unusual electrical equipment or systems.

8. **Vertical transportation:** The observer shall report the number and type of the equipment, elevator cabs, finishes, call and communication equipment, and validates the maintenance contract and type of service (maintenance).

9. **Life Safety/Fire Protection:** Indicate the life safety and fire protection system, (sprinklers, and standpipes), fire hydrants, fire alarm systems, water storage, smoke detectors, fire extinguishers, stairwell pressurization, and smoke evacuation, as well as determine the safety policies in place (battery replacement, drills).

10. **Interior Elements:** The observer should report any problematic features related to the material and the systems of common areas (lobbies, corridors, assembly areas, and restrooms), the typical finishes (flooring, walls, and ceilings), and to any special features such as spas, fountains, clubs, shops, restaurants, etc.

11. **Additional Consideration:** The observer shall report any problematic features related to any material, equipment, components, systems, and services or any standardization issues that are not listed in the above categories.

6.2.2.3 Cost Estimates

Estimating property maintenance and repair costs has always been a challenge. Facility managers are asked to perform many different estimates, often with little background information and not nearly enough time. Some examples of the items that have to be estimated are:

1. The cost to repair or replace a building component;
2. The value of deferred maintenance for an entire facility;
3. The annual maintenance budget;
4. Life cycle costs to justify a request for funds; and
5. The funds required to address the deficiencies identified during a recent property assessment report (PAR).

Items that are deemed deficient, but not significant in terms of importance, cost or their effect on the overall building condition will be considered to be within the scope of routine building maintenance. Routine maintenance is the day-to-day maintenance of facilities and equipment that will ensure their capability to perform their designed functions. Although definitions in the area of facility management are varied and sometimes incompatible, the range of work generally accepted as falling under routine maintenance includes:

1. Maintenance and minor repairs to equipment;
2. Maintenance painting;
3. Maintenance and minor repairs to HVAC distribution systems;
4. Maintenance and minor structural repairs to building and structures;
5. Maintenance and minor repairs to pavements; and
6. Maintenance and minor repairs to roofs.

Facility employees, except where overriding economic or labor-relation reasons dictate their contracted performance, should usually accomplish routine maintenance. For the purpose of this thesis, any item with a cost estimate less than $ 2000 will be considered within the scope of routine maintenance.

Cost estimates for maintenance and repairs presented in this thesis are from a Property Conditions Report (PCR), otherwise the cost and rates should be provided by approved resources such as “Hanscomb’s Yardsticks for Costing –

Cost data for the Canadian Construction Industry" published by R.S. Means Company or the BOMA database.

These estimates are intended only for global budgeting purpose; they should be used as a guide only, as actual cost may vary according to the time of year, the quality of material used, volume of work, actual site of conditions, etc.

6.3 Consumer Price Index -- CPI (Inflation Rate)

Statistics Canada provides different types of tables for Consumer Price Index (CPI) for 20 years (1991 – 2010) as per appendix D. Appendix D has two columns of information: all-items and changes from the previous year, which represents the inflation rate. Table 6- illustrates Canadian Inflation Rate for 20 years between 1991 and 2010.

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Inflation Rate %	5.6	1.4	1.9	o.1	2.2	1.5	1.7	1.0	1.8	2.7
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Inflation Rate %	2.5	2.2	2.8	1.8	2.2	2.0	2.2	2.3	0.3	1.8

Table 6- 5 Canada Inflation Rate for 20 Years (1991-2010) (Statistic Canada)

Average Inflation Rate: The average inflation rate for 20 years is 2.00%, which represents the rate in the forecasting equation.

R Square: Is another method used for two variables (Inflation and Year) to estimate the inflation rate for certain years by simulation the inflation for the previous years. This method is more accurate than the average inflation rate when the value of R Square is closer to 1. Any linear equation from first or second order has R square value, but this value depends on the collected data of the variables (x and y) and the relationship between them. For the above data (Years and Inflation Rate), four charts has created to determine R Square and linear equation individually. Figure 6- shows the first chart for all years inflation rate, R^2 = 0.0551 and the linear equation is Y=- 0.041X + 2.4753.

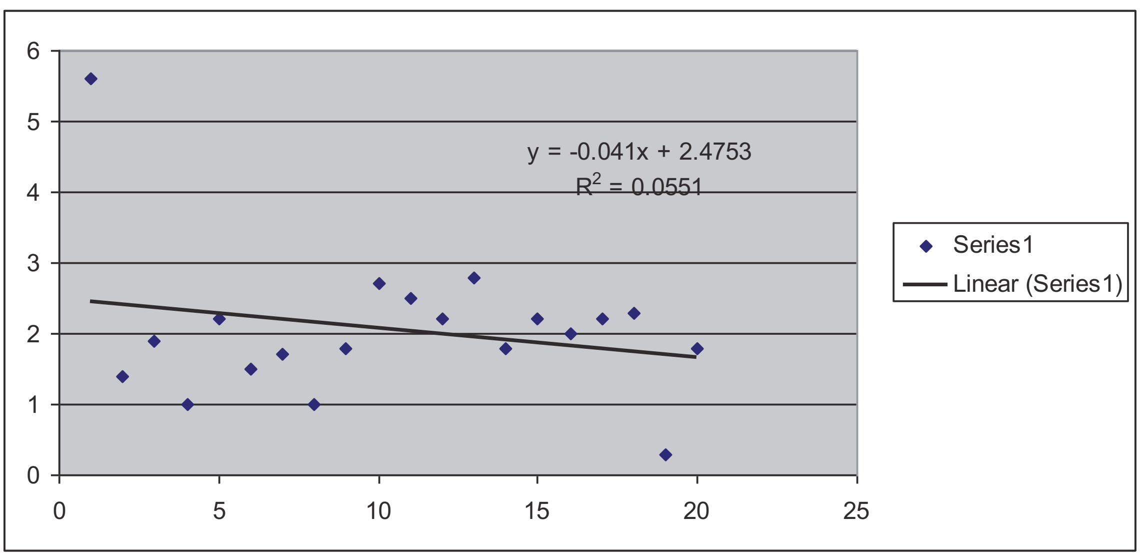


Figure 6- 3 Inflation Rate for all data

Figure 6- shows the second chart for the last 10 years, R^2 = 0.3958 and linear equation is Y = - 0.1273 X + 3.9818

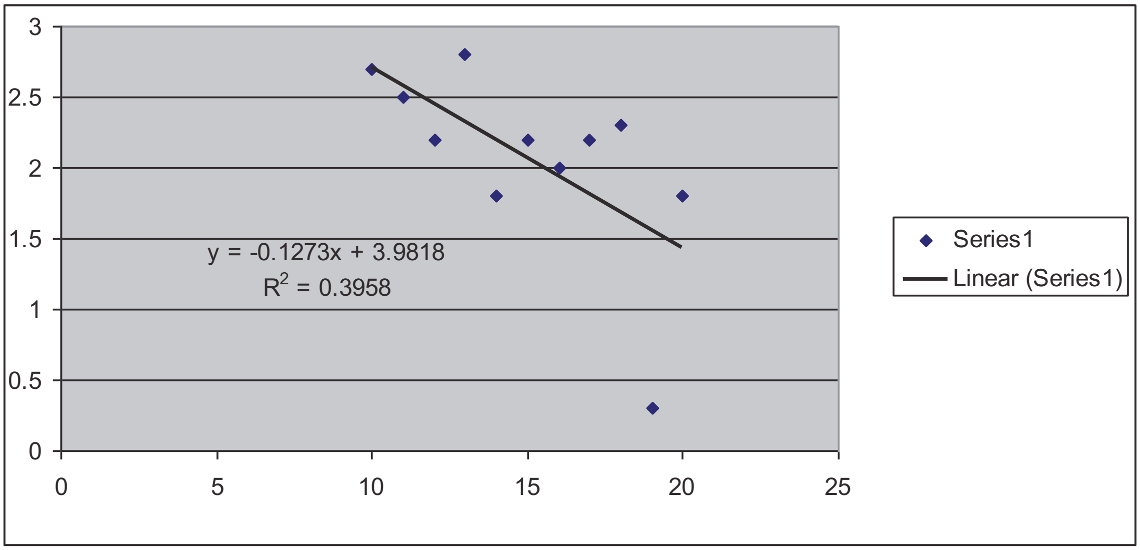


Figure 6- 4 Inflation Rate for Last 10 years

Figure 6- shows the third chart for the last 17 years by neglecting the first year and the last two years because they are not homogeneous with other data , R^2 = 0.2933 and linear equation is Y = - 0.0561 X + 1.4478

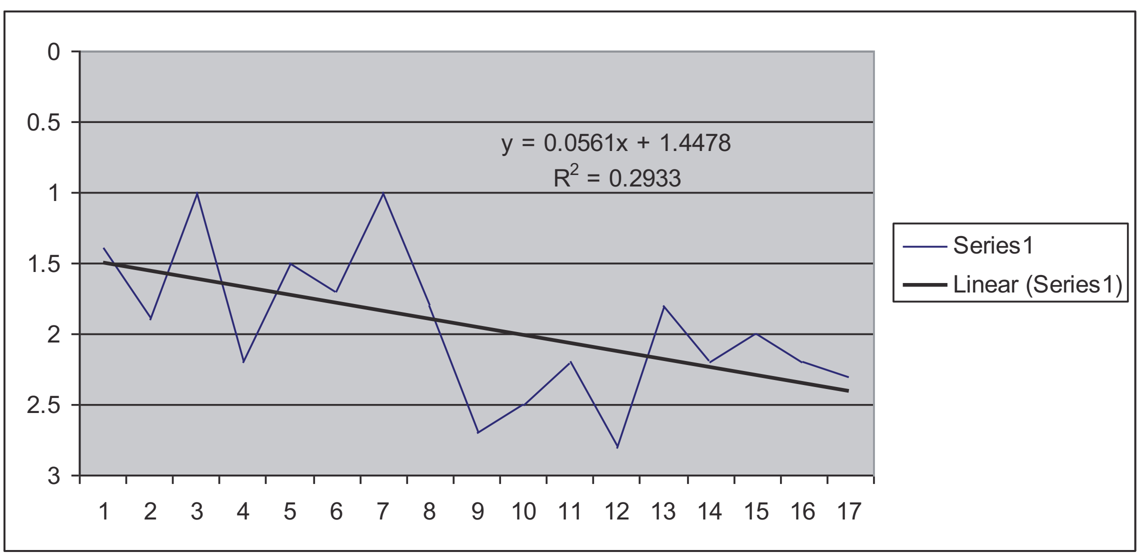


Figure 6- 5 Inflation Rate for 17 years

Figure 6- shows the forth chart for the 20 years, R^2 = 0.0736 and linear equation is Y = - 0.0046 X^2 – 0.138 X + 2.81

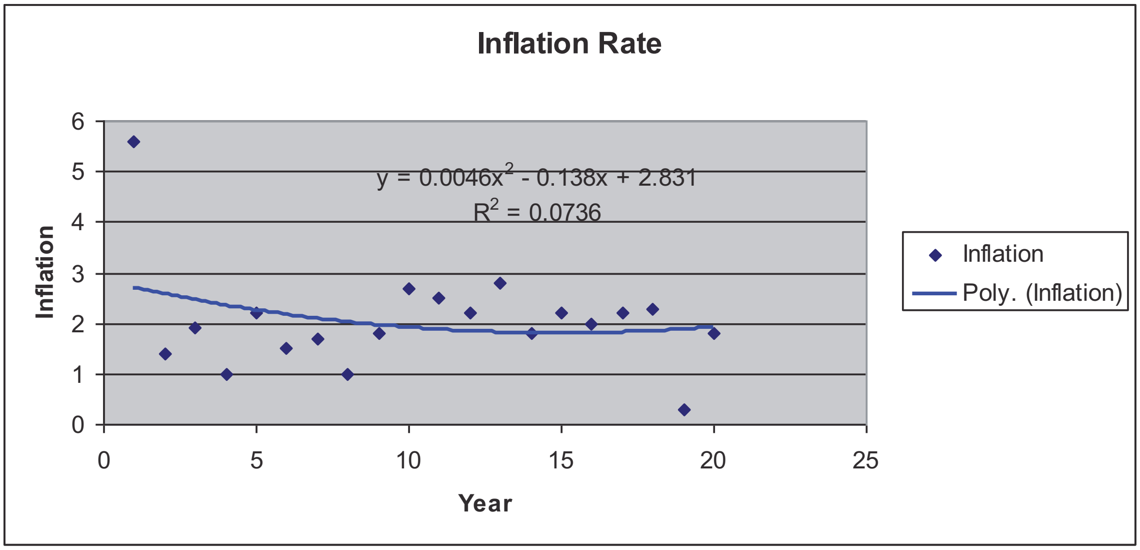


Figure 6- 6 Curve Inflation Rate for 20 years

Year	Serial # of Year	Inflation 1	Inflation 2	Inflation 3	Inflation 4
2011	21	1.6143	1.3148	2.6259	1.9616
2012	22	1.5733	1.1878	2.682	2.0214
2013	23	1.5323	1.0608	2.7381	2.0904
2014	24	1.4913	0.9338	2.7942	2.1686
2015	25	1.4503	0.8068	2.8503	2.256
2016	26	1.4093	0.6798	2.9064	2.3526
2017	27	1.3683	0.5528	2.9625	2.4584
2018	28	1.3273	0.4258	3.0186	2.5734
2019	29	1.2863	0.2988	3.0747	2.6976
2020	30	1.2453	0.1718	3.1308	2.831

Table 6- 6 Value of Simulation Inflation Rate According to the Four Charts

Observations: The average method is preferred on the R Square for the following rezones:

1. The R^2 value for the four charts are (0.0551, 0.3958, 0.2933, and 0.0736);

2. The four values of R^2 are too far from 1, which is the degree of R^2 Accuracy;

3. Table 6- illustrates Inflation Rate (IR) for each year from year 2011 until 2020 for the four charts calculated according to the equation mentioned in each chart;

4. Values of IR for chart 1 and 2 shows descending values while for chart 3 and 4 shows ascending values;

5. The reality values for IR between year 1991 and 2010 are irregularity as its clear in Table 6- ;

6. Any value for inflation rate after year # 20 (2010) will be not accurate if calculated by any equation as mentioned by the four charts;

7. The average of Inflation Rate (2.00) is the accurate value if its compared with the values calculated by any four equation;

8. The M&R strategic plan is designed for 10 years. Accordingly, the inflation rate value should be known and added once in a time to the program for 10 years not year by year; and

9. The above difficulties make the average inflation rate (2.00) is the superior value on the other values.

6.4 Forecasting Annual Maintenance and Repair Expenses (AM&RE)

An Annual Maintenance and Repair Ratio (AM&RR) has been calculated according to the BOMA EER 2009 report for all Canadian cities. This ratio is the reference for ten-year maintenance and repair strategic planning, which is the goal of any building owner or manager. The AM&RR for Montreal (All) is (7.25%). Montreal's inflation rate for the 20 years (1991 – 2010) was also calculated, and was 2.00% representing the rate (i) in the forecasting equation. On the other hand, ASTM E 2018 – 01 standardizes the Property Condition Assessment (PCA) and lists a table of contents for the property elements that need to investigate for maintenance and repair purpose. This PCA is good for five or ten-year periods. The ASTM table of contents is similar to the main elements of M&R in the BOMA EER report. Any consultant firm or authorized observer should provide his/her assessment report in detail and in summary form according to ASTM E 2018 – 01 and according to the BOMA EER report. In addition, a Property Condition Report (PCR) provides the approximate cost estimate for all maintenance and repair elements in terms of labor and material. Any cost for M&R that is less than $ 2000 is considered corrective maintenance (day-to-day) and is not included in the Preventive Maintenance Program (PMP). The FMMMR can forecast and manage ten-year annual M&R strategic plans, in accordance with the previous information, in addition to the Total Annual Income (TAI). The Allowable Annual Maintenance and Repair Expenses (AAM&RE) for any building in an EER report year is calculated by the following equation:

AAM&RE = TAI * AM&RR ------------------------------- equation 6.1

The Forecast Annual Maintenance and Repair Expenses (AM&RE) represent the maximum allowable AAM&RE for the current year. The proposed annual strategic plan should not exceed the allowable AAM&RE (AM&RE). In the research case study, the TAI is $ 2,793,132 for year 2010. Accordingly, the AAM&RE for year 2010 is

AAM&RE = 2,793,132 * 0.07

= $ 195,519

The $ 195,519 amount is the maximum allowable AM&R expenses for the data year (2010). The maximum allowable amount of the M&R expenses for ten years are estimated by forecasting the maximum AAM&RE for year 2010 by means of the equation:

$AAM\&REY_n = AAM\&REY * (1+i)^n$ ----------------------------- equation 6.2

Where:

$AAM\&REY_n$ = Allowable Annual Maintenance and Repair Expenses for Year (n)

AAM&REY = Allowable Annual Maintenance and Repair Expenses for Year EER (2010)

I = Average Inflation Rate = 2%

N = Number of years (1 – 10)

$AAM\&REY_1 = AAM\&REY * (1 + 0.02)^1$

$AAM\&REY_1 = 195{,}519 * 1.02$

$AAM\&REY_1 = \$ 199{,}430$

$AAM\&REY_2 = AAM\&REY * (1 + 0.02)^2$

$= 195{,}519 * 1.\ 0404$

$= \$ 203{,}418$, and at n = 10

$AAM\&REY_{10} = AAM\&REY * (1 + 0.02)^{10}$

$= 195{,}519 * (1 + 0.02)^{10}$

$= \$ 238{,}337$

6.5 Priority Rule

Maintenance and repair activities have nontrivial costs, and agencies responsible for maintenance and repair have limited budgets, making it necessary to determine what maintenance actions to perform, and when, in order to ensure a well-functioning system wit a reasonable cost [Stephen et al. 2010].

I. Flores-Colen discusses the importance of several criteria that can help the choice of maintenance and repair actions for facilities after PCA. He selected a set of 17 criteria based on their experience and a through literature review. 30

experts assessed the 17 criteria in a survey using a questionnaire. Accordingly, I. Flores-Colen proposes the priority rating scales and subclasses of each criterion, in order to help maintenance decision-making for property after PCA. I. Flores-Colen explains the difficulties facing the methodologies concerning the choice of the decision of criteria, which many include economic, functional, contextual, environmental, psychological, aesthetic, and cultural aspects. I. Flores-Colen lists five sources for buildings' systems and components that related with the failure, rupture, or with influence on the performance of a building during its service life: BS 7543; ISO 15686-3 (ISO 2002); Campante et al. 2001; Johnson and Wyatt 1999; and Layzell and Ledbetter 1998. Finally, a practical application of an indicator of maintenance and repair needs has been proposed by I. Flores-Colen for a school building that included three criteria for each construction element: (1) Gravity of problems-related to their effect on the performance requirements and user satisfaction; (2) extent of problem-related to the incidence of defects in each construction element; (3) criticality of the element [I. Flores-Colen et al. 2010].

At the same time, BOMA EER report has 11 M&R components without any priority to any of them to start the M&R action. Determining the priority to start an AM&R action with any component is the goal of many researchers as showed above and it depends on the technical performance of the component, its risk condition, and the M&R cost. Some of these components have maintenance action, some have only repair action, and some of them have both actions. Table 6-5 shows the M&R components with the required action. The payroll for operating engineers and maintenance personal, and elevator and HVAC systems have the highest priority, mostly because they have fixed annual contracts that must be implemented on a fixed schedule. Deferred Maintenance and Repair (DM&R) has the second priority, because it is an M&R program deferred from last year. The first year in the ten year M&R strategic plan generally has zero amounts for DM&R, because the plan has just started. Structural/Roofing has the third priority because of its position in the overall building and it has a direct impact on other building elements. General Building Exterior has the fourth priority after structural/roofing elements, because it relates to the exterior environment and any damage to the exterior building elements will impact the interior building elements, but to a lesser degree than from the impact of the third priority. Electrical components have the fifth priority, according to the same category of the priority rule. Accordingly, the other components have had their priority set as explained in table 6-5 below. The priority rule is useful and a valuable guide through the annual fund allocations to M&R components. It acts as a guide to allocate the proposed fund to the components in the planned year within ten years. Because it is impossible to forecast the future deterioration and maintenance needs of a facility with complete accuracy [Stephen et al. 2010]. Maintenance and repair policies are developed, which specify many different possible (M&R) schedules, along with a set of rules specifying which schedule is to be used under which realization. Ten-year maintenance and repair strategic plans, covered in the next section, and the following tables explain the priority rule concept very well.

Description	Maintenance action	Repair action	Priority
Payroll	X		1
Elevator	X		1
HVAC	X		1
Defer Maintenance	X	X	2
Electrical		X	5
Structural/Roofing		X	3
Plumbing		X	6
Fire/Life safety	X	X	8
General Building Interior		X	7
General Building Exterior		X	4
Parking		X	9
Miscellaneous/Other	X	X	10

Table 6-7 Priority rule

6.6 Ten-Year Maintenance and Repair Strategic Plans

Allocating funds and managing the AM&R expenses of a building within a strategic ten-year plan are the main goals of building owners and managers. These goals not only serve the building owner and manager, they also keep the building at its market value, protected from deterioration, as well as benefitting the users. In addition, managing the AM&R expenses will control cash flow according to the total income. Many researchers have been working in this field, especially in the first decade of this century. FMMMR was developed so that a building's owner, manager, and end users' goals and objectives can be realized with an automated program to allocate and manage the funds for annual expenses (M&R components) within a ten-year strategic plan, according to the total annual income. FMMMR depends on a BOMA EER database as the reference, on a PCA provided by a qualified observer or consultant, and the TAI for any building within the range of the BOMA EER report. A PCR indicates the proposed cost estimate for each component of M&R that will be implemented in one year (or longer) according to the total allowable annual fund. In addition, the PCR or Appendix B (questionnaire) indicates the TAI in addition to the AM&RE. The AM&RE calculates according to the previous information and equation 6.1. An AAM&RE represents the maximum allowable amount that can be spent on the AM&R components in the observation year. Forecasting the AAM&RE for ten years according to equation 6.2 is one of the FMMMR functions. Planning the M&R components for ten years or less according to the AAM&RE fund and the priority rule is another. Table 6-6 shows the Preventive Maintenance Program (PMP) for ten years, including all the elements and factors that participated in the scenario decision. The following sections (a practice example and a Process flow chart of the strategic plan) will explain this plan in more details. The inflation rate has been calculated taking the average inflation rate for 20 years from Statistics Canada. In maintenance contracts, such as for Elevator service and HVAC the average inflation rate sometimes is not suitable. Some contracts specify an annual increment of 5% or more, even as high as 10%. The PCR should mention the annual increment for these contracts. FMMMR considered this special case rate by separating its rate from other M&R components' rates. The rates for

Elevator are represented by $i_{E,}$ and for HVAC by i_H. Most payroll increments in Canada follow the average inflation rate. The other M&R components also will follow the average inflation rate.

Description	Priority rule	Estimated cost by PCA $	AAM&REY 1	AAM&REY 2	AAM&REY 3	AAM&REY 4	AAM&REY 5	AAM&REY 6	AAM&REY 7	AAM&REY 8	AAM&REY 9	AAM&REY 10
Payroll	1		1	1	1	1	1	1	1	1	1	1
Elevator	1		1	1	1	1	1	1	1	1	1	1
HVAC	1		1	1	1	1	1	1	1	1	1	1
Defer Maintenance	2		2	2	2	2	2	2	2	2	2	2
Electrical	5		5	5	5	5	5	5	5	5	5	5
Structural/Roofi ng	3		3	3	3	3	3	3	3	3	3	3
Plumbing	6		6	6	6	6	6	6	6	6	6	6
Fire/Life safety	8		8	8	8	8	8	8	8	8	8	8
General Building Interior	7		7	7	7	7	7	7	7	7	7	7
General Building	4		4	4	4	4	4	4	4	4	4	4
Parking Lot	9		9	9	9	9	9	9	9	9	9	9
Miscellaneous/ Other	10		10	10	10	10	10	10	10	10	10	10
Proposed AM&RE $			57	57	57	57	57	57	57	57	57	57

Table 6-8 Ten-year Annual Maintenance and Repair Expenses strategic plan

6.7 Practical Example

As outlined in the previous sections, the TAI for the case study building is $ 2,793,132, the AM&RR is 7.25%, the AAM&REY, $AAM\&REY_1$, $AAM\&REY_2$, and $AAM\&REY_{10}$ are calculated as $ 195,519, $ 199,430, $ 203,418, and $ 238,337, respectively. The proposed cost estimate for the M&R components, provided by PCR and the Appendix B (questionnaires) are shown in table 6-7. All the information is now in place to set the strategic plan scenarios. The first step is forecasting ten years ahead for all components under priority 1 (Payroll (P), Elevator (E), and HVAC), as per the following equation:

$P_n = P * (1 + 0.02)^n$ ………………………………………….. Equation 6.3

Where P is the annual payroll expenses for the observation year,

$E_n = E * (1 + i_E)^n$ ………………………………………… Equation 6.4

where E is the annual Elevator expenses for the observation year, and

$HVAC_n = HVAC * (1 + i_H)^n$ ……………………………… Equation 6.5

Where HVAC is the annual HVAC expenses for the observation year

In this example $i_E = i_H = I = 2\%$, and n is between 1 and 10.

Next, check if the Proposed Annual M&RE ($PAM\&REY_1$) amount still less than the amount of $AAM\&RE_1$ for the first year after assigning all the components under priority 1. If yes, then add the components under priority 2 (Deferred

Maintenance Program) to the strategic plan scenario and again check if the $PAM\&REY_1$ amount is still less than the amount of $AAM\&RE_1$ for the first year. If yes, add the components of priority 3 (Structural/Roofing) to the strategic plan scenario of the first year and then check if the $PAM\&REY_1$ amount is still less than the total $AAM\&RE_1$ for the first year. If the answer is no, add the components of priority 3 to the second year strategic plan scenario. The second year strategic plan scenario now has its priority 1 components. Continue with the same procedure to fill all ten years with the M&R components according to the priority rule and the amounts of each component to the PAM&RE for each year providing that it should not exceed the AAM&RE for that year. Table 6-7-A explains the assigning proposed amount of annual expenses for ten years of M&R components, only for those at priority 1. This is the first step to run the program, because all priority 1 components are financial (legal) commitments to others (contractors, workers, employees, insurance and suppliers) and cannot be deferred. Table 6-7-B shows the second step in the program, in which the first year strategic plan is beginning to be filled in by the remaining M&R components according to the priority rule. The amounts of the components added to the $PAM\&RE_1$ should not exceed the $AAM\&RE_1$. If the $PAM\&RE_1$ reaches the $AAM\&RE_1$, the remaining M&R components will transfer to the following year $PAM\&RE_2$. The program continues by the same procedures to fill all the M&R components in the ten years. The building in this case study has only a very small amount for maintenance and repair, less than the $AAM\&RE_1$, because the owner has consistently implemented an M&R Program (PMP) and kept the building in good condition, even though the building is more than 75 years old. Figure 6-3 shows the process flow chart of the ten-year AM&R strategic plan.

Database	TAI	2,793,132			AM&RR	0.0700	i	0.02	1+i	1.02	$1+i_E$	1.02	$1+i_H$	1.02
AAM&RE $		**195,519**	**Maintenance Program**		**AAM&REY 1**	**AAM&REY 2**	**AAM&REY 3**	**AAM&REY 4**	**AAM&REY 5**	**AAM&REY 6**	**AAM&REY 7**	**AAM&REY 8**	**AAM&REY 9**	**AAM&REY 10**
Description	**Priority rule**	**Cost estimated by PCA $**	**PMP**	**PrMP**	**199,430**	**203,418**	**207,487**	**211,636**	**215,869**	**220,186**	**224,590**	**229,082**	**233,664**	**238,337**
Payroll	**1**	**53,668**	**X**		54,741	55,836	56,953	58,092	59,254	60,439	61,648	62,881	64,138	65,421
Elevator	**1**	**19,796**	**X**		20,192	20,596	21,008	21,428	21,856	22,294	22,739	23,194	23,658	24,131
HVAC	**1**	**18,654**	**X**		19,027	19,408	19,796	20,192	20,596	21,007	21,428	21,856	22,293	22,739
Defer Maintenance	**2**	**0**			2	2	2	2	2	2	2	2	2	2
Electrical	**5**	**6,146**	**X**		5	5	5	5	5	5	5	5	5	5
Structural/Roofi ng	**3**	**2,790**	**X**		3	3	3	3	3	3	3	3	3	3
Plumbing	**6**	**8,782**	**X**		6	6	6	6	6	6	6	6	6	6
Fire/Life safety	**8**	**11,301**	**X**		8	8	8	8	8	8	8	8	8	8
General Building Interior	**7**	**1,226**	**X**		7	7	7	7	7	7	7	7	7	7
General Building	**4**	**3,120**	**X**		4	4	4	4	4	4	4	4	4	4
Parking Lot	**9**	**0**			9	9	9	9	9	9	9	9	9	9
Miscellaneous/ Other	**10**	**7,203**	**X**		10	10	10	10	10	10	10	10	10	10
Proposed AM&RE $		**132,686**			**94,014**	**95,894**	**97,810**	**99,765**	**101,760**	**103,794**	**105,869**	**107,985**	**110,144**	**112,345**

Table 6-9-A Calculating the proposed amount for M&R components of priority 1 only

Database	TAI	2,793,132			AM&RR	0.0700	i	0.02	1+i	1.02	1+i_E	1.02	1+i_H	1.02
AAM&RE $		195,519	Maintenance Program		AAM&REY 1	AAM&REY 2	AAM&REY 3	AAM&REY 4	AAM&REY 5	AAM&REY 6	AAM&REY 7	AAM&REY 8	AAM&REY 9	AAM&REY 10
Description	**Priority rule**	**Cost estimated by PCA $**	**PMP**	**PrMP**	199,430	203,418	207,487	211,636	215,869	220,186	224,590	229,082	233,664	238,337
Payroll	1	53,668	X		54,741	55,836	56,953	58,092	59,254	60,439	61,648	62,881	64,138	65,421
Elevator	1	19,796	X		20,192	20,596	21,008	21,428	21,856	22,294	22,739	23,194	23,658	24,131
HVAC	1	18,654	X		19,027	19,408	19,796	20,192	20,596	21,007	21,428	21,856	22,293	22,739
Defer Maintenance	2	0			0	0	0	0	0	0	0	0	0	0
Electrical	5	6,146	X		6,269	0	0	0	0	0	0	0	0	0
Structural/Roofi ng	3	2,790	X		2,846	0	0	0	0	0	0	0	0	0
Plumbing	6	8,782	X		8,958	0	0	0	0	0	0	0	0	0
Fire/Life safety	8	11,301	X		11,527	0	0	0	0	0	0	0	0	0
General Building Interior	7	1,226	X		1,251	0	0	0	0	0	0	0	0	0
General Building	4	3,120	X		3,182	0	0	0	0	0	0	0	0	0
Parking Lot	9	0			0	0	0	0	0	0	0	0	0	0
Miscellaneous/ Other	10	7,203	X		7,347	0	0	0	0	0	0	0	0	0
Proposed AAM&RE $		132,686			135,340	95,840	97,756	99,711	101,706	103,740	105,815	107,931	110,090	112,291

Table 6-9-B Calculating the proposed amount for priority 2 M&R components and then other priorities

6.8 Conclusion

This chapter explains database components and FMMMR functions. The BOMA's EER is a major component of an FMMMR database. BOMA EER tables, components, M&R components, and other important terms were presented in brief. The major comments the BOMA EER 2009 for Canadian cities were explained in detail. AM&RR, the main element in this research, can be calculated by dividing the AM&RE by the TAI for the same year. The importance of the AM&RR figure is that it provides the ability to calculate the PAM&RE for any building after knowing its TAI and PCR. The functioning of the priority rule for AM&R components, i.e. how it is set according to financial commitments, component position, and a component's AM&RE was given in detail. A sample ten-year AM&R strategic plan was established according to the AM&RR and PCR, and a flow chart for the ten-year process of AM&R was also provided. The FMMMR components, modules, and applications will be discussed in detail in chapter seven, in the context of a case study.

CHAPTER SEVEN: MODEL IMPLEMENTATION AND CASE STUDY

7.1 INTRODUCTION

The five steps of a system analysis approach have been applied in this research to develop quantitative and analytical methods that can be used in facility management for office buildings to manage annual maintenance and repair expenses. A property condition assessment identifies the state of a property's deterioration, the BOMA EER 2009 database provides the total annual income and annual maintenance and repair expenses, in order to determine the annual maintenance and repair ratio and the allowable annual maintenance and repair expenses, and then the priority rule for M&R components is integrated with this information to produce a 10-year strategic plan for maintenance and repair components. A 10-year strategic plan is the best solution for managing a limited budget and for scheduling the maintenance and repair of components according to the allowable annual maintenance and repair expenses, the priority rule, and component cost estimates. Each component for maintenance and repair is provided with preventive or predictive maintenance programs when a 10-year strategic plan is established.

This chapter discusses the model implementation by using different types of techniques, recommended in chapters 5 and 6, to develop a prototype model of a facility management model for the maintenance and repair of office buildings within a limited budget.

7.2 ANNUAL MAINTENANCE AND REPAIR STRATEGIES

As outlined in chapters 3 and 4, a number of maintenance and repair strategies are available for a facility when it is under deterioration action. Three types of maintenance and repair strategies are currently followed in facilities management. Assigning a maintenance and repair strategy to M&R components depends on the degree of deterioration, the cost estimate, the expected improvement, and the available funds.

The facility management model for the maintenance and repair of office buildings (FMMMR) therefore contains the three main strategies of Maintenance and Repair actions, as follows:

1. **Corrective Maintenance Program (CMP):** the routine maintenance or day-to-day upkeep of facilities and equipment that will ensure their capability to perform their designed functions. An FMMMR based on the BOMA EER rule considers any annual expenses of less than $ 2000 as part of the CMP. CMP items will not be included in a 10-year strategic plan for maintenance and repair. Tables 6-9-A and B do not have a column for CMP, but they do for PMP and PrMP (items 2 and 3 here). CMP should normally be accomplished by facility employees, except where overriding economic or labour-relation reasons dictate contract performance.

2. **Preventive Maintenance Program (PMP):** the planned and controlled program of ongoing inspections and corrective actions taken to ensure peak efficiency and minimize deterioration. The distinction between CMP and PMP is essentially one of

degree. In most facility management organizations the distinction is established by an arbitrary standard of dollars or worker-hours. Thus, in a single facility all repair work involving over $ 2000 in labour and material could be classified as PMP. Most PMP can be accomplished economically by contract. The FMMMR considers all M&R component works over $ 2000 to be PMP, unless a component requires major improvement or replacement according to the property condition assessment.

3. **Predictive Maintenance Program (PrMP):** The planned and controlled program to improve the functional or productive performance level of a facility, piece of equipment, or system that has had a major deterioration. Most PrMPs' requested budget amounts exceed the allowable annual maintenance and repair expenses for one year or even more. One M&R component may have both types of maintenance program, PMP and PrMP, depending on the contract and the component. In this case, the PrMP for any component can be placed in the Deferred Maintenance Program (DMP) to schedule it in a different year when the funds are available. A fund dedicated to PrMP may need to accumulate money from allowable annual maintenance and repair expenses categories for more than one year. An FMMMR offers the capability to accrue funds over time to accumulate the required amount for any M&R component that has been under PrMP. This aspect of the FMMMR provides the ability to schedule M&R program for a particular component at the optimal time within a 10-year strategic plan.

Scheduling component M&Rs within a 10-year strategic plan and categorizing them as either PMP or PrMP presents an optimal management of M&R for a facility.

7.3 FMMMR COMPONENTS AND FUNCTIONS

7.3.1 ENTITY RELATIONSHIP (ER) MODELING

Transferring the historical data and information from different stages of a building's life cycle to the operation and maintenance stage is a complex and costly process. Historical data contains important information that can be used to understand the behaviour of a structure and to develop trends which can be useful in the decision making process [Saleh 2008]. An office building can have a large amount of relevant data and information that is cumulative over a long life span and which must be transferred from the different stages of the data and information reports so that it can be used in operation and maintenance. BOMA EERs provide data and information associated with annual income and the annual operation and maintenance expenses of office buildings, and has done so for 100 years. A consultant or observer-specialist in property condition assessment can also provide a large amount of information in the form of a PCA, which must be saved in a useful form. Therefore, a central database system that has the ability to easily input, retrieve, modify, and update data is an important feature of any facility management model.

The FMMMR uses built-in procedures and algorithms to process the available data and information, modifying and updating, with the goal of developing decision recommendations.

Commercial database management systems generally use a rational network, or a hierarchical data model [Elmasri and Navathe 2000].

The database developed for the FMMMR is relational, which makes it more practical for engineering work. An Entity Relationship (ER) diagram most often is representative of a relational database. An **Entity** “is an object with a physical or conceptual existence and has a number of attributes that describe it” [Elmasri and Navathe 2000]. A building is a physical entity with a number of different attributes, each with a set of values. A building’s attributes define it, and include its address, the owner, etc. Chapter 3 explained the relationship entity diagram.

The developed prototype model uses a relational database as the relational model for data storage. The relational data model is implemented through a very sophisticated relational database management system. The user sees the relational database as a collection of tables in which data are stored. These tables are related to each other through the sharing of a common attribute. The FMMMR has entity tables, as shown in Figure 7-1. This figure illustrates the name and the key attribute(s) of each table. Each table stores a collection of pertinent data related to an entity and to what is required to perform the FMMMR tasks.

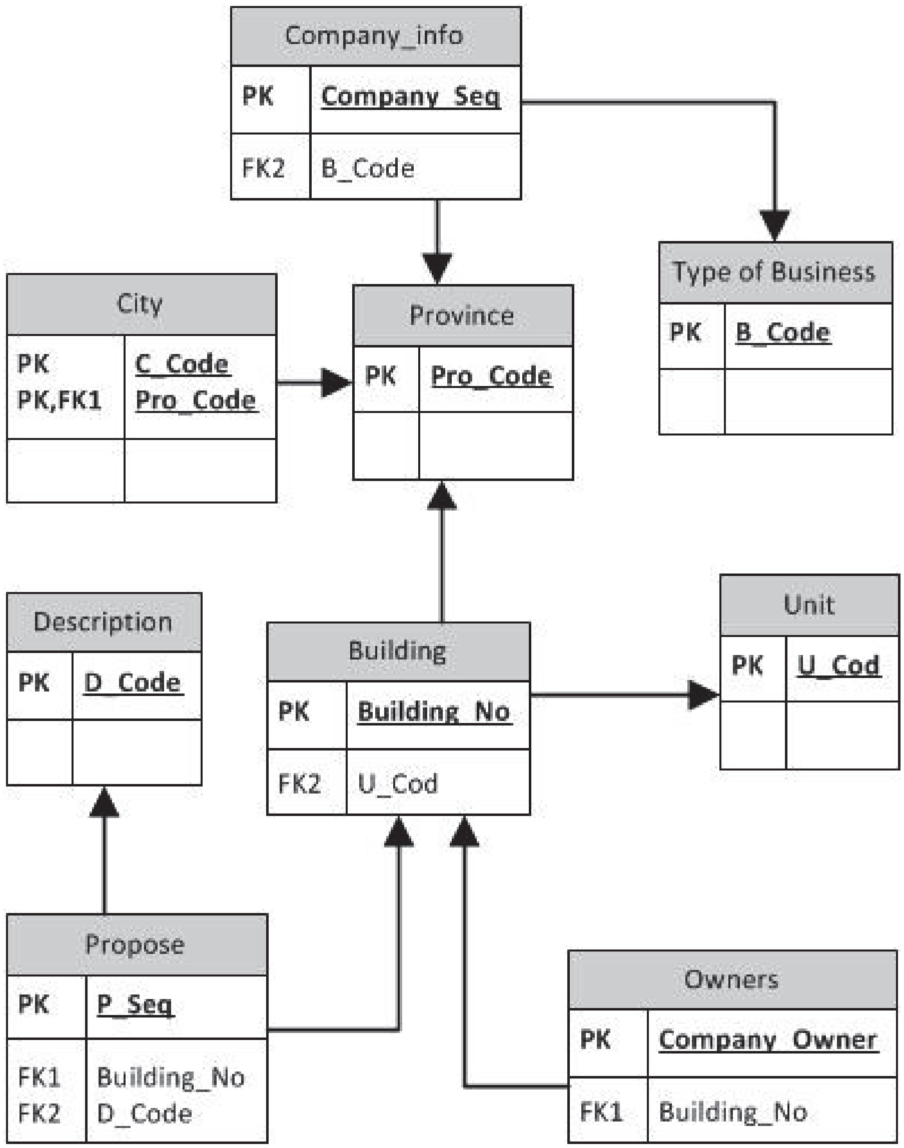


Figure 7-1 Entity Relational Diagram for FMMMR

The relationship between the “Owners” entity and a “Building” has multiple possibilities and permutations. One building could be owned by a single or multiple owner/s, and, at the same time, one owner may own more than one building. On the other hand, a building could be located in a province other than that of the owner/s. This potentially complex relationship between owners and building entities means that the software requires more input possibilities and more windows to adequately control the work flow and keep it accurate and efficient. The software should have the capability for a user to enter all the information related to the owner/s, such as company sequence, company name, owner’s first and last name, owner’s SIN and title, private or government classification, mailing address and so on. Some of these fields are mandated requirements, so-indicated by an asterisk, and some are not. If a building has more than one owner, the user can click on the New Record button to enter the information for a second or third owner.

7.3.2 FMMMR FLOW PROCESS

Figure 7-2 illustrates the FMMMR flow process. The user enters all the building information: province, city, street address, name, age, area, units, number of stories, contact name and information, owner name and rate (equity), as well as other data. The user can assign more than one owner to a building. The software should automatically generate a unique ID number for the new building. This ID number is associated with the building, and it provides access to the building information at any time. The format of this building ID is “BLDG #” and it is an automatic incremental number. The user should ‘save’ after entering the input data. After saving the building information, it is recommended to retrieve the data and adjust the AM&RR to validate that all the information regarding the new building is correct and has been properly assigned. When the input data has been validated, the next step is determining the Allowable Annual Maintenance and Repair Expenses (AAM&RE), by multiplying the TAI and the AM&RR for the same categories of a building. Forecasting the AAM&RE for ten years, by using the NPV equation follows. The next step is forecasting the proposed AM&RE for each M&R component individually for ten years by considering the priority value assigned to a component within its year and the limitation of the fund through the forecasting AAM&RE. Yearly and 10-year strategic plans are the outcomes for the FMMMR after all the above processes have been completed. Yearly plans for each of the next ten years and 10-year work plan reports can be generated if the user so requests.

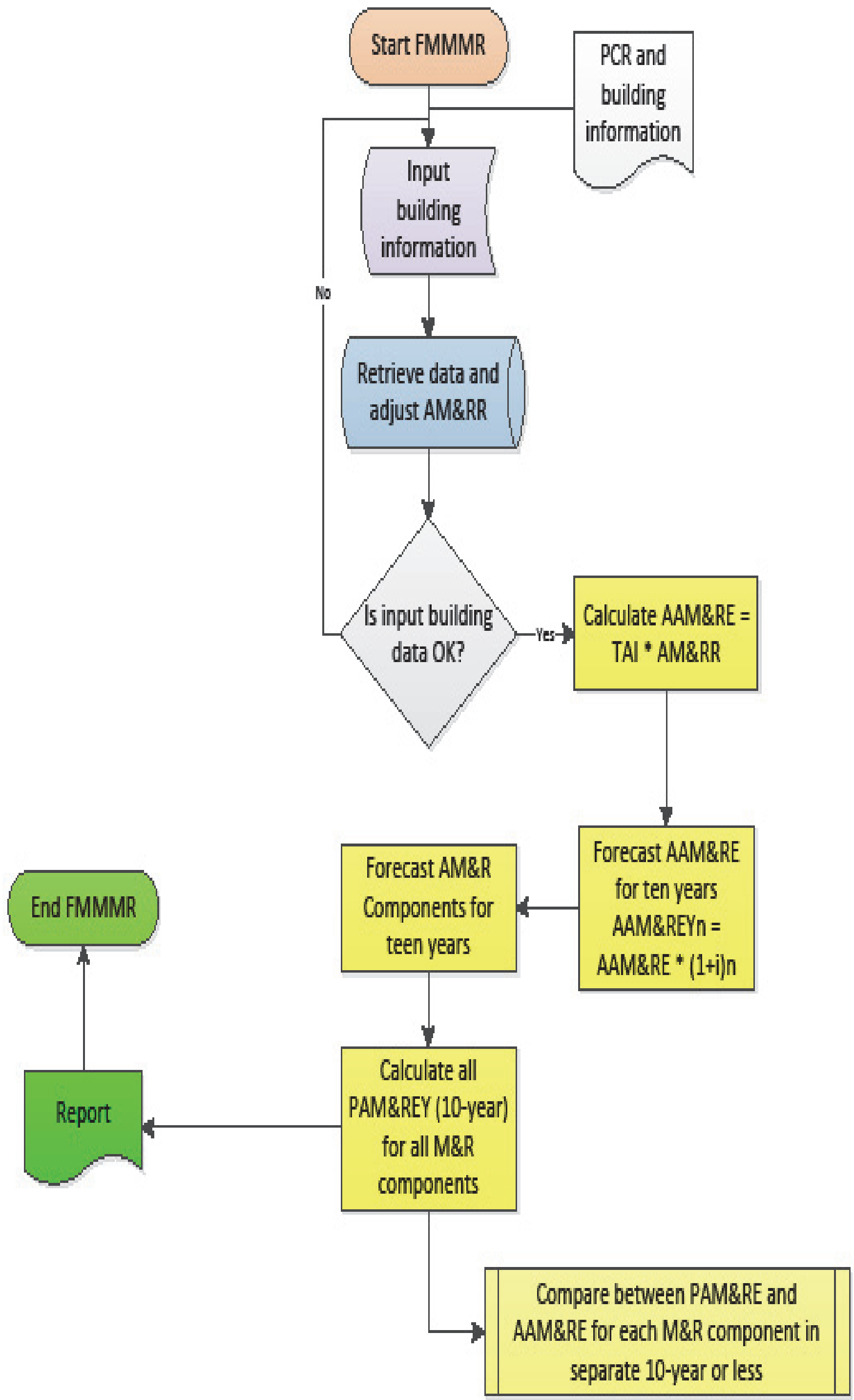


Figure 7-2 Flow Chart Process for Model Methodology

Figure 7-3 explains the complexity of the forecasting process for the PAM&RE of each M&R component and of assigning it to the suitable year by comparing the deterioration case of the component, the available funds, and the priority rule either using the default rules or a customized rule developed by the owner or by an expert to build a 10-year strategic plan. The flow chart process shows the distribution for each M&R component, starting with those of priority 1 to distribute for the first year. The second step is to start the M&R component at priority 2 to allocate it to the first year by studding the availability fund in the AAM&REY1. If the AAM&REY1 is higher than the required amount for the PA&MREY1 for the same component, the required amount for this component will be located in the first year. If the AAM&RY1 is less than the required amount for the PAM&REY1 for the same component, the component in the priority 2 category will be implemented in the following year. This procedure will continue on the same fashion for all M&R components, following the priority rule and according to the funds available, noted in the AAM&RE. Sometimes one or more components are allocated in the first year and the AAM&RE does not have sufficient funds for the other M&R components; in these cases, the balance amount from that AAM&RE will be added to its AAM&RE for the following year. This specific year will then have more AAM&RE. In this way, the savings amount from the previous year plus the AAM&RE will then be able to implement the entire planned M&R components listed in the PCR within 10 years or less. If the M&R components require a large monetary investment because the property has been faced with very bad deterioration for some time, the 10-year strategic plan may not be enough to complete the cycle. The FMMMR is most effective when a property has an up-to-date PCA.

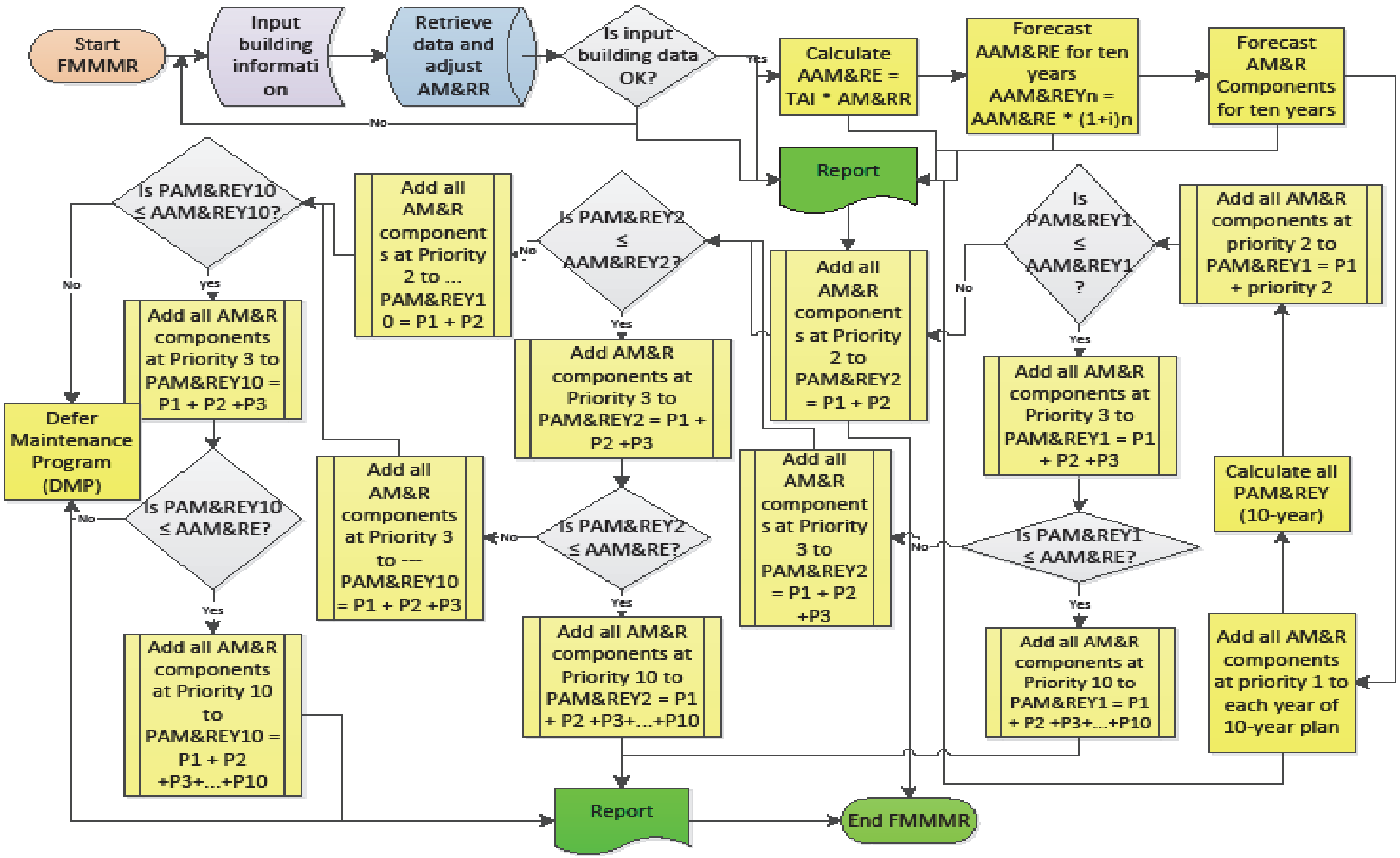


Figure 7-3 Flow chart process for a 10-year strategic plan

7.3.3 FMMMR Components

The model components consist of four modules: 1) Mainframe FMMMR; 2) a BOMA EER report; 3) the Property Condition Assessment (PCA); and 4) the Priority Rule. A ten-year AM&R strategic plan is the output for the four components. The four modules are integrated together, along with a database of the M&R components. Figure 7-4 shows the conceptual design for the FMMMR components. Chapter 6 explains the BOMA EER, PCA, priority rule, and ten-year strategic plan for AM&R components in detail.

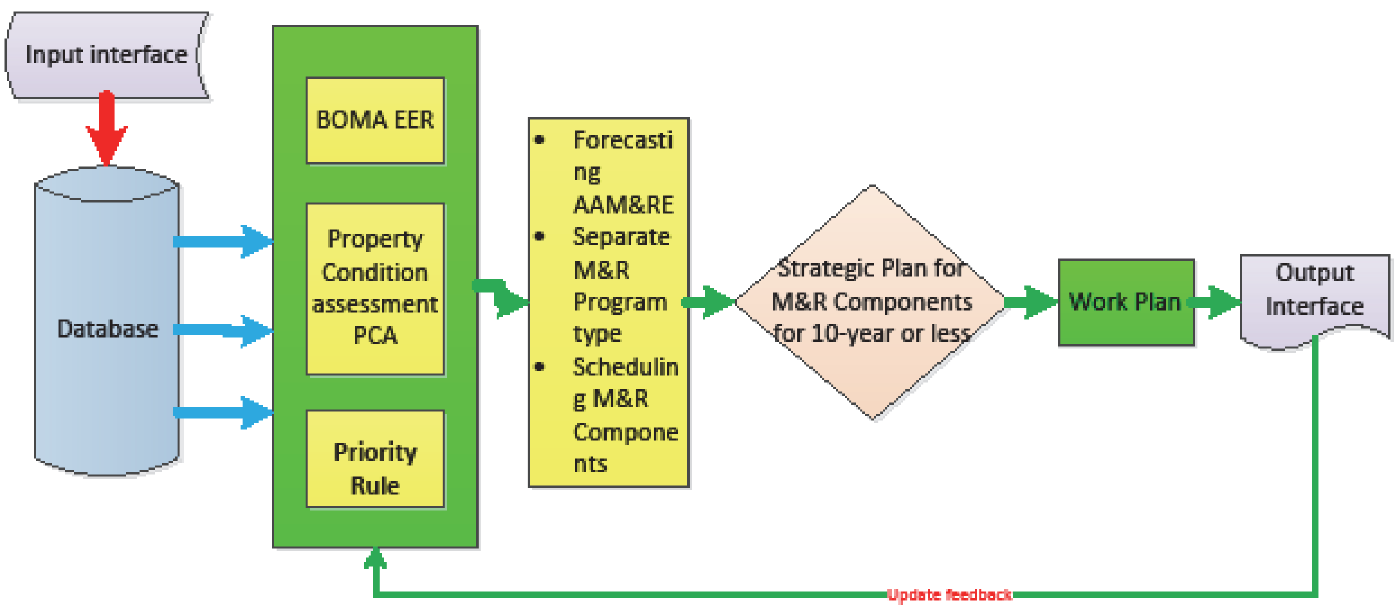


Figure 7- 4 Conceptual Design of the FMMMR

Mainframe FMMMR Component: Figure 2-6 illustrates facility management functions by dividing them into three functions: 1) Maintenance and Operation Management, 2) Property Management, and 3) Services. The sub-functions of each of these are also illustrated in the same figure. Any mainframe software in the facility management model should have the ability to contain or to add the infrastructure of facility management (functions and sub-functions). The basic FMMMR is designed to work with M&R sub-functions, but it has the ability to add any further sub-functions in the Maintenance and Operation Management function, such as Monitoring and Tracking or Space Management. It can also add functions and sub-functions in the Property Management and Services category. This ability and flexibly of the FMMMR in relation to facility management assures that it can inspire confidence in its predictions, be more comprehensive, and better simulate reality. This software is comprehensive for facility management, but is specialized in the maintenance and repair sub-function.

BOMA EER database Component: The FMMMR database has BOMA EER 2009 trend report data for M&R Components and TAI. Retrieving the BOMA EER database to modify or exchange the information is one of the most important abilities of the FMMMR, one that enables it to operate on a professional level. The FMMMR database has the ability to change the BOMA EER 2009 data to agree with any report in the past or in the future. The BOMA EER contains the building location, size, age, height, city, owners, etc. as well as the M&R components. The FMMMR database has the ability to modify and improve any information stored in the database accordingly.

Property Condition Assessment (PCA) Component: The PCA is the other component of the FMMMR database. It has the same elements of the M&R components, along with the estimated cost to maintain or repair those M&R components over 10 years. Occasionally, a PCA could be replaced by the responses to a questionnaire if the PCA was done a few years before the decision to do the MR work must be made. The PCA sometimes contains a comprehensive report for a property's infrastructure and its elements, but it should be gathered and categorized by the same standardization as that used by the BOMA EER for the M&R components so that the inputs and outputs keep to the same units. The user enters all of the cost estimates of the M&R components as listed in the PCA, or in a questionnaire form associated with the type of the TMP, Preventive Maintenance Program (PMP), or of any component that is undergoing replacement or a major development and requires a large amount of funding. The latter may be considered to be in a Predictive Maintenance Program (PrMP), as mentioned before in this chapter, and will be listed in the Deferred Maintenance Program component. Most of the M&R components that need to be replaced or that are under major development are in the elevator or the HVAC systems. If the M&R program has more than one component under replacement or major development, the second M&R component can be placed in the Miscellaneous/others component list and will be scheduled in the 10-year program.

Priority Rule Component: There is a priority for each M&R component that the software follows throughout the distribution of the available funds while implementing the 10-year strategic plan. Table 6-5 illustrated the priorities of M&R components by default. FMMMR software has the flexibility to utilize the experience and knowledge of a building owner or manager if they want to change the M&R components' priorities. Four buttons are available to implement this flexibility: Save; Browse; Display; and Next. The priority rule component also has the Type of Maintenance Program (TMP), because all of the M&R components are either under a Preventive Maintenance Program (PMP) or in a Predictive Maintenance Program (PrMP). M&R components each have two components, classified under Defer Maintenance and Miscellaneous/other. These two components give the software the flexibility to carry out all of the maintenance and repair program within a PrMP. If a building is under major development or will be replacing a big portion of a component it could be replaced in either of the two components. The software will schedule the replacement or a large development at the optimal time according to the available expenses. The priority rule is a unique component of the FMMMR which has no relationship to any previous research or to the BOMA EER.

10-Year AM&R Strategic Plan: The 10-year M&R Strategic Plan presents the results (output) for the process of the FMMMR components and the questions required to present the final work in a 10-year strategic plan for M&R components. The proposed M&R component's plans are distributed over ten years according to the priority rule, a component's deterioration case and cost, and the available funds. In addition, the yearly accumulative savings from the annual allowable maintenance and repair expenses are indicated in the results table. This step is the objective of all the previous processes. An FMMMR should have even more features so that it can accomplish additional tasks, such as Re-Calculate 10-Year, Save, and Show Building Info. The first feature launches a recalculation of the plan if the plan has not been accepted for any reason or to change the annual expenses for M&R components for any reason. The Save feature saves the plan information after the strategic plan has been completed satisfactorily. The third feature will show the building information before and after calculating and scheduling the 10-year strategic plan. In addition, the 10-year strategic plan window should have a "Backup" feature. This feature would back up the system (FMMMR) and store it as a dmp file in the building folder in drive C, where Oracle 8i and Developer 6i are installed. The name of the dmp file is automatically set and always initialed by the date of the backup action, such as 2502011.dmp. The user can then install an FMMMR via a dmp file on any PC if it has the two oracle software packages.

Reporting: The FMMMR provides a certain number of work plan reports. These reports contain the complete details for the annual work on M&R components or for a 10-year work plan. In addition, FMMMR provides another type of report that is related to the work plan, but for when the work has not been completed -- for example, when the assigned building information does not match the model parameters (limitations). The different types of work plan reports are explained below:

BUILDING INFORMATION REVIEW REPORT: This type of report will be generated after reviewing the building information in section 7.3.2. The user can print the report before or after saving the information.

ANNUAL M&R EXPENSES REPORT: This type of report can be generated after all the information for an assigned building has been entered and the user clicks on the Calculate 10-year button. This report contains all the required information about the building, linked to the building's ID. In addition, the other part of the report contains the assigned proposed annual maintenance and repair expenses, PAM&RE, for each M&R component. The report provides this information year by year for ten years. This type of report will facilitate the annual work plan, aiding users to schedule the work according to the available funds. The first three M&R components (Payroll, Elevator, and HVAC) will appear in each annual report, as they are contractual obligations throughout the ten years. Ten reports can be generated in this field, from year 1 to year 10.

10-Year Strategic Plan Report: This type of report can be generated after entering all the information for an assigned building. This report is similar to the previous reports, except that the information is for ten years, gathered in one report. This report presents 10-year work plans for all of the M&R components that have been proposed to be repaired within ten years. Most of these components will be distributed in the first year or within the first two years or even later, depending on the size of the total amount proposed by the PCA or by the questionnaire. In addition, this report contains another, very pertinent type of information -- the size of the savings that accumulate each year -- and it shows the fund distribution on the M&R components accordingly.

M&R LIMITATION REPORT: This report can be generated after all the data for an assigned building has been entered by the user and the Calculate 10-Year button has been clicked. The FMMMR generates this report when the total amount for M&R expenses proposed by the PCA or by the questionnaire is too large because the building is under major development or replacement and the FMMMR limitations (Parameters) are not able to accept this type of M&R for a 10-year strategic plan. This report has two parts. The first part contains the building information. The second part contains the following note "The rules and limitations of the 10-year strategic plan cannot proceed and schedule one or more of the M&R components because the building has major deterioration and requires significant investment funds for maintenance and repair".

7.4 FMMMR LIMITATIONS

Any information model should be designed with certain environmental limitations and assumptions. The assumptions of the FMMMR are that it:

1. Uses the BOMA EER Reports of Year 2009 and 2010 (data reported in 2008 and 2009, respectively);
2. Uses the following information: **Country**: Canada, **Zip Code** (as BOMA system structure): All, **Sector**: All, **Building Type**: All types, **Ownership Type**: All types, **No. of Floors**: All heights, **Building Size**: All sizes, **Unit of Measure**: Sq ft, **Locations**: All Locations, and **Building Age**: All ages;
3. Uses the Total Rental Income (Gross Income) provided by the building owner;
4. Has Annual Maintenance & Repair Expenses that are for the whole building area and provided by the BOMA EER Report in the Item 2 categories;
5. Is designed to have two options: New Building, when the user has a new record to enter, or Existing Building, when he/she wants to access the information of an existing building. The New Building option provides access to the "Building Owners Info", while the Existing Building option provides access to the recorded building information;
6. Should have the ability to add a city when the user checks if the province and city where the building is located are not available in the built-in-list. If they are not in the built-in-list, the user can add either or both to the list (province, city);
7. Should have a drop list for cities when there is more than one value for TAI, AM&RE and AM&RR, as in Montreal. Montreal has two options: Montreal (All);

and Montreal-Gov., (Government). Each field has a unique value for TAI_{avg}, $AM\&RE_{avg}$, and AM&RR. The value of AM&RR is completely dependent on the average values of TAI and AM&RE. The average values of TAI and AM&RE are delivered from the BOMA EER 2009, stored in the FMMMR database. The user must enter the Total Annual Income (TAI) of the assigned building. The value of Allowable Annual Maintenance and Repair Expenses (AAM&RE) will be calculated automatically according to the provided information.

8. The prototype software has three fields for entering the inflation rate information: I, which represents the average annual inflation rate (for 20 years) as calculated in chapter 6; i_E, which represents the annual rate increase in the elevator contract; and i_H, which represents the annual rate increase in the HVAC contract. All three rates could be the same if the elevator and HVAC contracts specify that the annual rate increase is linked to the Statistics Canada inflation rate.

7.5 VALIDATION AND PROTOTYPE CASE STUDY

The Montreal Downtown Office Building was used as a case study for this research and to validate the prototype model. The site is located on the north side of Rene-Levesque boulevard west, within the boundaries of Ste-Catherine Street west to the north, Rene-Levesque Boulevard west to the south, Bishop Street to the east and Mackay Street to the west, in Montreal, Quebec. The building site bears civic no. 1425 Rene-Levesque West. The coordinates of the building are $73^0$34'26.400" west longitude and $45^0$30'6.840" north latitude (298999 mN, MTM, NAD 83, zone 8) [Appendix C]. The site is occupied by a 12-story office tower with a basement. The site is located in a relatively flat area and is level with the surrounding streets and neighbouring properties.

This building is irregular in shape, covers an area of approximately 183,000 sq.ft and is located in the central commercial district of the city. According to the City of Montreal, the site's building was constructed in 1930. Overall, the building is a concrete structure with exterior brick walls. Two atrium windows are present at the front of the building. The roof is a flat steel deck [Appendix C].

The site building is a 12-story office tower with commercial spaces on the ground floor. The ground floor commercial spaces are occupied by a restaurant, an Internet café and a convenience store. The basement contains storage rooms, building maintenance rooms and the boiler room. The site building operates three cable-operated elevators. Figure 7-5 shows the building from Rene-Leveque Boulevard West.

Figure 7-5 Building Photograph of 1425 Rene-Leveque Boulevard West, Montreal, Québec [Appendix C].

7.5.1 PROPERTY CONDITION ASSESSMENT (PCA)

The Property Condition Assessment (PCA) for this downtown tower was conducted by Inspec-Sol in July, 2007. Inspec-Sol specializes in conducting property inspections in accordance to ASTM E 2018-01. A copy of the PCA is attached to this thesis in Appendix C.

Property Condition Report: Inspec-Sol has provided the PCR of the Montreal Downtown office tower conducted by Inspec-Sol staff in July 2007 to the building owner. The building owner is a company called “INSCANCO Inc”.

The 50-page PCR gives a detailed condition assessment of this Montreal downtown office tower according to ASTE E2018-0, step-by-step. This detailed condition assessment and cost estimate for all of the proposed maintenance and repair of the M&R components in 2007 was reviewed by Mr. Berger, building owner, in September 2010 to update the information. The total cost estimate in 2007 was $ 73,500. Updating the proposed annual maintenance and repair expenses by including the entire payroll, the elevator contract, and other contracts comes to $ 132,686.

7.5.2 QUESTIONNAIRES

A typical sample questionnaire is presented in Appendix B. The questionnaire has 11 M&R components, in addition to the general information and the total annual income questions. As outlined in the previous section, the cost estimate of the M&R components mentioned in the Inspec-Sol PCR was updated by the president/owner, Mr. Berger in September 2010. Figure 7-6 shows the data collected from the building owner for the entire payroll, contracts and regular maintenance and repair work for other components. The total cost estimated for the annual maintenance and repair expenses is $ 132,686.

APPENDIX B Questionnaire:

ANNUAL MAINTENANCE & REPAIR EXPESNE

Building Information					
Address	1425 Rene Levesque West				
City	Montreal				
Location	Downtown	X	Ownership	Private	X
	Suburban			Government	
Height (stories)		12	Occupancy (%)		87%
Total Constructed Area (SQFT)			surface - 27,400 GLA - 183,000	Age	75
Annual Maintenance & Repair Expense Information					
Payroll, Taxes, Fringes	53,668		Elevator	19,796	
HVAC	18,654		Electrical	6,146	
Structural/Roofing	2,790		Plumbing	8,782	
Fire/Life Safety	11,301		General Bld Exterior	3,120	
Parking Lot	0		General Bld Interior	1,226	
Miscellaneous/ Other	7,203				
Total Annual Income			2,793,132		
Notes					

Note: Please refer to the attached Definitions sheet for the above terms.

Saad Muhey
Department of Building, Civil, and Environment Engineering
Concordia University
1515 St. Catherine st. W.
Montreal, H3G 2W1

Figure 7-6 Completed questionnaire

7.5.3 NUMERICAL PROCESS

7.5.3.1 LOGIN WINDOW INTERFACE

The first user window interface is Login, illustrated in Figure 7-7. Users enter the information for user ID and Password and then click on the Login button or press enter. After a successful login, the building type window is displayed. If the user ID and/or Password are misspelled, the user will be prompted with an "Error in the Username or Password" message, re-enter the correct information and login. The Close button at the corner of the window closes the login interface and exits the software.

Figure 7- 7 Login Window Interface

7.5.3.2 Validation Building Information

The New Building Information window interface is displayed upon selecting the Next button in the Building Owner Information window interface as shown in figure 7-8. The main purpose of this window is to assign the building owner/s to a new building. The user should save after entering the building information. After saving the building information and clicking on the “Exit” button, the user will be returned to the previous window interface, “Building Owner Info”. Here, the user should change any information as needed or add new information if he/she has determined that the information was not available in the Building Information window. The user should then click on the “Existing Building” window interface as illustrated in figure 7-9 and validate that all the information regarding the new building is correct and has been assigned to the new building in the previous window.

The following information is linked to the downtown tower building: TAI $ 2,793,132; and Total Building area 183,000 sq. ft. as illustrated in Figure 7-9. The BOMA-TAI is 33.5 $/SF; the BOMA-AM&RE is 2.43 $/sq. ft.; and the BOMA-AM&RR is 0.07, according to the BOMA-EER database for Montreal, Quebec.

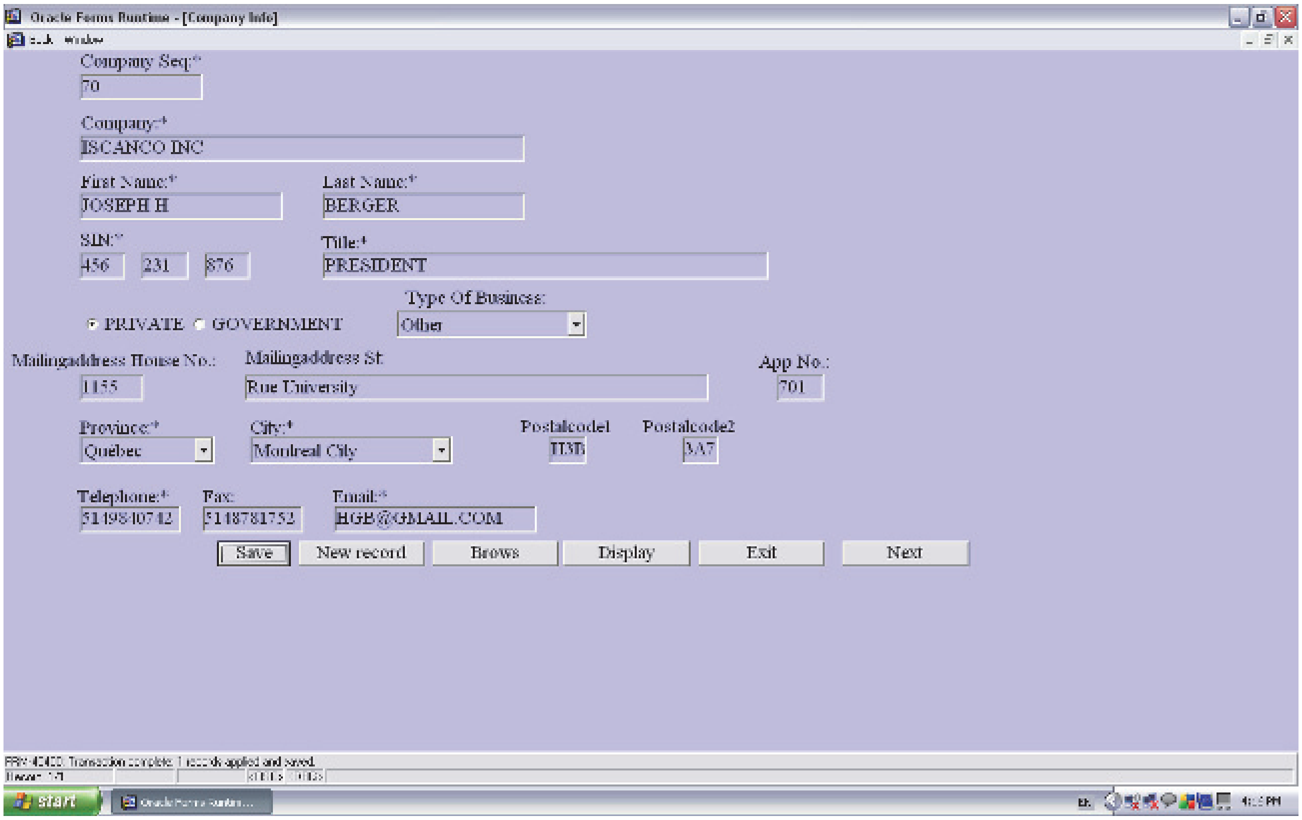


Figure 7- 8 Building Owner Information

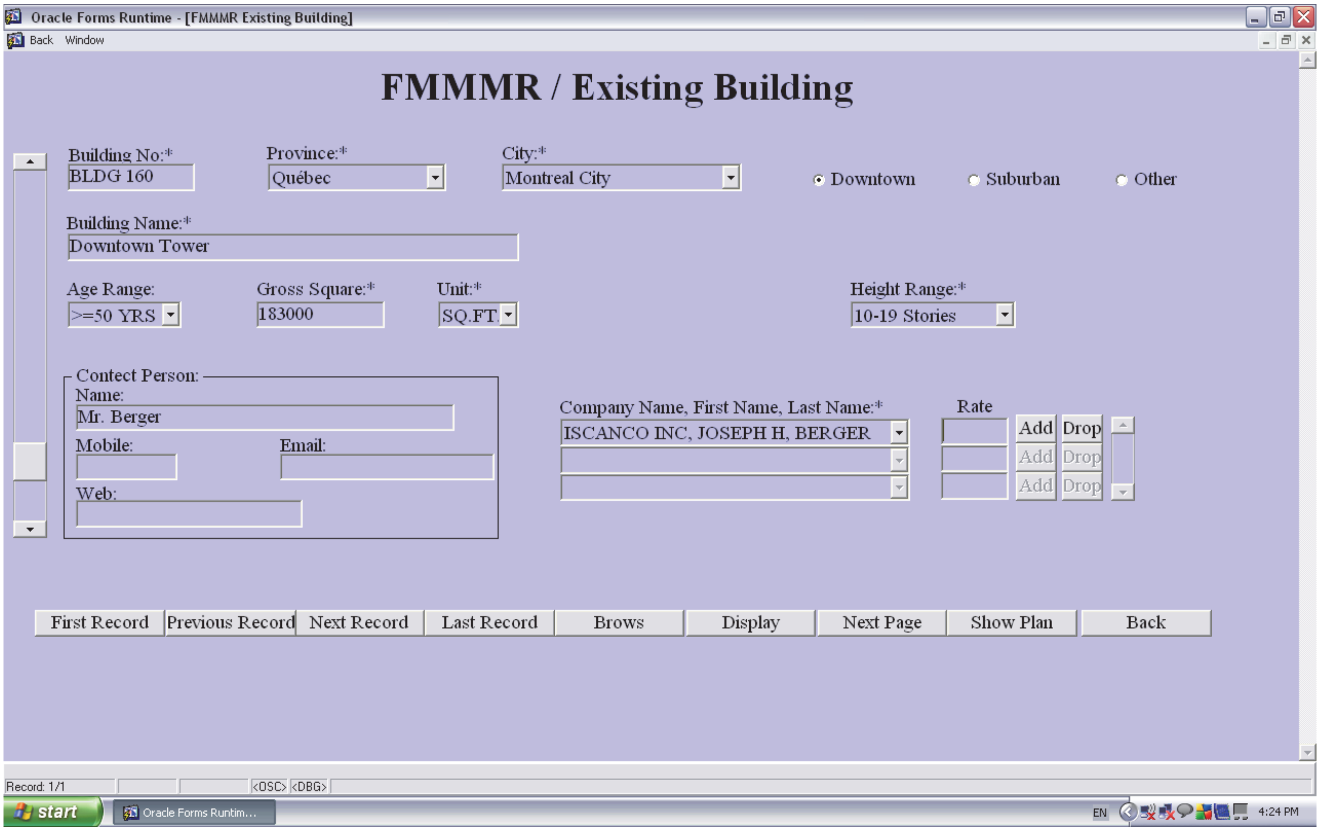


Figure 7- 9 Existing Building

7.5.3.3 Validation City Information

The user clicks the Next Page button to access the Facility Functions window, and then clicks the Operation and Maintenance button to access to that window, followed by the Maintenance and Repair button to access the Check City window illustrated in Figure 7-10.

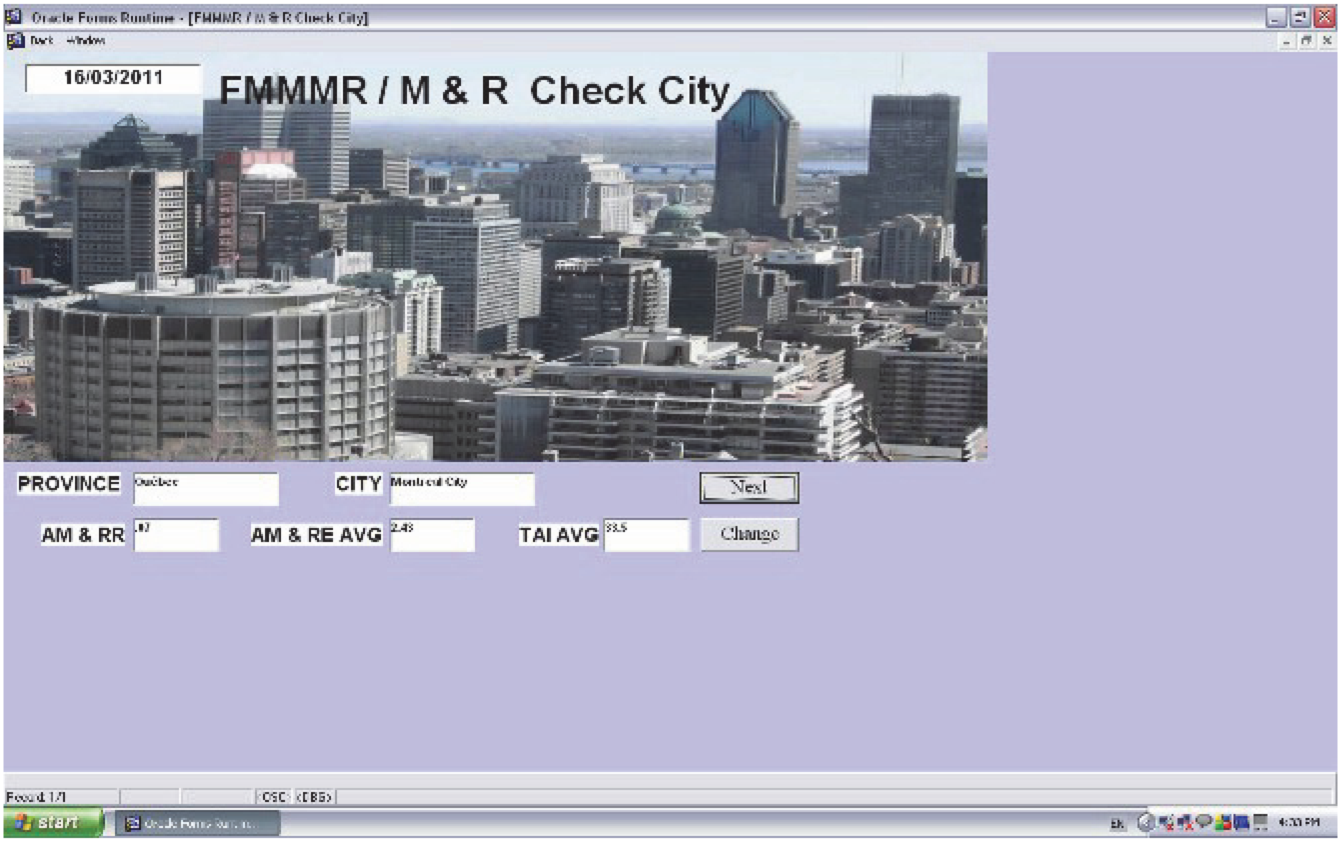
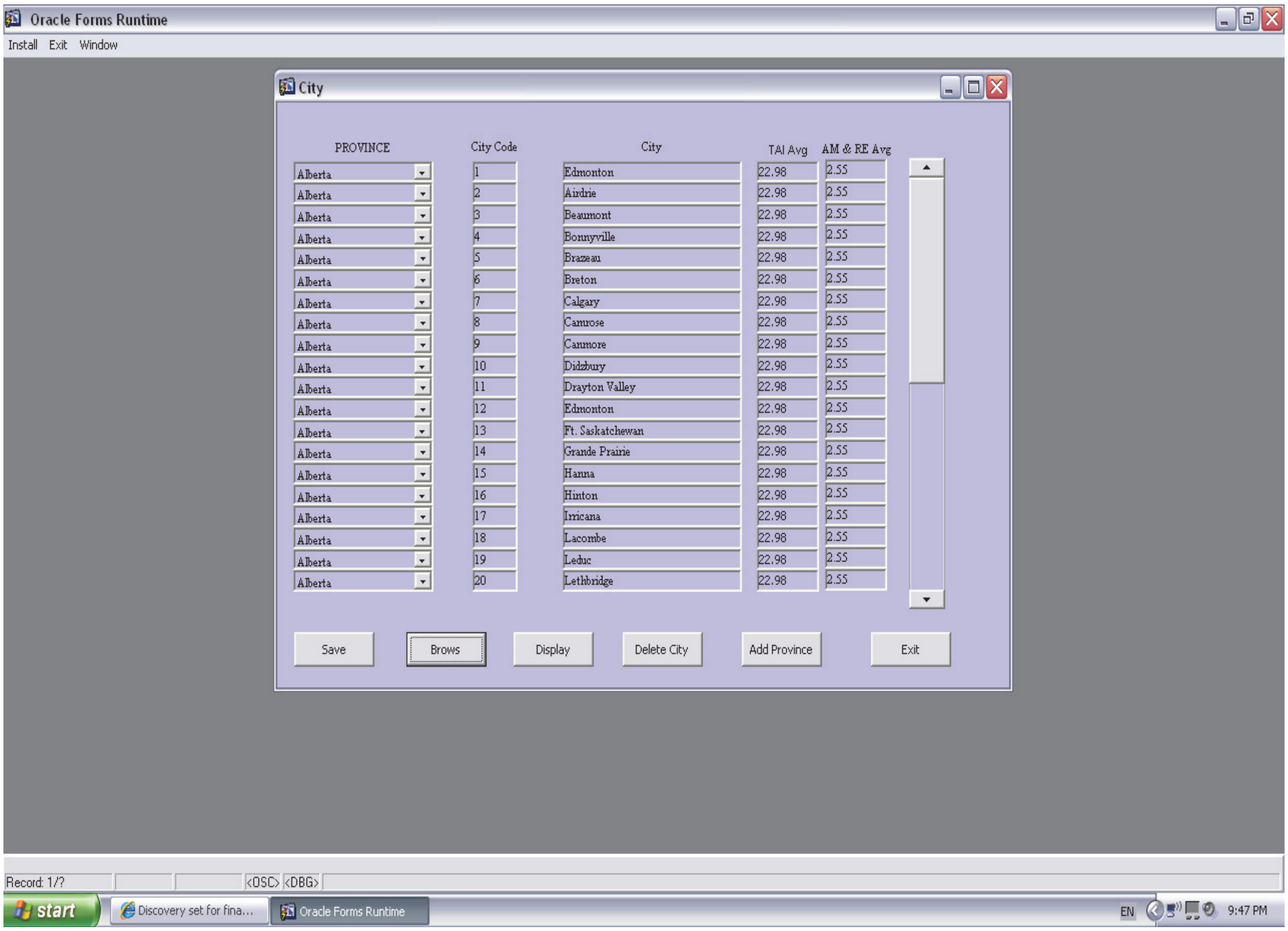


Figure 7-10 Check City

The user clicks the “Change” button to access the M&R City window interface if the city or the province is not available in the “building-drop-list” illustrated in figure 7-11. The user has the ability to add the city, province or both to the list through various buttons in this window. The user will click the Next button only if there is no change to be made in the information because the user is completely satisfied with the building information. The user will then be prompted to the M&R Priority Rule window. The user clicks the Next button here to access the subsequent window, Building Info, without any change in the Priority Rule window, because the available information for the case study tower does not require any change. The user then enters the information for the building’s

Total Annual Income, as illustrated in Figure 7-12, and clicks the Next button to access the M&R Inflation Rate window.



PROVINCE	City Code	City	TAI Avg	AM & RE Avg
Alberta	1	Edmonton	22.98	2.55
Alberta	2	Airdrie	22.98	2.55
Alberta	3	Beaumont	22.98	2.55
Alberta	4	Bonnyville	22.98	2.55
Alberta	5	Brazeau	22.98	2.55
Alberta	6	Breton	22.98	2.55
Alberta	7	Calgary	22.98	2.55
Alberta	8	Camrose	22.98	2.55
Alberta	9	Canmore	22.98	2.55
Alberta	10	Didsbury	22.98	2.55
Alberta	11	Drayton Valley	22.98	2.55
Alberta	12	Edmonton	22.98	2.55
Alberta	13	Ft. Saskatchewan	22.98	2.55
Alberta	14	Grande Prairie	22.98	2.55
Alberta	15	Hanna	22.98	2.55
Alberta	16	Hinton	22.98	2.55
Alberta	17	Irricana	22.98	2.55
Alberta	18	Lacombe	22.98	2.55
Alberta	19	Leduc	22.98	2.55
Alberta	20	Lethbridge	22.98	2.55

Figure 7-11 M&R City Window Interface

Figure 7-12 M&R Building Information

7.5.3.4 Validation Inflation Rate

The user enters the information regarding the average rate of inflation for the past 20 years (i=0.02), the elevator annual increment rate (i_E= 0.02), and the HVAC annual increment rate (i_H=0.02), as illustrated in Figure 7-13, and then clicks the Next button to access the M&R/Cost Estimate window.

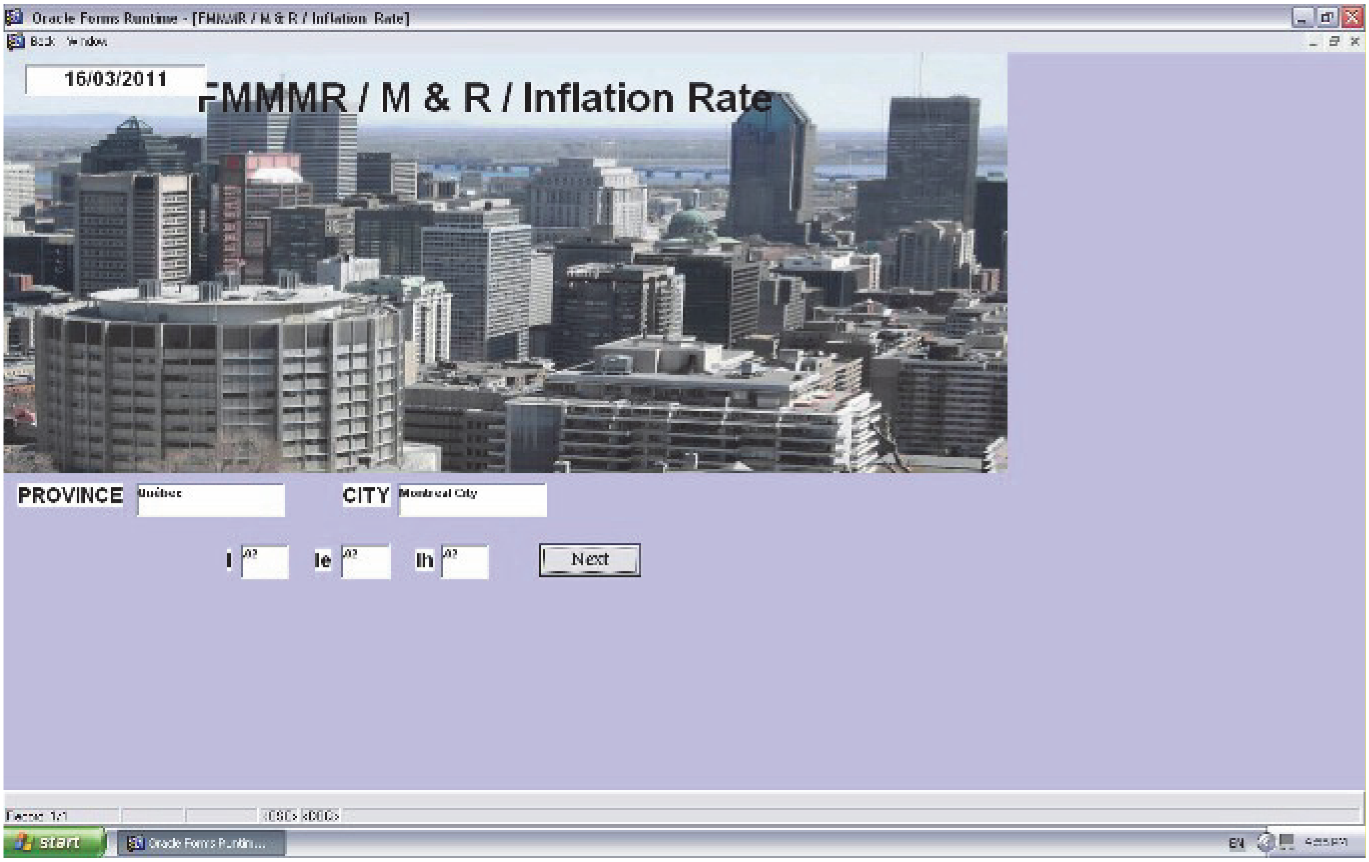


Figure 7-13 Inflation Rate

7.5.3.5 Validation of the Process

In the M&R/Cost Estimate window, the user reviews all the information that has been entered, and continues by entering the proposed amount for the M&R components, as illustrated in Figure 7-14.

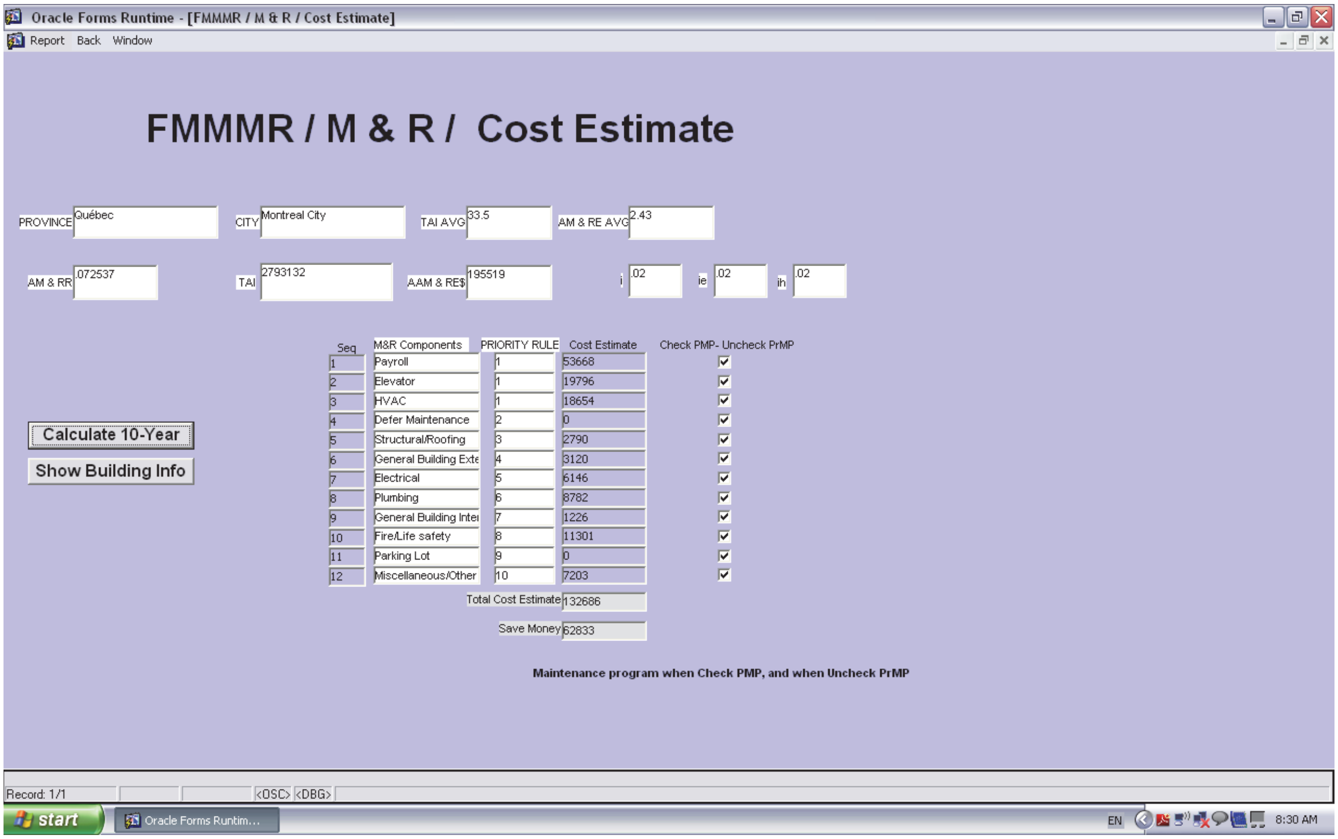
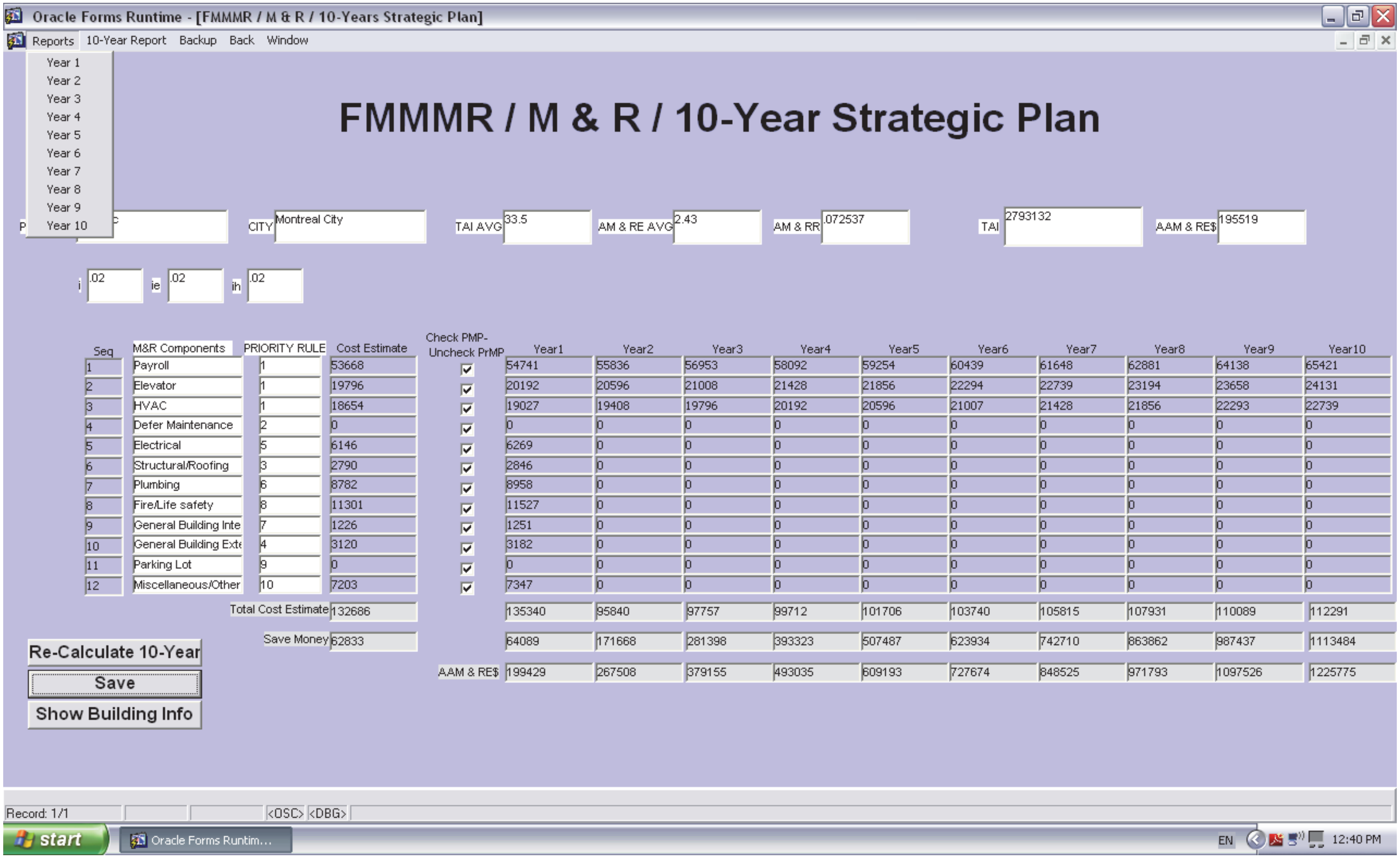


Figure 7-14 Cost Estimate

7.5.3.6 Validation of the 10-Year M&R Strategic Plan

The user clicks the Calculate 10-Year button after entering all the required information, and then receives the ten-year strategic plan for maintenance and operation components, illustrated in Figure 7-15.



Seq	M&R Components	PRIORITY RULE	Cost Estimate	Check PMP-Uncheck PrMP	Year1	Year2	Year3	Year4	Year5	Year6	Year7	Year8	Year9	Year10
1	Payroll	1	53668	✓	54741	55836	56953	58092	59254	60439	61648	62881	64138	65421
2	Elevator	1	19796	✓	20192	20596	21008	21428	21856	22294	22739	23194	23658	24131
3	HVAC	1	18654	✓	19027	19408	19796	20192	20596	21007	21428	21856	22293	22739
4	Defer Maintenance	2	0	✓	0	0	0	0	0	0	0	0	0	0
5	Electrical	5	6146	✓	6269	0	0	0	0	0	0	0	0	0
6	Structural/Roofing	3	2790	✓	2846	0	0	0	0	0	0	0	0	0
7	Plumbing	6	8782	✓	8958	0	0	0	0	0	0	0	0	0
8	Fire/Life safety	8	11301	✓	11527	0	0	0	0	0	0	0	0	0
9	General Building Inte	7	1226	✓	1251	0	0	0	0	0	0	0	0	0
10	General Building Exte	4	3120	✓	3182	0	0	0	0	0	0	0	0	0
11	Parking Lot	9	0	✓	0	0	0	0	0	0	0	0	0	0
12	Miscellaneous/Other	10	7203	✓	7347	0	0	0	0	0	0	0	0	0
		Total Cost Estimate	132686		135340	95840	97757	99712	101706	103740	105815	107931	110089	112291
		Save Money	62833		64089	171668	281398	393323	507487	623934	742710	863862	987437	1113484
				AAM & RE$	199429	267508	379155	493035	609193	727674	848525	971793	1097526	1225775

Figure 7-15 10-year Strategic Plan

The user must save the information or re-calculate the 10-year plan if he/she is not satisfied with the plan, changing the value of certain M&R components. The user clicks the Show Building Info button if he/she wishes to access the building information from this window, illustrated in Figure 7-16.

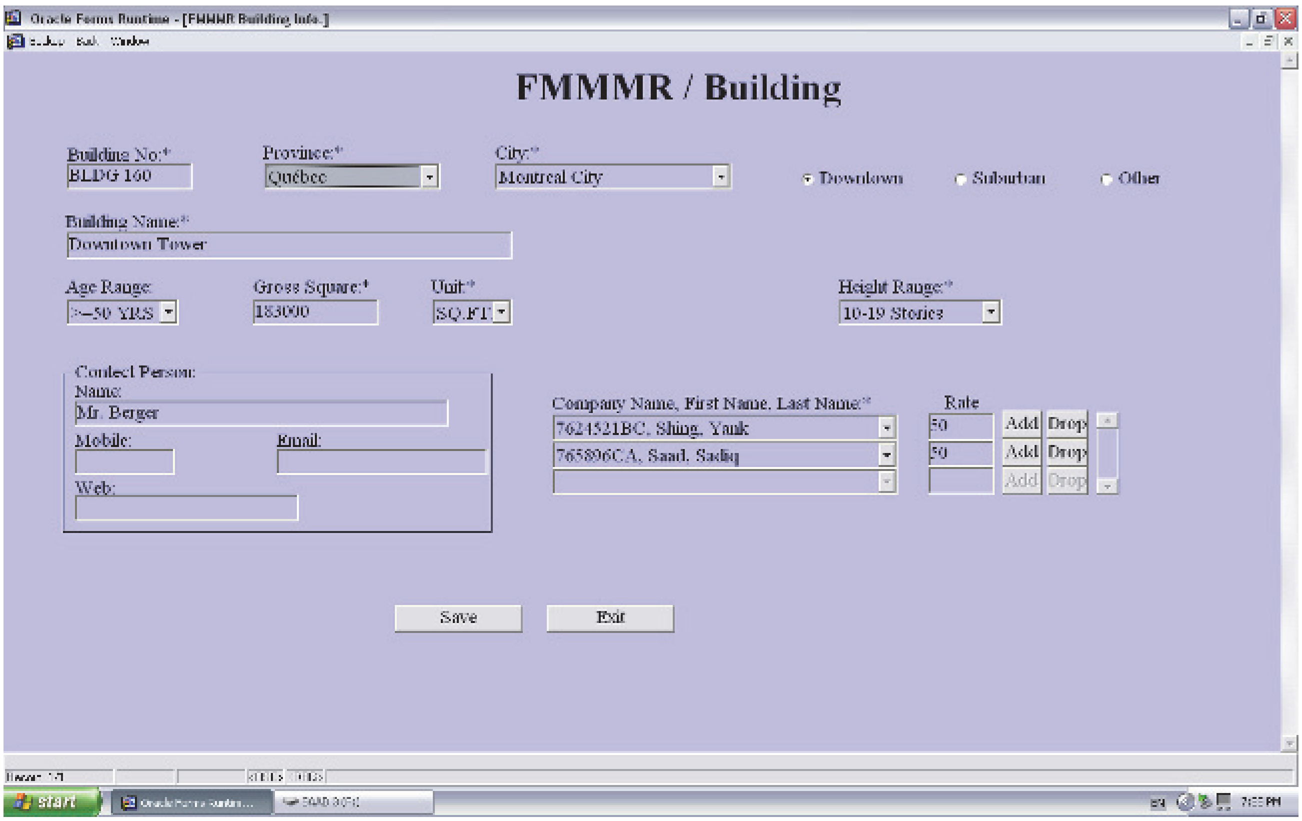


Figure 7-16 Show Building

7.5.3.7 Validation FMMMR Reports

The user clicks the Report icon in the menu bar if he/she needs to access the list of reports from year 1 to year 10. The user clicks report year 1 to access to the information shown in Figure 7-17.

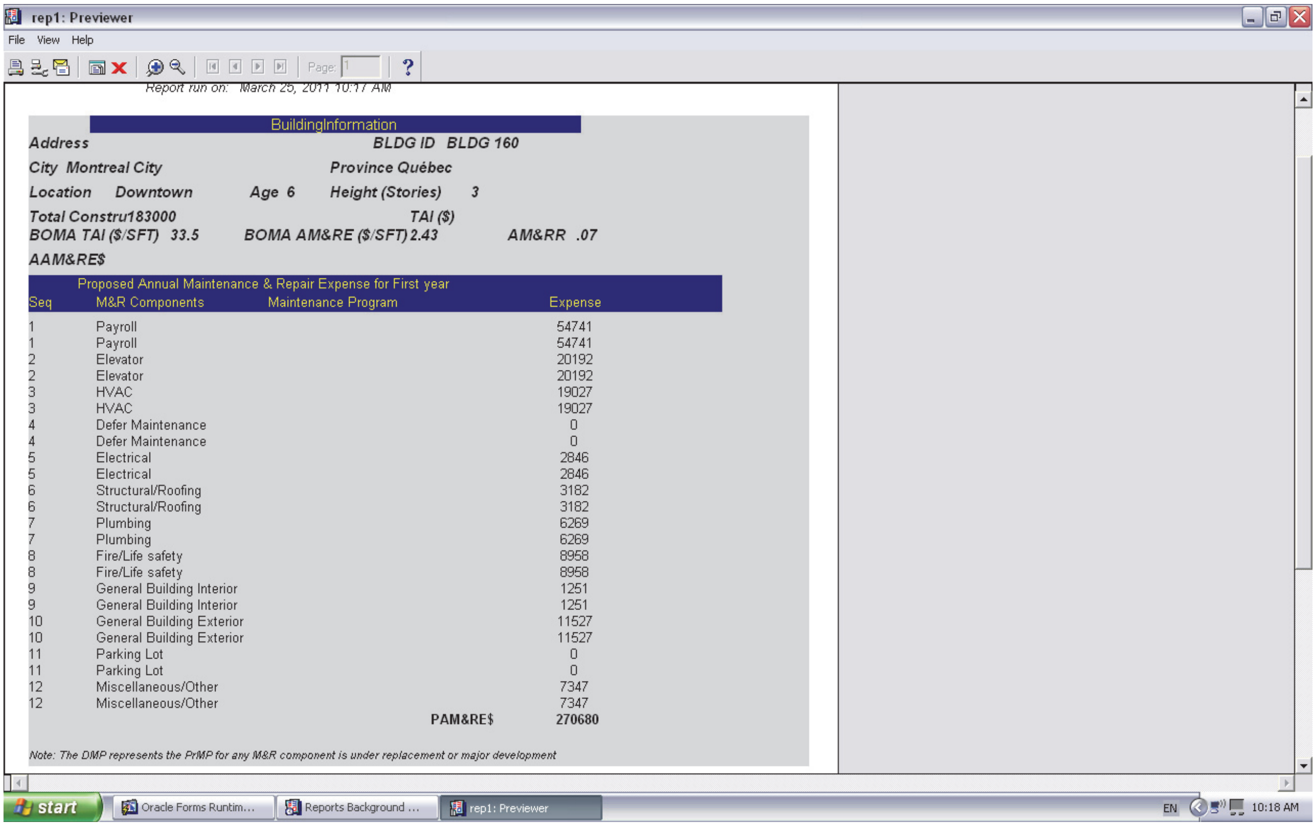
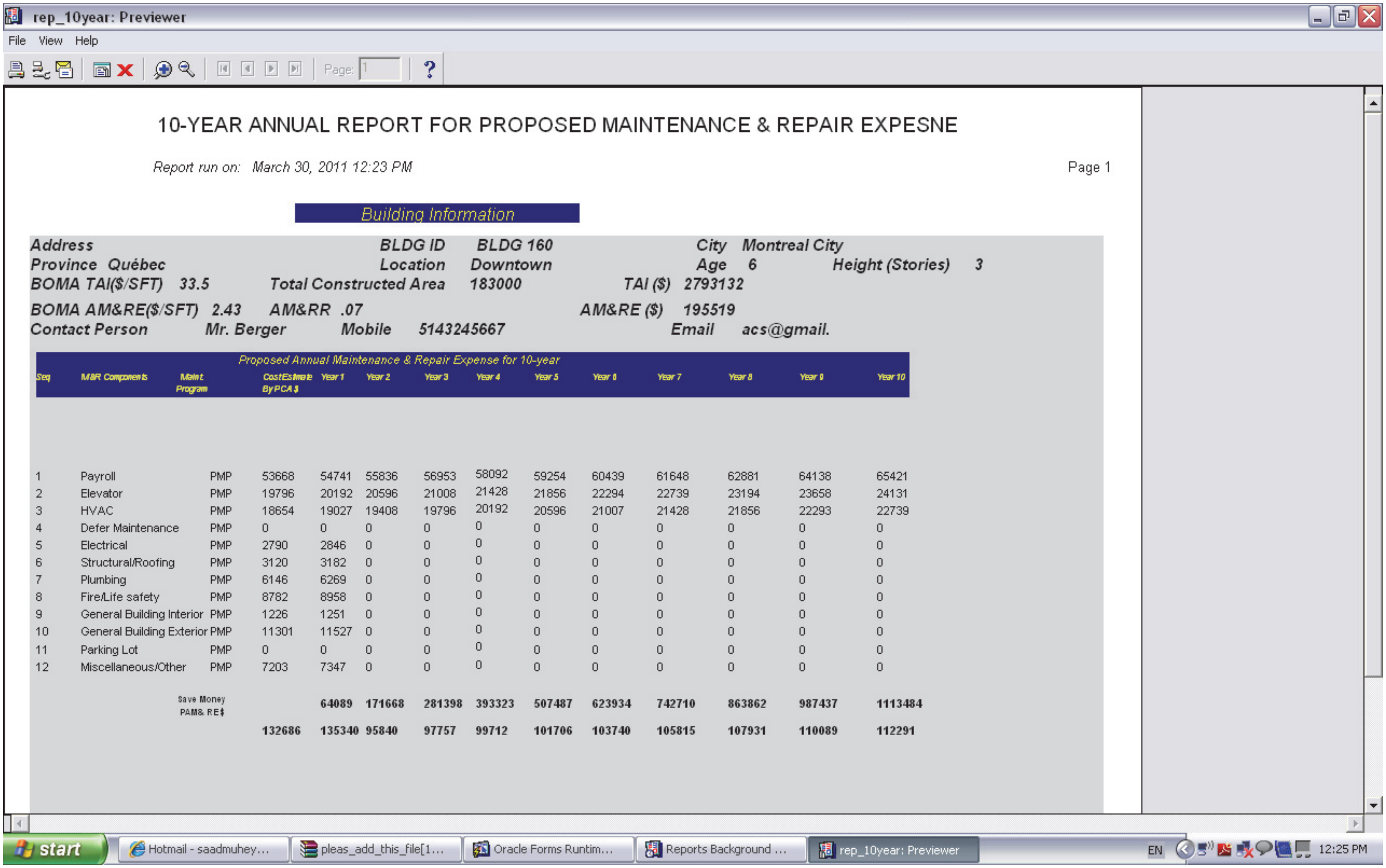


Figure 7-17 Report, First Year

To access the 10-year report, the user clicks on the“10-Year Report” icon in the menu bar and will receive the report, as illustrated in Figure 7-18.



10-YEAR ANNUAL REPORT FOR PROPOSED MAINTENANCE & REPAIR EXPESNE

Report run on: March 30, 2011 12:23 PM

Page 1

Building Information

Address **BLDG ID** **BLDG 160** **City** **Montreal City**
Province Québec **Location** **Downtown** **Age 6** **Height (Stories) 3**
BOMA TAI($/SFT) 33.5 **Total Constructed Area 183000** **TAI ($) 2793132**
BOMA AM&RE($/SFT) 2.43 **AM&RR .07** **AM&RE ($) 195519**
Contact Person **Mr. Berger** **Mobile 5143245667** **Email acs@gmail.**

Proposed Annual Maintenance & Repair Expense for 10-year

Seq	M&R Components	Maint. Program	CostEstimate By PCA $	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
1	Payroll	PMP	53668	54741	55836	56953	58092	59254	60439	61648	62881	64138	65421
2	Elevator	PMP	19796	20192	20596	21008	21428	21856	22294	22739	23194	23658	24131
3	HVAC	PMP	18654	19027	19408	19796	20192	20596	21007	21428	21856	22293	22739
4	Defer Maintenance	PMP	0	0	0	0	0	0	0	0	0	0	0
5	Electrical	PMP	2790	2846	0	0	0	0	0	0	0	0	0
6	Structural/Roofing	PMP	3120	3182	0	0	0	0	0	0	0	0	0
7	Plumbing	PMP	6146	6269	0	0	0	0	0	0	0	0	0
8	Fire/Life safety	PMP	8782	8958	0	0	0	0	0	0	0	0	0
9	General Building Interior	PMP	1226	1251	0	0	0	0	0	0	0	0	0
10	General Building Exterior	PMP	11301	11527	0	0	0	0	0	0	0	0	0
11	Parking Lot	PMP	0	0	0	0	0	0	0	0	0	0	0
12	Miscellaneous/Other	PMP	7203	7347	0	0	0	0	0	0	0	0	0
	Save Money			**64089**	**171668**	**281398**	**393323**	**507487**	**623934**	**742710**	**863862**	**987437**	**1113484**
	PAM& RE$		**132686**	**135340**	**95840**	**97757**	**99712**	**101706**	**103740**	**105815**	**107931**	**110089**	**112291**

Figure 7-18 10-year Report

7.6 Input, Output, and Outcome of FMMMR

The input, output, and outcome of the FMMMR are very clear and will be explained in more detail in this section, as follows:

Input: FMMMR is designed for quick input, to speed up (and increase the accuracy of) the required typing by using predictive technology. A user can use their mouse to select the required data to input, or type the required information. The data inputs are detailed as follows:

- Building and Building owners' information;
- Facility functions;
- Operation and Maintenance;
- M&R check city;
- M&R Priority rule;
- M&R building information;
- Inflation rate (typing); and
- M&R cost estimate (typing)

- **Output**: The FMMMR can produce professional-quality forms, reports, and other business documents. These documents can be printed or distributed electronically as faxes or email messages. A reliable document output strengthens the business process. Accordingly, the FMMMR outputs are listed below:
  - AM&RE (avg), TAI (avg), and AM&RR are the first outputs after entering the data regarding the province and city of the subject building from the built-in list, according to BOMA-EER 2010;

- AAM&RE is the second output after entering the annual income for the building;
- The 10-year M&R strategic plan is the main output after entering all the information listed in the previous FMMMR inputs;
- Save money is one of the more important output features of FMMMR, as it shows the annual money saved from the allowable annual maintenance and repair expenses. In addition, it indicates the cumulative savings over ten years -- unless the money is used in the M&R components;
- The Individual M&R strategic plan from year 1 to year 10; and
- Four types of reports: Building information review, Annual maintenance and repair expenses, 10-year strategic plan, and Maintenance and repair limitations.

- **Outcomes:** The outcomes from utilizing an FMMMR include the following:
  - Develops a comprehensive facility management platform model, which can cover the other two facility management functions: property management and services;
  - Extends the developed facility management platform model to manage the maintenance and repair components, a sub-function of maintenance/ operation management;
  - Develops three types of maintenance programs (corrective maintenance, preventive maintenance, and predictive maintenance) which, associated with

a ten-year strategic plan, will assist building owners and managers in managing their time and cost;

- Develops ten-year strategic plans for maintenance and repair according to the AM&RR, the AAM&RE, and the priority rule. Strategic plans can help to manage a budget's cash flow and assist in scheduling M&R activities;
- Develops yearly and ten-year work plans for M&R components according to a ten-year strategic plan; and
- Develops a prototype facility management model for the maintenance and repair of office buildings to implement and validate the proposed methodology.

7.7 CONCLUSION

Chapter seven presents the technique used to develop the prototype model for the FMMMR, in accordance with the design model explained in the previous chapters. These techniques make use of Oracle 8i and Developer 6i software to develop the prototype model. This chapter explains the prototype model's components and functions step by step. The input and output for the case study was also explained step by step through a numerical process to demonstrate the work program development approach. The annual expenses for the maintenance and repair components for the assigned building (Case study) were scheduled according to a 10-year strategic plan and based on the available funds. Different types of forms and reports were developed by the software to illustrate the required results.

CHAPTER 8

CONCLUSION, CONTRIBUTIONS, AND RECOMMENDATIONS

8.1 CONCLUSION

Preparing an annual maintenance and repair expenses plan and budget is one of the major tasks of a building's owner and manager. This task becomes more complicated when the owner has deferred maintenance and repair programs and when there has been a lack of planning. Maintenance and repair plays a key component in the annual operation and maintenance expenses of a facility. The cleaning, roads/grounds, security, utility, administration, etc are mostly fixed and known annual expense components of operation and maintenance. Building owners and managers need to know in advance the annual maintenance and repair expenses in order to plan and schedule these activities according to the allocated budget. This knowledge of the AM&RE should be based on trustworthy and historically accurate data. However, obtaining an accurate AM&RE for any building is complex and difficult because it includes uncertainty in terms of activities and costs.

The objective of this research was to develop a facility management model for the maintenance and repair of office buildings. An intensive literature study was conducted to review the previous studies in facility management. BOMA EER historical data were analyzed. Property condition assessment based on ASTM E 2018-01 was observed. Information technology tools were employed to integrate the database. The need to develop a management model of an annual plan for maintenance and repair in office buildings was established.

A conceptual design of the proposed facility management model for maintenance and repair was explained and the underlying methodology described. The model's components consists of four modules: 1) a BOMA EER report; 2) a Property Condition Assessment PCA; 3) the Priority Rule; and 4) a Ten-Year AM&R strategic Plan. The four modules are integrated together with a database which consists of the M&R components.

An annual maintenance and repair expenses ratio AM&RR was established for the majority of Canadian cities, based on total annual income and annual maintenance and repair expenses data obtained from the BOMA EERs for 2008 and 2009. This ratio is the reference for any year within ten-year maintenance and repair strategic planning, as such planning which should be the goal of any building owner or manager.

The Allowable Annual Maintenance and Repair Expenses (AAM&RE) for any building is calculated according to the total annual income of the assigned building and the AM&RR. Forecasting the AAM&RE for ten years, in accordance with the average inflation rate, represents the maximum allowable annual maintenance and repair expanses. The proposed annual maintenance and repair expenses PAM&RE should not exceed the AAM&RE of any year. The PAM&RE for M&R components are outlined by a property condition assessment or by questioner.

The priority rule was established to be able to rank M&R components. Priority contributed to the decisions to best distribute the budget fund to M&R components within a single year and in the ten-year strategic plan. A ten-year strategic plan for the annual expenses for M&R components was developed according to the priority rule, the

M&R component position, and the allocated fund. Yearly and ten-year work plans were established.

A prototype model was developed to test and validate the developed facility management model for the maintenance and repair of office buildings.

8.2 CONTRIBUTIONS

The contribution of this research would be beneficial to building owners and managers, engineering consultants, investors, real estate agencies, researchers, and municipalities, as well as insurance and database firms or organizations. The contributions of this research are summarized as follows:

1. The objective of this research was to develop a comprehensive facility management model for the maintenance and repair of office buildings. This model contributes in two aspects, as it:
    a. Develops a comprehensive facility management platform model, which can cover the other two facility management functions: property management and services; and
    b. Extends the developed facility management platform model to manage the maintenance and repair components, which is a sub-function of maintenance/ operation management (figure 2-6).

2. Development of the annual maintenance and repair ratio AM&RR, a useful reference to the facility management model for maintenance and repair and a new data element to which the BOMA EER can be added as a benchmark.
3. Development of allowable annual maintenance and repair expenses (AAM&RE), which is considered as a guide to building owners and managers for their annual funds for component maintenance and repair.
4. Development of a priority rule to apply to M&R components, ranking their relative position in the M&R budget. This priority rule gives building owners or managers the ability to customize, giving them more freedom to practice their experience and knowledge.
5. Development of ten-year strategic plans for maintenance and repair according to the AM&RR, the AAM&RE, and the priority rule. Strategic plans can help to manage budget's cash flow and assist in scheduling M&R activities.
6. Development of three types of maintenance programs (corrective maintenance program, preventive maintenance program, and predictive maintenance programs) which, associated with a ten-year strategic plan, will assist building owners and managers in managing their time and cost.
7. Development of yearly and ten-year work plans for M&R components according to a ten-year strategic plan.
8. A comprehensive review of the property condition assessment, which will contribute to increase the abilities and skills of the key players to develop more realistic models.

9. An intensive review of the previous work in facility management that will contribute to facilitate the references and objectives of other researchers.
10. Development of a prototype facility management model for maintenance and repair for office buildings to implement and validate the proposed methodology.

8.3 RECOMMENDATIONS FOR FUTURE WORKS

This research studied the methodology and prototype software developed for a facility management model for the maintenance and repair of office buildings. The model's four modules, the flexibility it gives to owners and managers to incorporate their experience and knowledge, and the ten-year strategic plan for maintenance and repair components are the main advantages of the developed methodology. Future research work recommendations should focus on the following subjects:

1. The developed model is specific for the annual maintenance and repair expenses as a part of total annual expenses. However, total annual expenses include other expenses: cleaning, roads/grounds, security, utilities, administration, fixed, directly-expensed leasing, amortized leasing, and parking. A sound model must include these expenses.
2. The developed model is specific for the maintenance and repair sub-function of the maintenance/operation management function. However, maintenance/operation management has other sub-functions, which are monitoring/tracking and space management. These other sub-functions will also need to be dealt with.

3. The developed model is specific for the maintenance and repair sub-function of facility management. However, facility management includes other functions, which are property management, and services. A comprehensive model should include these other functions.
4. The proposed methodology and prototype software validated by conducting a case study for building that needs a small fund for maintenance and repair components. The methodology and prototype software will be a successful if the case study would include large expenses on maintenance and repair components.
5. Methods to add to the priority rule for the sub-components of maintenance and repair components should be explored.

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APPENDICES

APPENDIX (A)

Sample of

BOMA

EXPERIENCE EXCHANGE TREND REPORT 2010

- **Important Components of an EER**
- **All Canadian Cities**
- **Montreal All Buildings**
- **Montreal Government Building**
- **Montreal Private Buildings**

- ## Important Components of an EER

Each EER table contains the following income, expense, and occupancy line items:

Office Occupancy (%): Is the square footage of the occupied office space divided by the total office square footage of the sample area

Total Income: Is the total of the rental income, tenant service income, miscellaneous (non-rental) income and gross parking income.

Total Rent: Is the total rental income produced from office, retail and other space, if applicable.

Office Area Income: This is the income generated from leasing office space. It includes base rent and other income categories such as additional rent (pass-through and/or operating cost escalations), base rent escalators, lease cancellations, and the effect of rent abatements. Rent abatements, as a contra-income account, should be interpreted as having negative values.

Retail Area Income: is income generated from leasing retail space in office buildings, grossed-up to 100% occupancy. Such income may include base rent, operating expense escalation/recovery, percentage rents, lease cancellations, rent abatements, (contra-income account), merchant association dues as well as tenant services income.

Other Area Income: This is the income generated from leasing space that is neither office nor retail, such as storage space or express parcel space rental, etc., grossed-up to 100% occupancy.

Rentable/Gross Square feet: The ratio of the total rentable square footage of the sample to the total constructed area of the sample -- the closer the ratio is to 1, the greater is the percentage of a property's rentable space. This ratio is designed to give the average efficiency ratio of the buildings in a sample.

Total Operating and fixed Expenses: This is the total of all expenditures including cleaning, repairs/maintenance, utilities, roads/grounds, security, administrative, and fixed expenses.

Total Operating Expenses: Is the total of all the cleaning, repairs/maintenance, utilities, roads/grounds, security, and administrative expenses.

Fixed Expenses: These are the total expenditures for all of the land and building real estate taxes, building insurance (fire, casualty, errors and omissions), personal property taxes and other annual, periodic taxes such as excise, gross sales or leasing taxes. The fixed expense category does not include any fixed expenses that are not operational-related, such as ground rent, which is treated as a financial expense and is not reported in the Experience Exchange Report.

Repairs and Maintenance Expenses: Are the expenses for the general repairs and maintenance of a building, including common areas and general upkeep. This category includes both in-house payrolls for operating engineers and maintenance personnel and contracted services for elevator, HVAC, electrical, structural/roof, plumbing, fire and life safety expenses and other building maintenance and supplies.

For each income and expense item listed in an EER table, the following data is presented and calculated as indicated:

Average: An average, presented in dollars per square foot, is the sum of all dollars reported for a particular line item divided by the sum the square footage. This average is a weighted average because it is given in relation to the total square footage rather than the total number of data points reported. As a result, larger buildings will affect the average value more than smaller buildings.

Median: A median measures the true midpoint of all of the data sets contributed. A set of dollars per square foot is sorted from the lowest value to the highest, and the median is the figure that lies in the middle of the data set.

Mid-Range Low: Is the number below which 25% of the data items lie when an array of dollars per square foot is sorted from the lowest value to the highest. It is also known as the 25th percentile or the first quartile.

Mid-Range High: Is the number above which 25% of the data items lie when an array of dollars per square foot is sorted from the lowest value to the highest. It is also known as the 75th percentile or the third quartile.

 # Bldgs: This figure indicates the number of buildings supplying the data for a given income or expense category. It is an indicator of data quality; the larger the number; the more reliable the calculations.

Capitalization Threshold: These are the larger expenditures in property operations which address major repairs or replacement and may be amortized (have their cost distributed over multiple years) for income tax reporting purposes. This threshold is the "breakpoint" level between expensing expenditure in one year and allocating it over multiple years, and follows the predictive maintenance concept.

Total Square footage: The Total Building Rentable square footage and the Total Office rentable square footage are provided for each data table, and this is their total. These figures are often used for calculating average building size and the percent of office space in relation to total space in a given table.

Experience Exchange Report ® (All Canadian Cities)

Report Year:	2009	**Sector:**	All Sectors	**Building Size:**	All Sizes	**Unit of Measure:**	ɥuare Feet
Country:	Canada	**Building Type:**	All Building Types	**Public Transit:**	Any Proximity	**Location:**	All Locations
Market:	All Markets	**Ownership Type:**	All Types	**All Electric:**	Any	**Building Age:**	All Ages
Zip Code:	All Zip Codes	**Number of Floors:**	All Heights	**Agency Managed:**	Any		

% Gov't Tenants:	All Occupancy Ranges	**% 24/7 Tenants:**	All Occupancy Ranges	**% Pvt. Tenants:**	All Occupancy Ranges

Occupancy Summary - 2009

Occupancy Info.	*# Blds*	*Avg*
SQFT per Office Tenant	204	15,599.39
SQFT per Retail Tenant	11	2,165.83
SQFT per Office Worker	13	207.29
SQFT per Maintenance Staff	17	36,540.69
Office Occupancy (%)	236	93.09
Retail Occupancy (%)	12	99.85
YR-End Rent ($ per SQFT)	13	22.11
Gross Parking INC per Stall ($)	12	898.79
Parking Ratio (Stalls per 1000 SQFT)	226	0.74
Rentable per Gross SQFT	227	0.74
Rentable per Usable SQFT	222	1.10
Total BTUs		
Capitalization Threshold ($)	5	15,300.00
Building Hours	193	84.36

Occupancy Summary - 2008

Occupancy Info.	*# Blds*	*Avg*
SQFT per Office Tenant	211	9,685.00
SQFT per Retail Tenant	12	1,031.48
SQFT per Office Worker	8	210.55
SQFT per Maintenance Staff	16	35,672.16
Office Occupancy (%)	239	94.60
Retail Occupancy (%)	13	74.11
YR-End Rent ($ per SQFT)	15	25.82
Gross Parking INC per Stall ($)	20	803.58
Parking Ratio (Stalls per 1000 SQFT)	230	0.74
Rentable per Gross SQFT	234	0.75
Rentable per Usable SQFT	221	1.17
Total BTUs		
Capitalization Threshold ($)	13	20,300.00
Building Hours	149	85.07

Income and Expense Overview - 2009

	Total Building Rentable Area					Total Office Rentable Area			
	236 Blds	34,283,038 Sq. Ft.				31,578,073 Sq. Ft.			
		Dollars/S.F.		**Mid Range**		**Dollars/S.F.**		**Mid Range**	
	# Blds	*Avg*	*Mdn*	*Low*	*High*	*Avg*	*Mdn*	*Low*	*High*
Income									
Total Rental Income	23	28.49	17.32	9.83	30.62	28.96	17.40	9.83	31.22
Total Income	23	30.45	17.54	9.97	32.54	30.95	17.62	9.97	33.33
Expense									
Total Oper Exp	178	9.74	10.73	8.59	12.85	10.51	12.15	9.48	14.79
Total Oper + Fixed Exp	199	13.83	14.57	11.79	17.42	14.97	16.22	12.99	19.87

Income and Expense Overview - Trend Data 2008

	Total Building Rentable Area					Total Office Rentable Area			
	240 Blds	32,257,376 Sq. Ft.				29,276,235 Sq. Ft.			
		Dollars/S.F.		**Mid Range**		**Dollars/S.F.**		**Mid Range**	
	# Blds	*Avg*	*Mdn*	*Low*	*High*	*Avg*	*Mdn*	*Low*	*High*
Income									
Total Income	198	21.24	19.61	15.84	23.85	23.79	22.24	18.71	26.82
Total Rental Income	18	22.98	20.10	10.33	29.35	23.93	20.10	10.33	29.35
Expense									
Total Oper Exp	180	9.06	10.07	8.30	12.46	9.97	11.68	8.99	14.70
Total Oper + Fixed Exp	192	13.14	13.78	11.64	16.47	14.50	15.78	12.75	19.07

Income and Expense Summary - 2009

Income									
Office Rent	24					27.71	13.01	10.65	29.87
Retail Rent									
Other Rent	6	16.78	16.36						
Telecom Income	8	0.05	0.06						
Miscellaneous Income	14	2.38	0.62	0.22	3.03				
Expense									
Cleaning	218	1.33	1.49	1.18	1.93	1.42	1.68	1.32	2.29
Repair / Maintenance	137	2.38	3.13	2.32	3.89	2.54	3.41	2.51	4.34
Utility	66	0.92	2.41	1.60	3.92	2.66	2.94	2.01	4.06
Roads / Grounds	214	0.33	0.41	0.17	0.94	0.36	0.46	0.17	1.16
Security	225	0.69	0.21	0.08	0.69	0.75	0.23	0.09	0.78
Administrative	205	1.35	1.75	1.40	2.37	1.47	2.06	1.56	2.85

Income and Expense Summary - Trend Data 2008

Income									
Office Rent	19					23.19	19.19	10.33	29.40
Retail Rent	5	3.03	18.14						
Other Rent									
Telecom Income	14	0.03	0.01	0.00	0.01				
Miscellaneous Income	15	1.85	0.66	0.16	1.14				
Expense									
Cleaning	211	1.27	1.38	1.11	1.80	1.38	1.55	1.23	2.20
Repair / Maintenance	122	2.55	2.92	2.40	3.55	2.73	3.27	2.49	3.91
Utility	203	2.54	2.60	1.99	3.33	2.75	3.00	2.20	3.97
Roads / Grounds	216	0.28	0.33	0.16	0.76	0.31	0.39	0.17	0.92
Security	214	0.70	0.15	0.07	0.70	0.77	0.18	0.08	0.78
Administrative	223	1.21	1.47	0.98	1.88	1.34	1.70	1.06	2.35

	# Blds	Avg	Mdn	Low	High	Avg	Mdn	Low	High
Fixed	226	4.41	2.74	1.78	4.17	4.78	3.29	2.03	4.53
Directly Expensed Leasing	44	0.58	0.23	0.03	0.81	0.63	0.24	0.03	0.99
Amortized Leasing	5	2.69	3.35			2.74	3.45		
Parking	9	0.55	0.39	0.12	0.60	0.57	0.40	0.12	0.61
Telecom	8	0.05	0.06			0.05	0.07		

Income and Expense Detail - 2009

	Total Building Rentable Area					Total Office Rentable Area			
		Dollars/S.F.		Mid Range		Dollars/S.F.		Mid Range	
	# Blds	*Avg*	*Mdn*	*Low*	*High*	*Avg*	*Mdn*	*Low*	*High*
Income									
Office Rent									
Base Rent	23					14.87	12.46	9.37	14.96
Pass Throughs	13					17.59	11.94	10.34	16.54
Escalations									
Lease Cancellations									
Rent Abatements (-)									
Telecom Income									
Rooftop Income									
Wire/Riser Access Income	7	0.04	0.06						
Miscellaneous Income									
Gross Parking Income	13	1.56	0.72	0.32	1.73				
Tenant Service Income	7	1.00	0.64						
Other Misc. Income	6	0.38	0.09	0.02	0.32				
Expense									
Cleaning									
Payroll,	6	0.33	0.14	0.01	1.84	0.35	0.14	0.01	2.01

	# Blds	Avg	Mdn	Low	High	Avg	Mdn	Low	High
Fixed	232	4.54	2.72	1.74	4.01	5.01	3.22	1.91	4.55
Directly Expensed Leasing	29	0.74	0.06	0.01	0.49	0.81	0.06	0.01	0.60
Amortized Leasing									
Parking	16	0.54	0.26	0.10	0.53	0.58	0.26	0.10	0.54
Telecom	6	0.02	0.01			0.02	0.01		

Income and Expense Detail - Trend Data 2008

	Total Building Rentable Area					Total Office Rentable Area			
		Dollars/S.F.		Mid Range		Dollars/S.F.		Mid Range	
	# Blds	*Avg*	*Mdn*	*Low*	*High*	*Avg*	*Mdn*	*Low*	*High*
Income									
Office Rent									
Base Rent	17					12.58	12.71	7.95	14.33
Pass Throughs	15					11.77	11.51	8.95	13.73
Escalations									
Lease Cancellations									
Rent Abatements (-)									
Telecom Income									
Rooftop Income									
Wire/Riser Access Income	12	0.00	0.00						
Miscellaneous Income									
Gross Parking Income	20	1.64	0.70	0.19	2.04				
Tenant Service Income	5	0.77	0.82						
Other Misc. Income									
Expense									
Cleaning									
Payroll,	11	0.89	0.08	0.06	0.25	0.92	0.08	0.06	0.27

Taxes, Fringes									
Routine Contracts	227	1.12	1.33	1.10	1.84	1.20	1.51	1.18	2.24
Window Washing	27	0.03	0.02	0.01	0.05	0.03	0.02	0.01	0.05
Other Specialized Contracts	22	0.02	0.03	0.01	0.05	0.02	0.03	0.01	0.05
Supplies / Materials	42	0.08	0.06	0.03	0.14	0.09	0.07	0.03	0.14
Trash Removal / Recycling	206	0.09	0.12	0.07	0.23	0.10	0.13	0.07	0.26
Miscellaneous / Other	34	0.02	0.02	0.01	0.05	0.03	0.02	0.01	0.05
Repair / Maintenance									
Payroll, Taxes, Fringes	197	0.95	1.00	0.72	1.57	1.04	1.14	0.84	1.89
Elevator	196	0.18	0.15	0.09	0.26	0.19	0.17	0.10	0.30
HVAC	231	0.57	0.42	0.20	0.86	0.61	0.47	0.24	0.97
Electrical	207	0.24	0.09	0.03	0.28	0.26	0.12	0.04	0.31
Structural / Roofing	98	0.15	0.02	0.01	0.11	0.16	0.02	0.01	0.11
Plumbing	153	0.08	0.03	0.01	0.09	0.08	0.04	0.01	0.11
Fire / Life Safety	210	0.23	0.14	0.07	0.26	0.24	0.15	0.07	0.28
General Building Interior	222	1.11	1.36	0.71	2.25	1.20	1.49	0.75	2.67
General Building Exterior	100	0.33	0.36	0.09	0.86	0.35	0.43	0.10	1.07
Parking Lot									
Miscellaneous / Other	134	0.26	0.22	0.08	0.66	0.28	0.24	0.10	0.70
Utility									
HVAC Electricity	197	0.09	0.07	0.05	0.09	2.08	1.97	1.39	3.00
Non - HVAC Electricity	32	2.08	3.33	2.05	3.89	2.09	3.33	2.05	3.89
Gas	123	0.02	0.03	0.02	0.19	0.45	0.65	0.38	1.00
Fuel Oil	120	0.01	0.01	0.00	0.04	0.11	0.04	0.01	1.38
Steam	31	0.02	0.02	0.02	0.04	0.98	0.90	0.74	1.26
Chilled Water	20	0.02	0.02	0.01	0.02	1.09	0.76	0.51	1.21

Taxes, Fringes									
Routine Contracts	219	1.14	1.28	1.03	1.69	1.24	1.49	1.12	2.09
Window Washing	30	0.06	0.04	0.02	0.08	0.06	0.04	0.02	0.08
Other Specialized Contracts	25	0.01	0.02	0.01	0.04	0.01	0.02	0.01	0.04
Supplies / Materials	40	0.07	0.05	0.02	0.11	0.07	0.05	0.02	0.11
Trash Removal / Recycling	209	0.08	0.09	0.06	0.18	0.08	0.11	0.06	0.22
Miscellaneous / Other	41	0.07	0.03	0.01	0.05	0.07	0.03	0.01	0.05
Repair / Maintenance									
Payroll, Taxes, Fringes	202	0.93	0.97	0.69	1.54	1.03	1.14	0.79	1.86
Elevator	193	0.21	0.16	0.09	0.26	0.22	0.17	0.11	0.31
HVAC	230	0.53	0.48	0.24	0.83	0.58	0.50	0.26	1.01
Electrical	212	0.26	0.13	0.05	0.28	0.28	0.15	0.06	0.32
Structural / Roofing	117	0.11	0.03	0.01	0.11	0.11	0.04	0.01	0.14
Plumbing	170	0.16	0.04	0.01	0.11	0.17	0.04	0.02	0.13
Fire / Life Safety	217	0.18	0.13	0.06	0.28	0.20	0.15	0.07	0.31
General Building Interior	228	1.31	1.34	0.71	2.22	1.43	1.54	0.88	2.86
General Building Exterior	112	0.43	0.45	0.12	1.25	0.47	0.50	0.14	1.29
Parking Lot									
Miscellaneous / Other	166	0.20	0.23	0.09	0.53	0.22	0.25	0.10	0.63
Utility									
HVAC Electricity	203	2.05	1.67	1.17	2.43	2.27	1.89	1.35	2.89
Non - HVAC Electricity	30	2.02	3.08	1.91	3.81	2.02	3.08	1.91	3.81
Gas	123	0.37	0.52	0.31	0.77	0.40	0.58	0.34	0.91
Fuel Oil	119	0.14	0.07	0.01	1.33	0.15	0.07	0.01	1.59
Steam	33	1.06	1.03	0.69	1.50	1.17	1.07	0.77	1.52
Chilled Water	18	0.77	0.73	0.47	0.85	0.84	0.78	0.54	0.91

Water / Sewer	48	0.06	0.12	0.06	0.23	0.24	0.13	0.09	0.30	Water / Sewer	164	0.15	0.13	0.08	0.20	0.17	0.15	0.09	0.25
Roads / Grounds										***Roads / Grounds***									
Landscaping	37	0.14	0.14	0.06	0.25	0.14	0.14	0.06	0.25	Landscaping	42	0.07	0.10	0.04	0.23	0.07	0.10	0.04	0.23
Snow Removal	38	0.10	0.38	0.13	0.92	0.11	0.38	0.13	0.92	Snow Removal	43	0.11	0.29	0.07	0.60	0.11	0.29	0.07	0.60
Miscellaneous / Other	9	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.05	Miscellaneous / Other	200	0.27	0.31	0.10	0.76	0.30	0.37	0.12	0.95
Security										***Security***									
Payroll, Taxes, Fringes	144	0.07	0.07	0.06	0.09	0.08	0.08	0.06	0.12	Payroll, Taxes, Fringes	146	0.07	0.07	0.05	0.08	0.08	0.07	0.06	0.11
Contracts	159	0.90	0.38	0.05	0.90	0.98	0.41	0.06	1.03	Contracts	133	0.82	0.43	0.06	0.91	0.89	0.47	0.06	1.03
Equipment	23	0.05	0.02	0.02	0.05	0.05	0.02	0.02	0.05	Equipment	35	0.08	0.04	0.02	0.10	0.08	0.04	0.02	0.10
Miscellaneous / Other	128	0.02	0.01	0.00	0.04	0.02	0.01	0.00	0.04	Miscellaneous / Other	112	0.11	0.01	0.00	0.03	0.12	0.01	0.00	0.04
Administrative										***Administrative***									
Payroll, Taxes, Fringes	209	0.81	0.94	0.80	1.32	0.88	1.13	0.85	1.61	Payroll, Taxes, Fringes	207	0.76	0.89	0.67	1.19	0.83	1.00	0.73	1.47
Management Fees	180	0.41	0.45	0.29	0.76	0.46	0.55	0.31	0.78	Management Fees	177	0.27	0.16	0.15	0.49	0.30	0.22	0.16	0.50
Professional Fees	159	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.02	Professional Fees	159	0.01	0.01	0.00	0.01	0.02	0.01	0.01	0.01
General Office Expenses	8	0.26	0.22			0.28	0.23			General Office Expenses	11	0.24	0.22	0.19	0.28	0.26	0.22	0.19	0.31
Employee Expenses	8	0.01	0.02			0.02	0.02			Employee Expenses	29	0.07	0.17	0.05	0.29	0.07	0.17	0.05	0.29
Miscellaneous / Other	218	0.29	0.41	0.24	0.64	0.32	0.44	0.26	0.81	Miscellaneous / Other	189	0.29	0.40	0.22	0.64	0.33	0.47	0.23	0.80
Fixed										***Fixed***									
Real Estate Taxes	48	4.45	2.36	1.61	3.92	4.57	2.36	1.61	3.92	Real Estate Taxes	50	5.34	2.50	1.70	4.73	5.45	2.50	1.70	4.73
Personal Property Tax										Personal Property Tax									
Other Tax	195	3.92	2.58	1.32	3.96	4.33	3.06	1.75	4.46	Other Tax	197	3.65	2.52	1.37	3.93	4.08	3.04	1.76	4.35
Building Insurance	22	0.31	0.33	0.26	0.34	0.31	0.33	0.27	0.34	Building Insurance	30	0.48	0.32	0.23	0.55	0.50	0.32	0.25	0.55
License / Fees / Permits	5	0.13	0.13			0.14	0.14			License / Fees / Permits									
Directly Expensed Leasing										***Directly Expensed Leasing***									
Payroll										Payroll									
Commissions / Fees										Commissions / Fees									

Advertising / Promotion	5	0.05	0.04	0.03	0.06	0.05	0.04	0.03	0.06
Professional Fees									
Tenant Improvements									
Other Leasing Costs									
Amortized Leasing									
Commissions / Fees									
Tenant Improvements									
Other Leasing Costs									
Parking									
In-house	5	0.04	0.04			0.04	0.04		
Contract	9	0.47	0.39	0.12	0.45	0.48	0.39	0.12	0.46
Snow Removal	6	0.14	0.12			0.14	0.13		
Shuttle									

Advertising / Promotion	5	0.05	0.05	0.03	0.06	0.05	0.05	0.04	0.06
Professional Fees	15	0.08	0.01	0.01	0.01	0.09	0.01	0.01	0.02
Tenant Improvements	10	0.91	0.63	0.36	2.27	1.03	0.76	0.36	2.53
Other Leasing Costs	6	0.98	0.02			1.00	0.02		
Amortized Leasing									
Commissions / Fees									
Tenant Improvements									
Other Leasing Costs									
Parking									
In-house									
Contract	16	0.44	0.26	0.10	0.53	0.47	0.26	0.10	0.54
Snow Removal	10	0.46	2.13			0.47	2.30		
Shuttle									

Montreal All Buildings

Experience Exchange Report ®

Report Year:	2009	**Sector:**	All Sectors	**Building Size:**	All Sizes	**Unit of Measure:**	Square Feet
Country:	Canada	**Building Type:**	All Building Types	**Public Transit:**	Any Proximity	**Location:**	All Locations
Market:	Montreal, PQ	**Ownership Type:**	All Types	**All Electric:**	Any	**Building Age:**	All Ages
Zip Code:	All Zip Codes	**Number of**	All Heights	**Agency**	Any		

		Floors:		**Managed:**	
% Gov't Tenants:	All Occupancy Ranges	**% 24/7 Tenants:**	All Occupancy Ranges	**% Pvt. Tenants:**	All Occupancy Ranges

Occupancy Summary - 2009

Occupancy Info.	*# Blds*	*Avg*
SQFT per Office Tenant	12	22,410.84
SQFT per Retail Tenant		
SQFT per Office Worker		
SQFT per Maintenance Staff		
Office Occupancy (%)	13	91.20
Retail Occupancy (%)		
YR-End Rent ($ per SQFT)		
Gross Parking INC per Stall ($)		
Parking Ratio (Stalls per 1000 SQFT)	11	0.45
Rentable per Gross SQFT	11	0.78
Rentable per Usable SQFT	11	1.06
Total BTUs		
Capitalization Threshold ($)		
Building Hours	12	102.08

Occupancy Summary - 2008

Occupancy Info.	*# Blds*	*Avg*
SQFT per Office Tenant	17	15,272.45
SQFT per Retail Tenant		
SQFT per Office Worker	5	213.50
SQFT per Maintenance Staff	6	27,793.40
Office Occupancy (%)	18	95.75
Retail Occupancy (%)		
YR-End Rent ($ per SQFT)		
Gross Parking INC per Stall ($)		
Parking Ratio (Stalls per 1000 SQFT)	15	0.38
Rentable per Gross SQFT	17	0.67
Rentable per Usable SQFT	17	1.06
Total BTUs		
Capitalization Threshold ($)		
Building Hours	14	103.38

Income and Expense Overview - 2009

		Total Building Rentable Area		**Total Office Rentable Area**	
	13 Blds	7,878,742 Sq. Ft.		7,401,334 Sq. Ft.	
		Dollars/S.F.	**Mid Range**	**Dollars/S.F.**	**Mid Range**

Income and Expense Overview - Trend Data 2008

	Total Building Rentable Area		**Total Office Rentable Area**	
18 Blds	8,088,642 Sq. Ft.		7,338,225 Sq. Ft.	
	Dollars/S.F.	**Mid Range**	**Dollars/S.F.**	**Mid**

	# Blds	Avg	Mdn	Low	High	Avg	Mdn	Low	High
Income									
Total Income									
Total Rental Income									
Expense									
Total Oper Exp	10	9.41	11.26	10.67	12.00	9.88	12.61	10.67	13.86
Total Oper + Fixed Exp	10	13.58	15.92	15.06	16.94	14.33	18.22	16.22	19.81

	# Blds	Avg	Mdn	Low	High	Avg	Mdn	Range Low	Range High
Income									
Total Income	16	20.05	21.12	19.91	24.47	22.41	23.96	22.07	28.68
Total Rental Income	6	33.50	29.35	25.43	29.67	34.06	29.35	25.43	30.01
Expense									
Total Oper Exp	14	8.73	9.06	8.69	11.02	9.54	11.38	8.83	11.94
Total Oper + Fixed Exp	14	12.63	13.45	12.88	16.04	13.95	16.54	14.18	18.82

Income and Expense Summary - 2009

Income									
Office Rent									
Retail Rent									
Other Rent									
Telecom Income									
Miscellaneous Income									
Expense									
Cleaning	11	1.29	1.55	1.05	1.86	1.35	1.55	1.25	2.02

Income and Expense Summary - Trend Data 2008

Income									
Office Rent	6					32.84	29.40	25.49	29.48
Retail Rent									
Other Rent									
Telecom Income									
Miscellaneous Income	6	2.94	1.29	0.99	3.56				
Expense									
Cleaning	17	1.36	1.49	1.13	1.74	1.45	1.56	1.30	1.

Repair / Maintenance	6	1.21	2.59	0.56	3.99	1.28	2.65	0.56	3.99
Utility									
Roads / Grounds	10	0.12	0.10	0.04	0.26	0.13	0.10	0.05	0.32
Security	13	0.67	0.68	0.48	1.10	0.71	0.68	0.64	1.10
Administrative	12	1.21	2.01	1.19	2.48	1.29	2.39	1.30	2.69
Fixed	13	4.28	4.49	2.82	5.55	4.56	5.28	3.45	5.55
Directly Expensed Leasing	8	0.30	0.23	0.05	0.62	0.32	0.23	0.06	0.74
Amortized Leasing									
Parking									
Telecom									

									90
Repair / Maintenance	10	2.43	3.09	2.31	3.47	2.58	3.23	2.34	3.82
Utility	17	2.31	2.52	2.12	2.90	2.47	2.98	2.17	3.32
Roads / Grounds	15	0.14	0.08	0.02	0.32	0.15	0.08	0.02	0.39
Security	17	1.00	0.82	0.46	1.33	1.10	0.92	0.46	1.66
Administrative	18	1.24	1.24	0.73	1.72	1.37	1.24	0.92	2.02
Fixed	18	5.71	5.07	3.95	5.92	6.30	5.60	4.95	6.55
Directly Expensed Leasing	7	0.18	0.04	0.01	0.22	0.20	0.04	0.01	0.23
Amortized Leasing									
Parking									
Telecom									

Income and Expense Detail - 2009

	Total Building Rentable Area					Total Office Rentable Area			
		Dollars/S.F.		Mid Range		Dollars/S.F.		Mid Range	
	# Blds	*Avg*	*Mdn*	*Low*	*High*	*Avg*	*Mdn*	*Low*	*High*
Income									
Office Rent									
Base Rent									

Income and Expense Detail - Trend Data 2008

	Total Building Rentable Area					Total Office Rentable Area			
		Dollars/S.F.		Mid Range		Dollars/S.F.		Mid Range	
	# Blds	*Avg*	*Mdn*	*Low*	*High*	*Avg*	*Mdn*	*Low*	*High*
Income									
Office Rent									
Base Rent	6					15.76	12.92	12.56	15.67

Pass Throughs									
Escalations									
Lease Cancellations									
Rent Abatements (-)									
Telecom Income									
Rooftop Income									
Wire/Riser Access Income									
Miscellaneous Income									
Gross Parking Income									
Tenant Service Income									
Other Misc. Income									
Expense									
Cleaning									
Payroll, Taxes, Fringes									
Routine Contracts	13	0.82	1.35	0.91	1.88	0.87	1.35	1.07	2.00
Window Washing									
Other Specialized Contracts									
Supplies / Materials									
Trash Removal / Recycling	10	0.05	0.05	0.04	0.07	0.05	0.05	0.04	0.07
Miscellaneous / Other									
Repair / Maintenance									
Payroll, Taxes, Fringes	10	0.76	1.33	0.63	1.63	0.82	1.54	0.64	2.10
Elevator	11	0.14	0.14	0.07	0.29	0.15	0.17	0.08	0.31
HVAC	13	0.47	0.56	0.19	0.96	0.50	0.66	0.27	1.10

Pass Throughs	5					17.40	14.93		
Escalations									
Lease Cancellations									
Rent Abatements (-)									
Telecom Income									
Rooftop Income									
Wire/Riser Access Income									
Miscellaneous Income									
Gross Parking Income									
Tenant Service Income	5	0.77	0.82						
Other Misc. Income									
Expense									
Cleaning									
Payroll, Taxes, Fringes									
Routine Contracts	17	1.28	1.37	1.07	1.67	1.36	1.49	1.25	1.83
Window Washing	7	0.04	0.06	0.03	0.06	0.04	0.06	0.03	0.06
Other Specialized Contracts									
Supplies / Materials									
Trash Removal / Recycling	17	0.04	0.04	0.03	0.05	0.04	0.04	0.03	0.06
Miscellaneous / Other									
Repair / Maintenance									
Payroll, Taxes, Fringes	15	0.99	1.34	0.77	1.54	1.09	1.51	0.77	1.89
Elevator	16	0.20	0.19	0.11	0.21	0.21	0.20	0.11	0.23
HVAC	17	0.56	0.54	0.35	0.95	0.60	0.57	0.39	1.04

Electrical	10	0.12	0.17	0.09	0.28	0.12	0.19	0.09	0.28
Structural / Roofing	6	0.18	0.02	0.00	0.04	0.19	0.02	0.01	0.04
Plumbing	11	0.06	0.05	0.02	0.13	0.06	0.06	0.02	0.15
Fire / Life Safety	12	0.07	0.09	0.07	0.20	0.07	0.10	0.07	0.21
General Building Interior	12	0.49	1.03	0.43	1.40	0.52	1.19	0.49	1.71
General Building Exterior	9	0.09	0.14	0.03	0.41	0.10	0.14	0.03	0.50
Parking Lot									
Miscellaneous / Other	10	0.32	0.43	0.07	0.57	0.33	0.46	0.07	0.66
Utility									
HVAC Electricity	12	0.13	0.07	0.06	1.60	1.34	2.23	1.75	2.70
Non - HVAC Electricity									
Gas	11	0.04	0.02	0.02	0.11	0.31	0.68	0.13	1.15
Fuel Oil	7	0.00	0.00	0.00	0.02	0.03	0.01	0.01	0.04
Steam									
Chilled Water									
Water / Sewer									
Roads / Grounds									
Landscaping									
Snow Removal									
Miscellaneous / Other									
Security									
Payroll, Taxes, Fringes									
Contracts	12	0.93	0.72	0.37	1.18	0.98	0.72	0.46	1.34
Equipment									
Miscellaneous / Other	9	0.01	0.01	0.00	0.02	0.01	0.01	0.00	0.02
Administrative									
Payroll, Taxes, Fringes	12	0.56	0.97	0.64	1.17	0.59	1.15	0.66	1.32
Management	10	0.44	0.57	0.56	0.57	0.47	0.68	0.57	0.79

Electrical	15	0.18	0.19	0.11	0.26	0.20	0.22	0.12	0.27
Structural / Roofing	10	0.05	0.03	0.01	0.04	0.05	0.03	0.01	0.04
Plumbing	17	0.29	0.05	0.03	0.10	0.31	0.05	0.03	0.11
Fire / Life Safety	17	0.13	0.12	0.07	0.21	0.14	0.14	0.07	0.25
General Building Interior	18	0.92	1.08	0.38	1.55	0.98	1.27	0.38	1.93
General Building Exterior	11	0.18	0.14	0.03	0.37	0.20	0.16	0.03	0.42
Parking Lot									
Miscellaneous / Other	15	0.19	0.11	0.03	0.37	0.21	0.11	0.03	0.43
Utility									
HVAC Electricity	16	1.97	1.88	1.82	2.21	2.14	2.21	1.99	2.33
Non - HVAC Electricity									
Gas	16	0.35	0.52	0.14	0.73	0.37	0.55	0.15	0.73
Fuel Oil	10	0.01	0.01	0.00	0.02	0.02	0.01	0.01	0.02
Steam									
Chilled Water									
Water / Sewer	8	0.11	0.19	0.04	0.28	0.13	0.22	0.05	0.33
Roads / Grounds									
Landscaping	6	0.04	0.04	0.01	0.04	0.04	0.04	0.01	0.04
Snow Removal	5	0.04	0.02	0.02	0.03	0.04	0.03	0.02	0.03
Miscellaneous / Other	9	0.18	0.19	0.01	0.38	0.21	0.21	0.02	0.53
Security									
Payroll, Taxes, Fringes	6	0.06	0.06	0.04	0.24	0.07	0.07	0.04	0.28
Contracts	17	0.92	0.70	0.17	1.09	1.01	0.77	0.18	1.29
Equipment									
Miscellaneous / Other	7	0.03	0.01	0.00	0.02	0.04	0.02	0.00	0.02
Administrative									
Payroll, Taxes, Fringes	16	0.66	0.78	0.53	0.98	0.72	0.80	0.57	1.17
Management	16	0.39	0.14	0.03	0.26	0.44	0.15	0.03	0.28

Fees										Fees									
Professional Fees	9	0.03	0.02	0.02	0.04	0.03	0.02	0.02	0.04	Professional Fees	15	0.01	0.01	0.01	0.03	0.02	0.01	0.01	0.03
General Office Expenses										General Office Expenses	6	0.20	0.21	0.16	0.22	0.20	0.22	0.16	0.22
Employee Expenses										Employee Expenses									
Miscellaneous / Other	12	0.22	0.29	0.12	0.37	0.23	0.34	0.12	0.41	Miscellaneous / Other	17	0.29	0.16	0.12	0.37	0.32	0.19	0.13	0.42
Fixed										***Fixed***									
Real Estate Taxes	5	4.04	3.77	2.01	6.88	4.23	3.77	2.01	6.96	Real Estate Taxes	7	6.62	5.86	5.77	7.08	6.69	5.86	5.77	7.16
Personal Property Tax										Personal Property Tax									
Other Tax	8	4.64	4.51	3.60	5.04	5.16	5.30	4.36	5.50	Other Tax	12	3.70	4.16	3.35	5.24	4.22	5.03	4.16	5.81
Building Insurance										Building Insurance	6	0.36	0.29	0.24	0.62	0.37	0.30	0.24	0.62
License / Fees / Permits										License / Fees / Permits									
Directly Expensed Leasing										***Directly Expensed Leasing***									
Payroll										Payroll									
Commissions / Fees										Commissions / Fees									
Advertising / Promotion										Advertising / Promotion									
Professional Fees										Professional Fees	6	0.10	0.01	0.00	0.09	0.11	0.01	0.00	0.09
Tenant Improvements										Tenant Improvements									
Other Leasing Costs										Other Leasing Costs									
Amortized Leasing										***Amortized Leasing***									
Commissions / Fees										Commissions / Fees									
Tenant Improvements										Tenant Improvements									
Other Leasing Costs										Other Leasing Costs									
Parking										***Parking***									
In-house										In-house									
Contract										Contract									
Snow										Snow									

Removal		Removal	
Shuttle		Shuttle	

Montreal Government Buildings

Experience Exchange Report ®

Report Year: 2009
Country: Canada
Market: Montreal, PQ
Zip Code: All Zip Codes
% Gov't Tenants: All Occupancy Ranges
Sector: Government
Building Type: All Building Types
Ownership Type: All Types
Number of Floors: All Heights
% 24/7 Tenants: All Occupancy Ranges
Building Size: All Sizes
Public Transit: Any Proximity
All Electric: Any
Agency Managed: Any
% Pvt. Tenants: All Occupancy Ranges
Unit of Measure: Square Feet
Location: All Locations
Building Age: All Ages

Occupancy Summary - 2009			Occupancy Summary - 2008		
Occupancy Info.	*# Blds*	*Avg*	**Occupancy Info.**	*# Blds*	*Avg*
SQFT per Office Tenant	8	12,153.95	SQFT per Office Tenant	14	15,455.67
SQFT per Retail Tenant			SQFT per Retail Tenant		
SQFT per Office Worker			SQFT per Office Worker		
SQFT per Maintenance Staff			SQFT per Maintenance Staff		
Office Occupancy (%)	8	98.16	Office Occupancy (%)	14	97.60
Retail Occupancy (%)			Retail Occupancy (%)		
YR-End Rent ($ per SQFT)			YR-End Rent ($ per SQFT)		
Gross Parking INC per Stall ($)			Gross Parking INC per Stall ($)		
Parking Ratio (Stalls per 1000 SQFT)	7	0.50	Parking Ratio (Stalls per 1000 SQFT)	11	0.22
Rentable per Gross SQFT	7	0.49	Rentable per Gross SQFT	13	0.57
Rentable per Usable SQFT	7	0.81	Rentable per Usable SQFT	13	1.00
Total BTUs			Total BTUs		
Capitalization Threshold ($)			Capitalization Threshold ($)		
Building Hours	8	83.25	Building Hours	11	94.80

Income and Expense Overview - 2009

	Total Building Rentable Area					Total Office Rentable Area			
	8 Blds	2,283,839 Sq. Ft.				2,055,341 Sq. Ft.			
		Dollars/S.F.		**Mid Range**		**Dollars/S.F.**		**Mid Range**	
	# Blds	*Avg*	*Mdn*	*Low*	*High*	*Avg*	*Mdn*	*Low*	*High*
Expense									
Total Oper Exp	7	11.17	11.80	10.79	12.21	12.37	13.44	12.58	14.22
Total Oper + Fixed	7	15.82	16.22	15.13	16.61	17.52	18.89	17.08	19.52

Income and Expense Overview - Trend Data 2008

	Total Building Rentable Area					Total Office Rentable Area			
	14 Blds	4,988,073 Sq. Ft.				4,275,759 Sq. Ft.			
		Dollars/S.F.		**Mid Range**		**Dollars/S.F.**		**Mid Range**	
	# Blds	*Avg*	*Mdn*	*Low*	*High*	*Avg*	*Mdn*	*Low*	*High*
Income									
Total Rental Income									
Total Income	13	22.05	21.37	20.28	24.47	25.56	25.02	22.96	28.68
Expense									
Total Oper Exp	10	9.40	9.37	8.75	11.02	10.89	11.74	10.11	13.76
Total Oper + Fixed	11	13.72	13.88	12.88	16.76	15.91	16.82	14.68	20.84

Income and Expense Summary - 2009

	# Blds	Avg	Mdn	Low	High	Avg	Mdn	Low	High
Income									
Office Rent									
Retail Rent									
Other Rent									
Telecom Income									
Miscellaneous Income									
Expense									
Cleaning	8	1.26	1.60	1.05	1.95	1.38	1.66	1.25	2.16
Repair / Maintenance									
Utility									
Roads / Grounds	6	0.10	0.15	0.02	0.37	0.12	0.19	0.02	0.52
Security	8	1.21	0.81	0.33	1.37	1.34	0.88	0.42	1.65
Administrative	8	1.39	2.01	1.50	2.48	1.55	2.39	1.82	2.69
Fixed	8	4.64	4.51	3.60	5.04	5.16	5.30	4.36	5.50
Directly Expensed	6	0.35	0.26	0.01	0.81	0.42	0.32	0.02	0.94
Amortized Leasing									
Parking									
Telecom									

Income and Expense Summary - Trend Data 2008

	# Blds	Avg	Mdn	Low	High	Avg	Mdn	Low	High
Income									
Office Rent									
Retail Rent									
Other Rent									
Telecom Income									
Miscellaneous Income									
Expense									
Cleaning	13	1.42	1.51	1.13	1.87	1.59	1.65	1.34	2.36
Repair / Maintenance	6	2.99	3.34	2.41	3.47	3.31	3.68	2.81	4.14
Utility	13	2.58	2.68	2.48	3.06	2.88	3.09	2.86	3.53
Roads / Grounds	11	0.17	0.12	0.02	0.38	0.20	0.13	0.02	0.53
Security	13	1.11	0.93	0.22	1.47	1.29	1.04	0.23	1.95
Administrative	14	0.87	1.24	0.73	1.70	1.01	1.24	0.92	1.87
Fixed	14	4.96	4.41	3.95	5.60	5.79	5.26	4.95	6.24
Directly Expensed									
Amortized Leasing									
Parking									
Telecom									

Income and Expense Detail - 2009

	Total Building Rentable Area					Total Office Rentable Area			
		Dollars/S.F.		Mid Range		Dollars/S.F.		Mid Range	
	# Blds	Avg	Mdn	Low	High	Avg	Mdn	Low	High
Income									
Office Rent									
Base Rent									
Pass Throughs									
Escalations									
Lease Cancellations									
Rent Abatements (-)									
Telecom Income									
Rooftop Income									
Wire/Riser Access Income									
Miscellaneous Income									
Gross Parking Income									
Tenant Service Income									
Other Misc. Income									
Expense									
Cleaning									
Payroll, Taxes, Fringes									
Routine Contracts	8	1.22	1.52	1.00	1.90	1.33	1.62	1.20	2.06
Window Washing									
Other Specialized									

Income and Expense Detail - Trend Data 2008

	Total Building Rentable Area					Total Office Rentable Area			
		Dollars/S.F.		Mid Range		Dollars/S.F.		Mid Range	
	# Blds	Avg	Mdn	Low	High	Avg	Mdn	Low	High
Income									
Office Rent									
Base Rent									
Pass Throughs									
Escalations									
Lease Cancellations									
Rent Abatements (-)									
Telecom Income									
Rooftop Income									
Wire/Riser Access Income									
Miscellaneous Income									
Gross Parking Income									
Tenant Service Income									
Other Misc. Income									
Expense									
Cleaning									
Payroll, Taxes, Fringes									
Routine Contracts	13	1.38	1.46	1.09	1.83	1.54	1.61	1.29	2.31
Window Washing									
Other Specialized									

Contracts									
Supplies / Materials									
Trash Removal / Recycling	7	0.05	0.05	0.04	0.06	0.05	0.05	0.04	0.07
Miscellaneous / Other									
Repair / Maintenance									
Payroll, Taxes, Fringes	8	1.53	1.48	1.09	1.71	1.68	1.72	1.22	2.13
Elevator	7	0.11	0.14	0.07	0.17	0.12	0.17	0.08	0.20
HVAC	8	0.93	0.89	0.38	1.06	1.02	0.97	0.46	1.26
Electrical	6	0.22	0.21	0.09	0.31	0.24	0.23	0.11	0.31
Structural / Roofing									
Plumbing	7	0.16	0.06	0.04	0.22	0.18	0.08	0.05	0.23
Fire / Life Safety	8	0.16	0.17	0.08	0.23	0.18	0.18	0.10	0.27
General Building Interior	8	1.19	1.33	1.03	1.63	1.31	1.45	1.19	1.92
General Building Exterior	7	0.23	0.28	0.09	0.53	0.25	0.33	0.10	0.63
Parking Lot									
Miscellaneous / Other	6	0.35	0.43	0.07	0.47	0.38	0.46	0.07	0.66
Utility									
HVAC Electricity	8	0.07	0.07	0.06	0.07	2.06	2.23	1.84	2.53
Non - HVAC Electricity									
Gas	7	0.03	0.02	0.02	0.03	0.90	0.84	0.69	1.48
Fuel Oil	6	0.00	0.00	0.00	0.01	0.02	0.01	0.01	0.03
Steam									
Chilled Water									
Water / Sewer									
Roads / Grounds									
Landscaping									
Snow Removal									

Contracts									
Supplies / Materials									
Trash Removal / Recycling	13	0.04	0.04	0.03	0.05	0.04	0.04	0.03	0.06
Miscellaneous / Other									
Repair / Maintenance									
Payroll, Taxes, Fringes	13	1.01	1.34	0.84	1.66	1.13	1.56	0.84	2.00
Elevator	12	0.15	0.14	0.09	0.19	0.17	0.16	0.09	0.22
HVAC	13	0.56	0.56	0.45	0.95	0.63	0.60	0.54	1.07
Electrical	11	0.22	0.22	0.18	0.28	0.25	0.24	0.21	0.34
Structural / Roofing	6	0.08	0.04	0.03	0.08	0.09	0.04	0.03	0.10
Plumbing	13	0.46	0.06	0.03	0.14	0.51	0.06	0.04	0.17
Fire / Life Safety	13	0.18	0.17	0.10	0.25	0.21	0.21	0.12	0.27
General Building Interior	14	1.25	1.35	0.77	1.82	1.39	1.49	0.90	2.09
General Building Exterior	10	0.20	0.15	0.03	0.46	0.22	0.18	0.03	0.50
Parking Lot									
Miscellaneous / Other	12	0.18	0.07	0.03	0.24	0.20	0.08	0.03	0.28
Utility									
HVAC Electricity	13	1.94	1.89	1.82	2.22	2.17	2.23	2.13	2.35
Non - HVAC Electricity									
Gas	12	0.53	0.59	0.51	0.86	0.60	0.69	0.54	0.97
Fuel Oil	10	0.01	0.01	0.00	0.02	0.02	0.01	0.01	0.02
Steam									
Chilled Water									
Water / Sewer	8	0.11	0.19	0.04	0.28	0.13	0.22	0.05	0.33
Roads / Grounds									
Landscaping									
Snow Removal									

Miscellaneous / Other									
Security									
Payroll, Taxes, Fringes									
Contracts	8	1.15	0.79	0.18	1.37	1.28	0.84	0.23	1.65
Equipment									
Miscellaneous / Other	7	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.01
Administrative									
Payroll, Taxes, Fringes	8	0.84	1.05	0.92	1.25	0.93	1.29	1.15	1.39
Management Fees	7	0.41	0.57	0.56	0.57	0.45	0.66	0.61	0.70
Professional Fees	7	0.02	0.02	0.01	0.02	0.02	0.02	0.01	0.02
General Office Expenses									
Employee Expenses									
Miscellaneous / Other	8	0.21	0.29	0.16	0.50	0.24	0.34	0.18	0.54
Fixed									
Real Estate Taxes									
Personal Property Tax									
Other Tax	8	4.64	4.51	3.60	5.04	5.16	5.30	4.36	5.50
Building Insurance									
License / Fees / Permits									
Directly Expensed Leasing									
Payroll									
Commissions / Fees									
Advertising / Promotion									
Professional Fees									
Tenant Improvements									

Miscellaneous / Other	9	0.18	0.19	0.01	0.38	0.21	0.21	0.02	0.53
Security									
Payroll, Taxes, Fringes	6	0.06	0.06	0.04	0.24	0.07	0.07	0.04	0.28
Contracts	13	1.06	0.76	0.12	1.30	1.23	0.89	0.14	1.63
Equipment									
Miscellaneous / Other	6	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.02
Administrative									
Payroll, Taxes, Fringes	13	0.60	0.78	0.50	1.08	0.70	0.89	0.56	1.21
Management Fees	13	0.15	0.08	0.03	0.14	0.18	0.09	0.03	0.18
Professional Fees	12	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
General Office Expenses									
Employee Expenses									
Miscellaneous / Other	14	0.15	0.15	0.13	0.28	0.17	0.17	0.14	0.33
Fixed									
Real Estate Taxes									
Personal Property Tax									
Other Tax	11	4.77	4.26	3.76	5.24	5.68	5.06	4.65	5.81
Building Insurance									
License / Fees / Permits									
Directly Expensed Leasing									
Payroll									
Commissions / Fees									
Advertising / Promotion									
Professional Fees									
Tenant Improvements									

Other Leasing Costs		Other Leasing Costs	
Amortized Leasing		***Amortized Leasing***	
Commissions / Fees		Commissions / Fees	
Tenant Improvements		Tenant Improvements	
Other Leasing Costs		Other Leasing Costs	
Parking		***Parking***	
In-house		In-house	
Contract		Contract	
Snow Removal		Snow Removal	
Shuttle		Shuttle	

Occupancy Summary - 2009

Occupancy Info.	*# Blds*	*Avg*
SQFT per Office Tenant		
SQFT per Retail Tenant		
SQFT per Office Worker		
SQFT per Maintenance Staff		
Office Occupancy (%)	5	88.53
Retail Occupancy (%)		
YR-End Rent ($ per SQFT)		
Gross Parking INC per Stall ($)		
Parking Ratio (Stalls per 1000 SQFT)		
Rentable per Gross SQFT		
Rentable per Usable SQFT		
Total BTUs		
Capitalization Threshold ($)		
Building Hours		

Occupancy Summary - 2008

Occupancy Info.	*# Blds*	*Avg*
SQFT per Office Tenant		
SQFT per Retail Tenant		
SQFT per Office Worker		
SQFT per Maintenance Staff		
Office Occupancy (%)		
Retail Occupancy (%)		
YR-End Rent ($ per SQFT)		
Gross Parking INC per Stall ($)		
Parking Ratio (Stalls per 1000 SQFT)		
Rentable per Gross SQFT		
Rentable per Usable SQFT		
Total BTUs		
Capitalization Threshold ($)		
Building Hours		

Montreal Private Buildings

Experience Exchange Report ®

Report Year:	2009	**Sector:**	Private	**Building Size:**	All Sizes	**Unit of Measure:**	Square Feet
Country:	Canada	**Building Type:**	All Building Types	**Public Transit:**	Any Proximity	**Location:**	All Locations
Market:	Montreal, PQ	**Ownership Type:**	All Types	**All Electric:**	Any	**Building Age:**	All Ages
Zip Code:	All Zip Codes	**Number of Floors:**	All Heights	**Agency Managed:**	Any		
% Gov't Tenants:	All Occupancy Ranges	**% 24/7 Tenants:**	All Occupancy Ranges	**% Pvt. Tenants:**	All Occupancy Ranges		

Income and Expense Overview - 2009

	Total Building Rentable Area					Total Office Rentable Area			
	5 Blds	5,594,903 Sq. Ft.				5,345,993 Sq. Ft.			
		Dollars/S.F.		Mid Range		Dollars/S.F.		Mid Range	
	# Blds	*Avg*	*Mdn*	*Low*	*High*	*Avg*	*Mdn*	*Low*	*High*
Income									
Total Income									
Total Rental Income									
Expense									
Total Oper + Fixed Exp									
Total Oper Exp									

Income and Expense Overview - Trend Data 2008

	Total Building Rentable Area					Total Office Rentable Area			
	4 Blds	3,100,569 Sq. Ft.				3,062,466 Sq. Ft.			
		Dollars/S.F.		Mid Range		Dollars/S.F.		Mid Range	
	# Blds	*Avg*	*Mdn*	*Low*	*High*	*Avg*	*Mdn*	*Low*	*High*
Income									
Total Income									
Total Rental Income									
Expense									
Total Oper + Fixed Exp									
Total Oper Exp									

Income and Expense Summary - 2009

Income and Expense Summary - Trend Data 2008

Income									
Office Rent									
Retail Rent									
Other Rent									
Telecom Income									
Miscellaneous Income									
Expense									
Cleaning									
Repair / Maintenance									
Utility									
Roads / Grounds									
Security	5	0.45	0.68	0.65	0.80	0.47	0.68	0.66	0.80
Administrative									
Fixed	5	4.13	3.77	2.61	7.14	4.32	3.77	2.61	7.22
Directly Expensed Leasing									
Amortized Leasing									
Parking									
Telecom									

Income		
Office Rent		
Retail Rent		
Other Rent		
Telecom Income		
Miscellaneous Income		
Expense		
Cleaning		
Repair / Maintenance		
Utility		
Roads / Grounds		
Security		
Administrative		
Fixed		
Directly Expensed Leasing		
Amortized Leasing		
Parking		
Telecom		

Income and Expense Detail - 2009

	Total Building Rentable Area					Total Office Rentable Area			
		Dollars/S.F.		Mid Range		Dollars/S.F.		Mid Range	
	# Blds	*Avg*	*Mdn*	*Low*	*High*	*Avg*	*Mdn*	*Low*	*High*
Income									
Office Rent									

Income and Expense Detail - Trend Data 2008

	Total Building Rentable Area					Total Office Rentable Area			
		Dollars/S.F.		Mid Range		Dollars/S.F.		Mid Range	
	# Blds	*Avg*	*Mdn*	*Low*	*High*	*Avg*	*Mdn*	*Low*	*High*
Income									
Office Rent									

Base Rent									
Pass Throughs									
Escalations									
Lease Cancellations									
Rent Abatements (-)									
Telecom Income									
Rooftop Income									
Wire/Riser Access Income									
Miscellaneous Income									
Gross Parking Income									
Tenant Service Income									
Other Misc. Income									
Expense									
Cleaning									
Payroll, Taxes, Fringes									
Routine Contracts	5	0.66	1.32	0.78	1.56	0.69	1.32	0.78	1.58
Window Washing									
Other Specialized Contracts									
Supplies / Materials									
Trash Removal / Recycling									
Miscellaneous / Other									
Repair / Maintenance									
Payroll, Taxes, Fringes									
Elevator									
HVAC	5	0.29	0.28	0.19	0.32	0.30	0.28	0.19	0.32
Electrical									
Structural /									

Base Rent		
Pass Throughs		
Escalations		
Lease Cancellations		
Rent Abatements (-)		
Telecom Income		
Rooftop Income		
Wire/Riser Access Income		
Miscellaneous Income		
Gross Parking Income		
Tenant Service Income		
Other Misc. Income		
Expense		
Cleaning		
Payroll, Taxes, Fringes		
Routine Contracts		
Window Washing		
Other Specialized Contracts		
Supplies / Materials		
Trash Removal / Recycling		
Miscellaneous / Other		
Repair / Maintenance		
Payroll, Taxes, Fringes		
Elevator		
HVAC		
Electrical		
Structural /		

Roofing	
Plumbing	
Fire / Life Safety	
General Building Interior	
General Building Exterior	
Parking Lot	
Miscellaneous / Other	
Utility	
HVAC Electricity	
Non - HVAC Electricity	
Gas	
Fuel Oil	
Steam	
Chilled Water	
Water / Sewer	
Roads / Grounds	
Landscaping	
Snow Removal	
Miscellaneous / Other	
Security	
Payroll, Taxes, Fringes	
Contracts	
Equipment	
Miscellaneous / Other	
Administrative	
Payroll, Taxes, Fringes	
Management Fees	
Professional Fees	
General Office Expenses	

Roofing	
Plumbing	
Fire / Life Safety	
General Building Interior	
General Building Exterior	
Parking Lot	
Miscellaneous / Other	
Utility	
HVAC Electricity	
Non - HVAC Electricity	
Gas	
Fuel Oil	
Steam	
Chilled Water	
Water / Sewer	
Roads / Grounds	
Landscaping	
Snow Removal	
Miscellaneous / Other	
Security	
Payroll, Taxes, Fringes	
Contracts	
Equipment	
Miscellaneous / Other	
Administrative	
Payroll, Taxes, Fringes	
Management Fees	
Professional Fees	
General Office Expenses	

Employee Expenses										Employee Expenses	
Miscellaneous / Other										Miscellaneous / Other	
Fixed										***Fixed***	
Real Estate Taxes	5	4.04	3.77	2.01	6.88	4.23	3.77	2.01	6.96	Real Estate Taxes	
Personal Property Tax										Personal Property Tax	
Other Tax										Other Tax	
Building Insurance										Building Insurance	
License / Fees / Permits										License / Fees / Permits	
Directly Expensed Leasing										***Directly Expensed Leasing***	
Payroll										Payroll	
Commissions / Fees										Commissions / Fees	
Advertising / Promotion										Advertising / Promotion	
Professional Fees										Professional Fees	
Tenant Improvements										Tenant Improvements	
Other Leasing Costs										Other Leasing Costs	
Amortized Leasing										***Amortized Leasing***	
Commissions / Fees										Commissions / Fees	
Tenant Improvements										Tenant Improvements	
Other Leasing Costs										Other Leasing Costs	
Parking										***Parking***	
In-house										In-house	
Contract										Contract	
Snow Removal										Snow Removal	
Shuttle										Shuttle	

APPENDIX (B) Questionnaires

ANNUAL MAINTENANCE & REPAIR EXPESNE

Building Information					
Address					
City					
Location	Downtown		Ownership	Private	
	Suburban			Government	
Height (stories)			Occupancy (%)		
Total Constructed Area (SQFT)				Age	
Annual Maintenance & Repair Expense Information					
Payroll, Taxes,			Elevator		
HVAC			Electrical		
Structural/ Roofing			Plumbing		
Fire/Life Safety			General Bld Exterior		
Parking Lot			General Bld Interior		
Miscellane ous/ Other					
Total Annual Income					
Notes					

Note: Please refer to the attached Definitions sheet for the above terms.

Saad Muhey
Department of Building, Civil, and Environment Engineering
Concordia University
1515 St. Catherine st. W.
Montreal, H3G 2W1

Definitions

Office Occupancy (%): It is the total occupied office square footage of the sample divided by the total office square footage.

Total Annual Income: It is the total of rental income, tenant service income, miscellaneous (non-rental) income and gross parking income.

Maintenance and Repair Expenses: It is the expenses for the general repairs and maintenance of a building including common areas and general upkeep. It includes both in-house payrolls for operating engineers and maintenance personnel and contracted services for elevator, HVAC, electrical, structural/roof, plumbing, fire and life safety expenses and other building maintenance and supplies.

APPENDIX (C)

PROPERTY CONDITION ASSESSMENT PCA

By

Inspec-Sol

Sep 2007

INSPEC-SOL
INGÉNIERIE ET SOLUTIONS

4010205 CANADA INC.
Level I Property Condition Assessment
Office Building
1425 René-Lévesque Boulevard West
Montreal, Quebec

Date: **July 23, 2007**	**Reference No: M021799-G1**

INSPEC·SOL
INGÉNIERIE ET SOLUTIONS

INSPEC-SOL INC. 4600, boul. de la Côte-Vertu, Montréal (Québec) H4S 1C7 • Tél. : (514) 333-5151 • Téléc. / Fax : (514) 333-4674 • SMQ ISO 9001 : 2000

Reference No. M021799-G1

July 23, 2007

Mr. Joseph Berger
4010205 Canada Inc.
1155 University Avenue, Suite 710
Montreal, Quebec
H3B 3A7

Re: Property Condition Assessment
Office Building
1425 René-Lévesque Boulevard West
Montreal, Quebec

Dear Mr. Berger:

In accordance with our Proposal No. PG-17324, dated June 29, 2007, we have completed a Level I Property Condition Assessment for the above-noted building and are pleased to present herewith our report.

We trust that this provides the required information. Should any additional questions arise, please do not hesitate to contact us.

Yours very truly,

INSPEC-SOL INC.

Myles A. Carter

Myles A. Carter, M.Sc., P.G.
Associate
Manager, Building Science Division

MAC/njb

Enclosures:

In duplicate (Copy by e-mail: jhberger2004@yahoo.ca) and mail

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EXECUTIVE SUMMARY
LEVEL I PROPERTY CONDITION ASSESSMENT
Office Building
1425 René-Lévesque Boulevard West
Montreal, Quebec

The services of Inspec-Sol Inc. (**Inspec-Sol**) were retained by Mr. Joe Berger (Client) to provide 4010205 Canada Inc. with a Level I Property Condition Assessment (PCA I) of an office building located at 1425 René-Lévesque Boulevard West in Montreal, Quebec (Site or Property).

Overall, the building was found to be in good condition with localised repairs required.

The following actions are required immediately:

- Fire extinguishers located in the basement require inspection.

The following further investigations are required:

- No further investigations are currently required.

The following further actions are required during regular building maintenance:

- Localised cracks repairs on the south-eastern exterior foundation wall.
- Cover to be replaced on a floor drain located in the basement slab.
- Localised surface degradation repairs to the concrete sidewalk.
- Replace the cover of an open electric box on the east elevation of roof Basin No. 1.
- Replacement of four (4) broken windowpanes noted on the west elevation of roof Basin No. 6.
- Sealing two (2) window openings located on the second floor of the north-western elevation currently enclosed with OSB (Oriented Strand Board) to improve the thermal performance of the envelope.
- Localised spalled brick repairs on the 12th floor south-western elevation.
- Sealing of a penetration into the wall of the west elevation of roof Basin No. 6 to prevent water infiltration.
- Repairs to localised cracks on the concrete sills of interior and exterior windows.

- Repairs or local replacement to corroded aluminium frames.
- Localised crack to the concrete sills of interior and exterior windows.
- Periodic roofing inspections.
- Repairs to a wall-mounted HID lamp located on the west elevation of the building missing the protective cover and bulb.

The following actions will be required over the investment horizon:

- Repairs to roof parapet in Year 1.
- Repairs to areas of localised spalled brick and re-pointing.
- Re-caulking around several south and east elevation window units.
- Repairs to the flashing surrounding the architectural elements on the exterior wall above the windows on the 10^{th}, 11^{th}, and 12^{th} floors. Repairs to the 12^{th} floor flashing are a priority.
- Repairs to roof Basin Nos. 5, 7, and 8.

Based upon the building assessment, a budget to correct deficiencies has been generated over the prescribed thirteen (13) year period:

Time Frame	***Estimated Capital Expenditure***
Immediate	**$0.00**
Year 1 to 13 (Uninflated)	**$73,500.00**
Year 1 to 13 (Inflated: 3% / year)	**$73,590.00**

Based on the reported leasable area of 181,793 ft^2, the cost per square foot per year will be as follows:

	Cost Per Square Foot Per Year
Uninflated	**$0.03**
Inflated (3% / year)	**$0.03**

1.0 INTRODUCTION

1.1 Scope of Work

The services of Inspec-Sol Inc. (**Inspec-Sol**) were retained by Mr. Joe Berger (Client), represented by with an assessment of the construction details, physical performance and attributes of the Property's systems (PCA I) for the building on Site.

The PCA I procedures and documentation have been carried out following ASTM E-2018-01: "Standard Guide for Property Condition Assessments" (Baseline Property Condition Assessment Process).

The American Society for Testing and Materials (ASTM) defines a physical deficiency as conspicuous defects or significant deferred maintenance of a subject property's material systems, components, or equipment as observed during the field observer's walkthrough survey. Included within this definition are issues affecting life-safety and material systems, components, or equipment that are approaching, have reached, or have exceeded their typical Expected Useful Life or which Remaining Useful Life should not be relied upon in view of actual or effective age, abuse, excessive wear and tear, exposure to the elements, lack of proper or routine maintenance, etc. This definition specifically excludes deficiencies that could be remedied with routine maintenance, miscellaneous minor repairs, normal operating maintenance, etc., and excludes conditions that generally do not constitute a material physical deficiency of the subject Property.

All of the reasonably accessible areas were examined during the on-Site inspections of the Property. Selected office floors (the 4th, 7th, and 11th floors) were inspected, although no photographs of the interior were allowed in some of the occupied tenant space. A typical mechanical floor was seen on the 4th floor. The commercial locale occupying the west side of the basement was closed and not accessible during the Site visit.

Our mandate did not include non-destructive or destructive testing, openings of roofing systems, wall assemblies or other enclosures, or testing of mechanical, electrical or life-safety systems. Our mandate did not include verification or engineering calculations of the building or component design.

The assessment of the electrical systems was strictly visual to determine the type of system, age and aesthetic condition. Operating conditions of the actual equipment were determined through interviews with Site contacts and maintenance personnel. No physical testing or intrusive investigative techniques were used.

It should be noted that the mandate did not include a review of the National Building and Fire Codes or compliance of the Property to these codes nor the assessment of the mechanical systems.

This report is not intended to address, or provide comment on, the presence or absence of organic growth organisms commonly referred to as mould, through statements, inferences or omissions.

The particular physical components of the Site which are addressed in this assessment are as follows:

Site Conditions

- Topography, Drainage, Paving, Flatwork, Landscaping, Decks and Terraces.
- Property Access and Egress, Recreational Facilities and Utilities.

Building Structure

- Foundations, Structural Steel and/or Concrete Frame.
- Slab-on-grade.

Building Envelope

- Exterior Walls.
- Windows, Doors, Loading Docks and Overhead Doors and Skylights.
- Balconies and Railings.
- Roofing Systems, Visible Waterproofing Membranes and Flashing Details.

Electrical and Mechanical Systems

- Main Heating and Ventilation Systems.
- Plumbing (domestic water supply and wastewater systems).
- Electrical (service entry, emergency power supply, and lighting systems).

Vertical Transportation

- Elevators and Escalators, Service Contractors.

Fire Protection and Alarm Systems

- Fire Suppression Systems (sprinklers, extinguishers and hose cabinets).
- Fire Alarm Systems (annunciator panels, flow detectors, smoke and heat detectors).

Interior Partitions

- Interior Surfaces (floors, walls and ceilings).
- Warehouse Partitions and Mitoyen Walls.

1.2 Out-of-Scope Issues

In the context of ASTM E-2018-01: "Standard Guide for Property Condition Assessments" (Baseline Property Condition Assessment Process), an Out-of-Scope Issue is defined as "Any aspect of the condition of the subject building that cannot be readily ascertained during a walkthrough investigation." Any barriers that prevent or limit the direct and continuous visual observation of a system or item will render the item Out of Scope (see Section No. 3.0 – Limitations, and Appendix III – Out-of-Scope Issues).

1.3 Definition of Terms

The following terms and their respective definitions will be used to describe the condition of the building systems:

- Excellent: The system or equipment was found to be in new or nearly new condition with no deficiencies or damages.
- Good: The system or equipment was found to be in satisfactory condition with no recommendations for repairs or improvements.
- Fair: The system or equipment was found to be in satisfactory condition with recommendations to correct minor deficiencies. May indicate that immediate attention is required to minor deficiencies.
- Poor: The system or equipment was found to be in unsatisfactory condition and must be replaced or repaired in the short term.

The following terms are commonly used in a Property Condition Assessment (PCA) to describe the state of the building and the appropriate maintenance strategies for the required repairs:

- Walkthrough Investigation — Non-intrusive, visual observations of the subject Property and survey of readily accessible, easily visible components and systems of the subject Property. A walkthrough investigation is not technically exhaustive, and excludes concealed physical deficiencies and other Out-of-Scope Issues. Observations of the building (exterior and interior) are limited to vantage points that are on-grade, from readily accessible balconies, rooftops, platforms, etc.

- Remaining Useful Life (RUL) — A subjective estimate of the number of remaining years that an item, component or system will be able to function in accordance with its intended purpose before warranting replacement.

- Expected Useful Life (EUL) — The average amount of time in years that an item, component or system is estimated to function when installed new and assuming routine maintenance is practised.

- Immediate Costs — Costs that will be incurred due to 1) existing or potential unsafe conditions, 2) fire hazards, 3) condition that, if left un-remedied, can result in a critical failure of a system within one year, or result in a significant escalation of remedial costs.

- Replacement Reserve Costs — Future budgetary recommendations for items, components or systems based on their respective Remaining Useful Life (RUL).

- Regular Building Maintenance — Maintenance that can be carried out by building staff without requiring specialised sub-contractors, equipment, or any significant interruptions to the building's use. These items will generally be of minor expense, and can often be carried out in phases over long periods of time.

Definitions of additional selected Building Science and maintenance terms can be found in the Glossary of Selected Terms included in Appendix IV.

1.4 Cost Estimates

The estimated costs associated with the deficiencies and conditions reported herein are presented in Appendix II: Replacement Reserve Cost Table. The term "Replacement Cost" as it pertains to the Replacement Reserve Cost Table, means the cost to replace defective elements of the building or to fully repair the deficient elements within a given building system.

Items that are deemed to be deficient, but not significant in terms of importance, cost or their effect on the overall building condition will be considered to lie within the scope of regular building maintenance. For the purpose of this report, any item having a cost estimate of less than $2,000.00 will be considered to be within the scope of regular building maintenance.

For the purpose of this report, and the accompanying Replacement Reserve Cost Table, the repair timetable will be divided into thirteen (13) time periods. All of the prices quoted are in Canadian, year-2007 dollars.

Cost estimates for repairs and system replacements presented in this report are not derived from quantity surveys or detailed engineering calculations. The costs and unit rates provided are based on the following information sources:

- Our experience with contractors specialising in the fields in question;
- Direct inquiries to service contractors involved with the Property; and

- Industry-accepted costing tools including, but not limited to, "Hanscomb's Yardsticks for Costing – Cost Data for the Canadian Construction Industry", published by the R.S. Means Company.

These estimates are intended only for global budgeting purposes; they should be used as a guide only, as costs may vary according to the time of year, quality of materials used, volume of work, actual Site conditions, etc. Note that the estimates do not include applicable taxes.

Actual costs for work can only be determined after preparing specifications and tender documents, understanding Site restrictions that may impact work, and establishing a construction schedule.

The range of prices for the roofing, where applicable, depends on various factors, such as the condition of the insulation and the correction of the slopes for drainage. Also, increasing the number of roof sections (splitting a large roof into smaller sections is recommended) could extend the time frame for the re-roofing program. Prices are estimated assuming that each section is repaired (or re-roofed) alone; hence, the estimation could decrease when work is for more than one section at a time. Furthermore, the estimates are based on the replacement of a given roofing system with an equivalent system; thus, the estimation could vary significantly if upgrades are implemented, such as increasing the thickness of the insulation or using an alternative membrane. The implementation of a regular maintenance program could also extend the service life of the roof and delay the proposed schedule.

The range of estimated costs for asphalt repairs, where applicable, depends on whether the granular foundation should be upgraded or reconstructed and if additional drainage is needed. Since shallow boreholes or other testing such as sieve analyses, etc., have not been carried out, the asphalt repair assumes the sub-grade is acceptable and that only surface work is required.

2.0 LEVEL I PROPERTY CONDITION ASSESSMENT

2.1 Site Inspection

Observations of the Property and building were compiled and are presented hereafter. Construction drawings were not consulted. Selected photographs are enclosed in Appendix I.

Inspections for the current Level I Property Condition Assessment (PCA I) were conducted by **Inspec-Sol** qualified building science professionals. The purpose of the PCA I was to review and document all major building components and systems.

The visit for the building assessment was conducted on July 18, 2007, under partly cloudy conditions and an outdoor temperature of 22°C. The inspection was carried out by Siu Ming Wong, Eng. and Cherisse Vanloo, Jr.Eng, technical representatives of **Inspec-Sol**.

Inspec-Sol also undertook a concurrent Phase I Environmental Site Assessment (presented under separate cover as report Reference No. M021799-E1) on the Site for the Client.

Ms. Nancy Savard, Property Manager for ISCANCO, provided **Inspec-Sol** with building access and background information and guided the Site visit for the interior of the building.

2.2 Property

2.2.1 Description

The Site of the subject building is located on the north side of René-Lévesque Boulevard West in Montreal, Quebec, within the boundaries of Bishop Street to the east, Belmont Street to the south, and Mackay Street to the west. The subject building bears Civic Nos. 1425 René-Lévesque Boulevard West and 1158, 1160 and 1168 Bishop Street. The Site is legally described as Lot No. 1 341 121 in the Official Cadastre of Quebec in the Registration Division of Montreal. The Site is irregular in shape, covers an approximate area of 27,400 square feet and is located in an area developed for commercial use. The Site is relatively flat and level with René-Lévesque Boulevard West.

For the purpose of this report, it is assumed the building faces south onto René-Lévesque Boulevard West.

2.2.2 Seismic Data

Seismic data for Canadian cities is compiled by members of the Canadian National Committee on Earthquake Engineering (CNCEE). This data set consists of two (2) parameters: Zone Acceleration, Z (a), and Zone Velocity, Z (v).

Based on an on-going statistical analysis of this data set, as well as the known geological and tectonic information, the CNCEE uses this data to classify cities into Seismic Zones. Zone classifications range from zero (0), indicating the lowest risk of earthquake, to six (6), indicating the highest risk.

The Seismic Zone classifications are published in Appendix C (Climatic Information for Building Design in Canada) of the NRC - National Building Code of Canada, 1995. The Seismic Zone classifications for the subject Property are as follows:

Table No. 1
Seismic Zone Classification

City	Acceleration	Velocity
Region of Montreal, Quebec	Z(a) = 4	Z(v) = 2

As both figures are below Zone rating five (5), the preparation of a Probable Maximum Loss Analysis is not recommended.

2.2.3 Utilities

The public and private utilities that are supplied to the Property are detailed below:

Table No. 2
List of Public and Private Utilities

Utility	Supplier	Comments
Water	Municipal	None
Electricity	Hydro-Quebec	None
Natural Gas	Gaz Metropolitan	None
Sanitary Sewer	Municipal	None
Storm Sewer	Municipal	None
Other	N/A	

2.2.4 Site Conditions

General Description and Condition:

Topography: The Site is relatively flat and level with René-Lévesque Boulevard.

Storm Water Drainage: Storm water on the Property is collected and/or discharged by the following methods:

- Sloping of the property's improved surfaces (concrete-covered surfaces, flat roof basins) to collect precipitation for subsequent discharge into centralised drains and catch basins connected to the Municipal combined storm-wastewater drainage sewer systems.

It should be noted that no rain had fallen prior to the site assessment and we cannot comment on the efficacy of the surface drainage.

Vehicular Access and Egress: Vehicular access to the lane giving access to the delivery area on the north-western corner of the building is from Mackay Street.

Paving, Curbing and Parking: There is an asphalt-covered access lane at the rear of the building. Only a 150 square foot section of this lane is on the building property.

Flatwork: Poured concrete sidewalks are located along the north and east sides of the Site.

Landscaping and Appurtenances: There are no landscaped areas on the Property. The building is annexed to buildings on north and west elevations.

Recreational Facilities: There are no recreational facilities on the Property.

Observations and Recommendations:

1. At the time of the assessment, the asphalt-covered access lane area appeared to be in good condition.
2. Minor surfaces deficiencies were noted in the concrete sidewalk. The localised surface degradation was noted on the concrete sidewalk and should be repaired during regular building maintenance.

2.3 *Building Conditions*

The building structure was visually examined, where possible, during a walkthrough inspection. The structural components (columns, joists, etc.) were randomly inspected to assess the overall condition. Original architectural and structural drawings were not consulted to verify or analyse design loads or design details.

2.3.1 *Building Description*

The subject building is a twelve-storey multi-tenant commercial building, with a basement. The basement covers the entire building and extends underneath the laneway located along the back (north-west side) of the building. According to Ms. Savard, historically the north end of this basement projection was connected to a neighbouring building located on the opposite side of the laneway. There is a laneway located along the north-west side of the building. According to information supplied by the City of Montreal, the subject building was constructed in 1930. The building covers approximately 100% of the Property, which represents an approximate area of 2,500 m^2 (27,400 ft^2). The total Gross Leaseable Area (GLA) is reported to be 181,793 ft^2.

2.3.2 *Structure*

The building's structure was visually examined, where visible, during a walkthrough inspection. Original architectural and structural drawings were not consulted to verify or analyse design loads or design details.

2.3.2.1 *Foundations*

General Description and Condition:

The foundation walls are constructed of cast-in-place concrete. The concrete foundation walls were visible around the perimeter of the building between grade level and the bottom of the exterior cladding.

Observations and Recommendations:

1. At the time of our assessment, Ms. Savard reported a flood in 2006 in the north section of the building's basement, part of which is located underneath the laneway. Ms. Savard reported that repairs conducted in 2005 and 2006 to the affected basement area included removal of the water, and crack injection into the basement foundation walls. Previous water damage was noted on the foundation walls.
2. Localised cracks were noted on the south - exterior foundation wall. Repairs should be done as part of regular building maintenance.

2.3.2.2 Frame

General Description and Condition:

The subject building is constructed primarily of reinforced concrete with sections of structural steel. In most areas, the structure was hidden behind interior finishes and therefore not available for direct observation. It should be noted that the type of structure in the four-storey annex was not observed due to the finishes.

Observations and Recommendations:

1. At the time of our assessment, there were no significant cracks or obvious deformations transferred to the interior finishes noted (including floors, walls and ceilings) that would indicate significant or ongoing structural movement. The visible portions of the structure in the north-western basement area of the building appeared had injection ports still in place from the aforementioned crack injections in 2005 and 2006.

2.3.2.3 Slab-on-Grade

General Description and Condition:

The slab-on-grade was visible throughout the building's basement area. The minor cracks noted in the concrete slabs appear to be due to long-term dry shrinkage over the early life of the building.

Cracking of a slab-on-grade may be due to long-term dry shrinkage over the early life of the building, the nature of the granular base, the type of in-situ soils or loading conditions, the manner in which it was installed or reinforced (if at all), and/or the location of the control joint grid pattern.

Observations and Recommendations:

1. Generally, the slab-on-grade appeared to be in good condition with no significant cracking or associated heaving. No serious defects that would imply a problem with groundwater or unstable soil conditions were noted.
2. A floor drain located in the basement slab was not covered, although the opening has construction pylons around its perimeter, it poses as a safety hazard. The grill should be replaced as part of regular building maintenance.

2.3.3 Building Envelope

2.3.3.1 Exterior Walls

General Description and Condition:

The exterior walls are finished with red clay brick with two full-height glass atriums on the front elevation. Architectural elements covered with metal sheeting are located on the top portion of the front (south) elevations. Generally, the masonry cladding and the glass atriums were found to be in good to fair condition.

Observations and Recommendations:

1. Localised spalled brick was noted on the 12th floor south-western elevation. This repair work should be done as a part of regular building maintenance.
2. Anchors were noted on the roof supporting the parapet brick wall on the north-eastern section of the roof. Bulging of the parapet brick wall was noted on the south-eastern section of the roof. At the time of our visit, deteriorated mortar joints and loose bricks were noted on the parapet brick walls. This is a potential falling hazard, as the parapet walls are directly above public access ways, re-pointing of the parapet walls should be prioritise for public safety. A quote for these repairs to the loose mortar joints located on the roof and brick was provided by *Reparation de Beton Duraseal* and has been included in Appendix It should be stressed that these repairs should be done within the current construction season. The cost estimate provided is not a detailed work specification and as such, **Inspec-Sol** cannot verify that the proposed work will address all of the above-mentioned deficiencies.
3. Re-pointing is required to the exterior brick wall at the entrance of 1160 Bishop on the east elevation. This repair should be done in Year 1.

4. Localised efflorescence and localised brick spalling was noted on the 4th floor of the west elevation. These repairs should be done in Year 1.
5. Localised cracks were noted on the concrete sills of interior and exterior windows. These repairs can be done during regular building maintenance.
6. Corroded aluminium frames were noted along the base perimeter of the glass vestibule entrance frame. Repairs or local replacement to these frames should be done as part of regular building maintenance.
7. A penetration into the wall of the west elevation of roof Basin No. 6 should be sealed to prevent water infiltration, and be conducted as part of regular building maintenance.
8. Repairs are required to the flashing surrounding the architectural elements on the exterior wall above the windows on the 10th, 11th, and 12th floors on the south, east, and west elevations. Repairs to the 12th floor flashing are a priority and should be done in Year 1. In order to reduce mobilization costs, all repairs could be done in Year 1, or in future years at an additional cost.

2.3.3.2 Windows and Doors

General Description and Condition:

The glazing, over the entire building is single and double-paned fixed IGU's (Insulated Glass Units) mounted in metal frames. Units that were spot-checked were noted to have stamped manufacturing dates of 1980 and 1981. The window units appeared to be in good condition when examined. The windows were examined for condensation or rust in the air spaces between the glazing, which would indicate possible broken seals. The caulking and gaskets around the glazing and window frames was noted to be generally in good to fair condition.

The main building entrance is located on the south and east elevations of the building. These entrances have glass doors with metal frames. There are also metal man-doors with metal frames leading to the access lane on the south elevations that are used for emergency exits and merchandise delivery. The glass and exterior metal man-doors were noted to be in good condition.

Observations and Recommendations:

The following conditions were noted:

1. Four (4) broken windowpanes were noted on the west elevation of roof Basin No. 6 and should be replaced as part of regular building maintenance.
2. Displaced window frames were noted on the north side of the east elevation.

3. At the time of the assessment, the caulking around several of the south and east elevation window units had deteriorated and pulled away from the frame. These sections should be re-caulked to prevent water infiltration. These repairs should be carried out during regular building maintenance.
4. Two (2) window openings located on the second floor of the north-western elevation were enclosed with OSB (Oriented Strand Board). These windows should be properly sealed or have the windowpanes replaced to improve the thermal performance of the envelope. This repair should be carried out during regular building maintenance.

2.3.3.3 Balconies

There are no balconies, decks or terraces on the Property.

2.3.3.4 Loading Docks and Doors

There are no loading docks or door on the Property.

2.3.3.5 Roofing

General Description and Condition:

The roof consists of nine (9) basins on three (3) levels and is accessed from the interior of the building. The roof assembly consists of conventional multi-ply asphalt and modified bitumen-roofing systems. The roof basin layout is included in the appendices.

This type of roofing system generally has an Expected Useful Life of 20 years, depending on the quality of the installation, materials and roofing maintenance program. Based on our observations, the roof was in good to fair condition, with some minor deficiencies. The Remaining Useful Life of the subject roof is estimated to be approximately 10 years to 20 years, assuming on-going yearly maintenance and repairs are carried out.

Observations and Recommendations:

1. A rusted cap flashing was noted on the west side of the building. This should be repaired as part of regular building maintenance.
2. Evidence of previous water infiltration was noted on the ceiling in the elevator room. There is no report of current water infiltration.

3. No deficiencies were reported for Basin Nos. 1, 2, 3, 4, 6, and 9. Repairs to Basin No. 5 include re-sealing of the anchor legs around the atriums, drain cleaning, removal and proper sealing of an abandoned roof anchor.
4. At the time of the roof assessment, a depression was noted in Basin No 7 due to apparent weakness of the insulation below the membrane. This should be further investigated. Basin No.8 requires repair to a missing support at the base of the metal stairs. See table below for outline of repair and re-roofing costs.

Table No. 3
Roof Repair and Re-Roofing Costs

Basin No.	Area (ft^2)	Remaining Service Life	Repair Cost	Re-Roofing Cost
1	360	20 years	$0.00	$0.00
2	80	20 years	$0.00	$0.00
3	240	20 years	$0.00	$0.00
4	950	20 years	$0.00	$0.00
5	15,550	15 years	$4,800.00	$0.00
6	400	+10 years	$0.00	$0.00
7	2,800	+10 years	$0.00	$0.00
8	3,700	+10 years	$1,000.00	$0.00
9	2,400	+10 years	$0.00	$0.00

All roof basins have Remaining Useful Lives which extent beyond the ten (10) year time period.

As part of regular building maintenance, a qualified roofing inspector should make periodic checks.

2.4 Electrical and Mechanical Systems

The building electrical and mechanical systems were visually examined, where possible, during the walkthrough inspection. The system components were randomly reviewed to assess their overall condition. Information concerning capacity, adequacy, efficiency and condition of the electrical and mechanical systems, where possible, was obtained through interviews with the service contractors, tenants, owners or their representatives and building management.

2.4.1 Electrical Systems

General Description and Condition:

Main Service: The main electrical entrance as supplied by Hydro-Quebec is rated to provide 600V at 400A. A 2000 kVA, dry-type transformer steps down a portion of the supplied power to 347V to accommodate all of the lighting and heating in the building.

Metering: The power is metered at the main panels only.

Distribution: A vertical bus duct distributes power to individual electrical rooms on each floor. Each of these electrical rooms is equipped with panels rated at 600V/200A and 30 kVA dry-type transformers.

Interior Lighting: Conventional 120V fluorescent lighting fixtures provide the office spaces. 240V and 120V fluorescent lighting fixtures provided lighting for the office and common areas.

Exterior Lighting: Several wall-mounted HID (High Intensity Discharge) lamps provide the exterior lighting. As the visit was carried out during daytime, the efficiency of this lighting could not be assessed.

Emergency Generators: Emergency power to the building is provided by a diesel generator, which was found to be in good condition. There is an ongoing service contract in place with *Lagden Equipment Services Inc.* to maintain the generator.

Emergency Lighting: There are local battery-powered lighting units providing temporary emergency lighting in various areas of the building.

Observations and Recommendations:

1. At the time of the investigation, no deficiencies with respect to power supply were reported.
2. An electric box located on the east elevation of roof Basin No. 1 is missing a protective cover. This repair should be done as part of regular building maintenance.

3. A wall-mounted HID lamp located on the west elevation of the building was missing the protective cover and bulb. This should be repaired as part of regular building maintenance.
4. Mr. Glenn Lagden of Lagden Equipment Services Inc. reported that the generator was last inspected in April 2007 and was in good working condition.

2.4.2 Heating, Ventilating and Air-Conditioning (HVAC)

General Description and Condition:

Heating: Local electric baseboards located on the perimeter of the building provide heating. A few electrical duct heaters are used in the forced-air system to supplement the heating.

Cooling: The cooling operation is accomplished using a split-system evaporator on each floor, all of which are linked to two (2) cooling towers on the roof. There are additional rooftop HVAC units serving tenants in the four-storey annex who require additional cooling. Ms. Savard reported that three (3) 7.5 tons units are located on each office floor.

Ventilation: Individual forced air units distribute the air.

Observations and Recommendations:

1. It was reported that *Kolostat* conducts on-call servicing of the mechanical equipment.
2. Currently, building personnel carries out the regular replacement of filters and drive-belts. Ms. Savard reported that a new air conditioning unit was installed on the west wing of the 7^{th} floor in November 2005.
3. Mr. Yanick Caplette of *Kolostat* reported that all mechanical equipment was found to be in good condition and no major renovations are necessary.

2.4.3 Plumbing

2.4.3.1 Distribution

General Description and Condition:

Distribution: The municipally treated distribution network supplies domestic water.

Drainage: The domestic wastewater for the building is discharged to the municipal sewer, which is separate from the storm sewer.

Domestic Hot Water: Two (2) natural gas hot water tanks are located in the basement supply the domestic hot water to the tenants and common washrooms. No information is available on the make and model of these units.

Observations and Recommendations:

1. Random verification of fixtures, valves and water pressure revealed that the plumbing system appears to two water fountains located in the basement were not functioning. Ms. Savard reported no significant deficiencies at the time of our visit.

2.5 Vertical Transportation

There are three (3) passenger elevators and two (2) freight elevators present in the building. All of these elevators are cable driven. The passenger elevators and one of the freight elevators run the full height of the building. One escalator is located on the ground floor leading to the basement. The remaining freight elevator only serves the first four (4) floors. The elevators are inspected and serviced monthly under an ongoing contract with *Koné Quebec Inc.*

Observations and Recommendations:

1. The elevator appeared to be in good condition at the time of the assessment. At the time of the preparation of this report, no information from *Koné Quebec Inc.* pertaining to the maintenance of the elevators was available.
2. It was noted that the escalator has not been functional for eight (8) years. Ms. Savard noted that the escalator would be removed during future renovations.

2.6 Fire Protection and Alarm Systems

General Description and Condition:

Sprinkler Systems: A wet sprinkler system and standpipe with a Siamese connection protect the subject building. The sprinkler room is centrally located in the basement with pressure alarms on each floor.

Fire Extinguishers: The fire extinguishers and hoses are located on every floor within the common areas. Those inspected at random were found to have inspection tags, as placed by Globe Fire Equipment Inc., dated October 2006 and March 2005.

Fire Alarm Systems: The fire alarm system consisting of smoke detectors in HVAC ducts, pull-stations, hose cabinets, emergency phones and alarm bells. The fire alarm system is services by Stanex.

Observations and Recommendations:

1. The sprinkler system is maintained under an ongoing service contract with *Modern Sprinklers Company Inc*. It was reported, by Ms. Savard, that the last inspection of the sprinkler system was in May 2007. Ms. Savard also reported a new fire panel was installed in January 2007 by ADT.
2. Ms. Savard reported that Stanex last inspected the fire alarm system in November 2006. We were unable to contact them at the time of the preparation of this report.
3. Fire extinguishers located in the basement require inspection. This should be done in Year 1. All fire extinguishers should be inspected and tagged annually.

2.7 Interior Partitions

General Description and Condition:

The interior surfaces are generally finished in painted gypsum with carpet, ceramic tile or vinyl tile flooring. The ceilings are finished in suspended acoustic tiles. Several other materials were present as per the individual tenant requirements.

Observations and Recommendations:

1. The interior finishes were examined for stains, cracks and other signs of water penetration or condensation. At the time of our inspection, the surfaces were found to be dry and in good condition with no major visible deficiencies.

3.0 LIMITATIONS OF THE INVESTIGATION

3.1 Reliance Information

This report has been prepared for the exclusive use of 4010205 Canada Inc and Merrill Lynch. This report may not be relied upon by any other party without the written concurrence of **Inspec-Sol**.

Merrill Lynch Capital Canada Inc. and Computershare Trust Company of Canada ("Merrill Lynch") and its assigns may rely on the above-referenced report as if it were an original addressee. Also, please be advised as follows:

- The Report may be relied upon by Merrill Lynch in determining whether to make a mortgage loan secured by the Property.
- The Report may be made available to any purchaser determining whether to purchase the loan from Merrill Lynch or purchase an interest in a pool of loans containing this Property.
- The Report may be made available to any Rating Agency rating securities issued by Merrill Lynch and representing an interest in the loan.
- Merrill Lynch is permitted to refer to the Report, and/or include it in materials offering the loan, or an interest in the loan, for sale.

Inspec-Sol Inc. expressly does not accept any responsibility, directly or indirectly, for the unauthorised use or distribution of The Report, nor for the interpretations made by third parties, other than for the intended use.

3.2 Technical Limitations / Out-of-Scope Issues

The ASTM specifically limits the scope of a Property Condition Assessment by defining Out-of-Scope Issues as "any aspect of the condition of the subject building that cannot be readily ascertained during a walkthrough investigation". Additional information regarding Out-of-Scope Issues is included in Appendix III. The examples therein do not constitute an exhaustive list of limitations. In fact, any barriers that prevent or limit the direct, continuous and safe visual observation of a system or item will render the item Out of Scope.

The following specific technical limitations of this investigation should be noted:

- Our mandate did not include non-destructive or destructive testing, openings of roofing systems, wall assemblies or other enclosures, or testing of mechanical, electrical or life-safety systems.

- Our mandate did not include verification or engineering calculations of the building or component design.
- The assessment of the mechanical and electrical systems was strictly visual to determine the type of system, age and aesthetic condition. Operating conditions of the actual equipment were determined through review of available logbooks, interviews with Site contacts and maintenance personnel. No physical testing or intrusive investigative techniques were used.
- It should be noted that the mandate did not include a review of the National Building and Fire Codes or compliance of the Property to these codes.
- It should be noted that our verification for the presence of organic growth organisms, commonly referred to as mould during our walkthrough visit of the Property, was strictly visual and limited to exposed surfaces. No physical testing or intrusive investigative techniques were used.
- Cost estimates for repairs presented in this report are not based on quantity surveys or detailed engineering calculations and are intended only for global budgeting purposes.
- Determining the extent of infestation or remedy for treatment, pertaining to any type of pests such as wood-damaging organisms, rodents, or insects.

3.3 Legal Limitations

This report is intended solely for the Client named. The material in it reflects our best judgement in light of the information available to **Inspec-Sol** at the time of preparation. No portion of this report may be used as a separate entity; it is written to be read in its entirety. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties.

The information presented in this Level I Property Condition Assessment report was obtained through interviews, a review of drawings when available and observations of the subject building. Documentation and data provided by the Client, designated representatives of the Client, interested third parties or subcontractors not retained by **Inspec-Sol** and referred to in the preparation of this assessment, have been used and referenced with the understanding that **Inspec-Sol** assumes no responsibility or liability for their accuracy.

The findings and conclusions of the Level I Property Condition Assessment are developed in accordance with generally accepted standards of practice within the industry in the Province in which the building is located, the information made available and/or professional judgement. The findings represent the best judgement of the assessors during the time of the inspection and cannot warrant against undiscovered deficiencies. **Inspec-Sol** will not accept liability for any loss, injury, claim, or damage arising directly or indirectly from any use or reliance on this report by any person or entity other than the addressee.

By conducting a PCA I and preparing a Property Condition Report, **Inspec-Sol** is merely providing an opinion and does not warrant or guarantee the present or future condition of the subject Property, nor may the PCA I be construed as either a warranty or guarantee of any of the building's components or systems.

Furthermore, changes in the use of the Property, renovations or modifications made to the Property may affect the findings and conclusions stated in this Level I Property Condition Assessment report. Therefore, it is important that the Client periodically re-evaluates the facility and reviews developments or operations that may potentially impact the facilities.

We trust this report meets your present requirements. Please do not hesitate to contact us, if any questions arise.

Cherisse Vanloo, Jr. Eng.

Myles A. Carter, M.Sc., P.G.
Associate
Manager, Building Science Division

INSPEC-SOL INC.

CV/njb

Enclosures:

In duplicate (Copy by e-mail: jhberger2004@yahoo.ca) and mail

APPENDIX I

Site Photographs
Supporting Documents
Roof Plan

4010205 CANADA INC.

OFFICE BUILDING

1425 RENE LEVESQUE WEST, MONTREAL, QUEBEC

Photo No. 1 – Minor cracks on concrete sidewalk located on the north elevation.

Photo No. 2 – Cracks to foundation wall located on south-eastern corner of the building.

4010205 CANADA INC.
OFFICE BUILDING
1425 RENE LEVESQUE WEST, MONTREAL, QUEBEC

Photo No. 3 – Loose bricks and deteriorated mortar joints on east elevation of parapet.

Photo No. 4 – Bulging of the brick parapet wall with loose bricks and deteriorated mortar joints located on the south-eastern section of the roof.

4010205 CANADA INC.

OFFICE BUILDING

1425 RENE LEVESQUE WEST, MONTREAL, QUEBEC

Photo No. 5 – Previous crack injection repairs to the foundation walls in the north-western basement.

Photo No. 6 – Broken window panes and penetration hole on west elevation of roof Basin No. 6.

4010205 CANADA INC.
OFFICE BUILDING
1425 RENE LEVESQUE WEST, MONTREAL, QUEBEC

Photo No. 7 – Re-pointing work required to joints at the entrance of 1160 Bishop.

Photo No. 8 – Flashing at top of 12th floor windows requires repair and localised spalled brick.

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4010205 CANADA INC.

OFFICE BUILDING

1425 RENE LEVESQUE WEST, MONTREAL, QUEBEC

Photo No. 9 – deteriorated and pulled away caulking around window units on east elevation.

Photo No. 10 – Window openings located on the second floor of the north-western elevation currently enclosed with OSB (Oriented Strand Board) and re-pointing repairs.

INSPEC-SOL

REPARATION DE BETON DURASEAL

RBQ LIC #292-2014-17

260 VALLEE
ST-ANNE-DE-BELLEVUE, QUEBEC
H9X 3W2
514-457-7272
FAX 514-457-8926

July 31, 2007

ISCANCO
NANCY SAVARD
1425 RENE LEVESQUE
MONTREAL, QUEBEC
861-7007
368-6336

SUBJECT: BRICK REPAIR WORK TO PARAPET WALL

FOLLOWING OUR SITE VISIT AT THE ABOVE MENTIONNED ADDRESS , WE EXAMINED SOME LOOSE MORTAR JOINTS AND BRICKS REPAIRS LOCATED ON THE ROOF PEDESTILS.

WE ESTIMATE AN APPROXIMATE 7 DAY'S OF WORK FOR A TOTAL COST OF 9,500.00$ + TAX INCLUDING LABOUR AND MATERIAL

WE COMPLY WITH ALL CCQ AND CSST REQUIREMENTS AND CARRY A 2 MILLION DOLLAR LIABILITY INSURANCE

REPARATION DE BETON DURASEAL

LOUIS VERDONI

REPARATION DE BETON DURASEAL

RBQ LIC 8292-2014-17

260 VALLEE
ST-ANNE-DE-BELLEVUE, QUEBEC
H9X 3W2
514-457-7272
FAX 514-457-8926

May 30, 2005

ISCANCO
NANCY SAVARD
1425 RENE LEVESQUE
MONTREAL, QUEBEC
861-7007
868-6336

SUBJECT: STEEL WORK ON ROOF PEDESTILL OF 1425 RENE LEVESQUE

FOLLOWING OUR SITE VISIT AT THE ABOVE MENTIONNED WORK SITE, WE ARE PREPARED TO EXECUTE THE WORK ACCORDING TO ING JIM NABI'S PLANS SUBMITTED FOR A LUMP SUM OF TEN THOUSAND THREE HUNDRED DOLLARS + TAX (10300.00$ + TAX)

TERMS OF PAYMENT 30 DAY'S

WE COMPLY WITH ALL CCQ AND CSST REQUIREMENTS AND CARRY A 2 MILLION DOLLAR LIABILITY INSURANCE

REPARATION DE BETON DURASEAL

LOUIS VERDONI

REPARATION DE BETON DURASEAL
9124-4044 QUEBEC INC

LIC RBQ 8292-2014-17

August 24, 2005

INVOICE # 227-05

A:

4010205 CANADA INC
ISCANCO
1425 RENE LEVESQUE O
MTL,QUEBEC
H3G 1T7

P.O# 0457964

DE:

REPARATION DE BETON DURASEAL
LOUIS VERDONI
268 VALLEE
SAINT ANNE DE BELLEVUE, QUEBEC
H9X 3W2

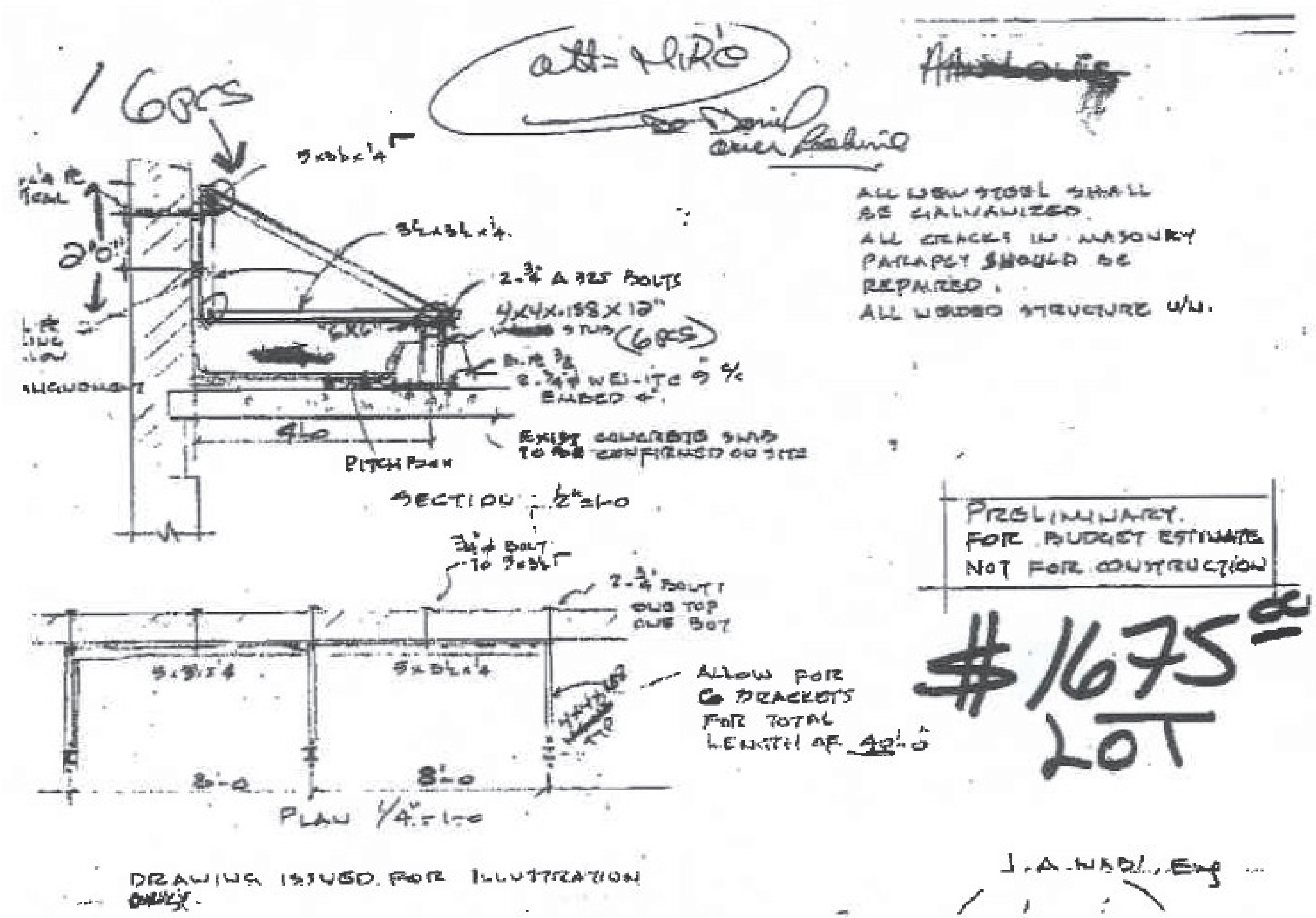
TEL: (514) 457-7272
FAX: (514) 457-8926
TPS 892646902
TVQ 1202845912
LIC RBQ 8292-2014-17
CCQ 60-368-788

TRAVAUX AUX 1425 RENE LEVESQUE

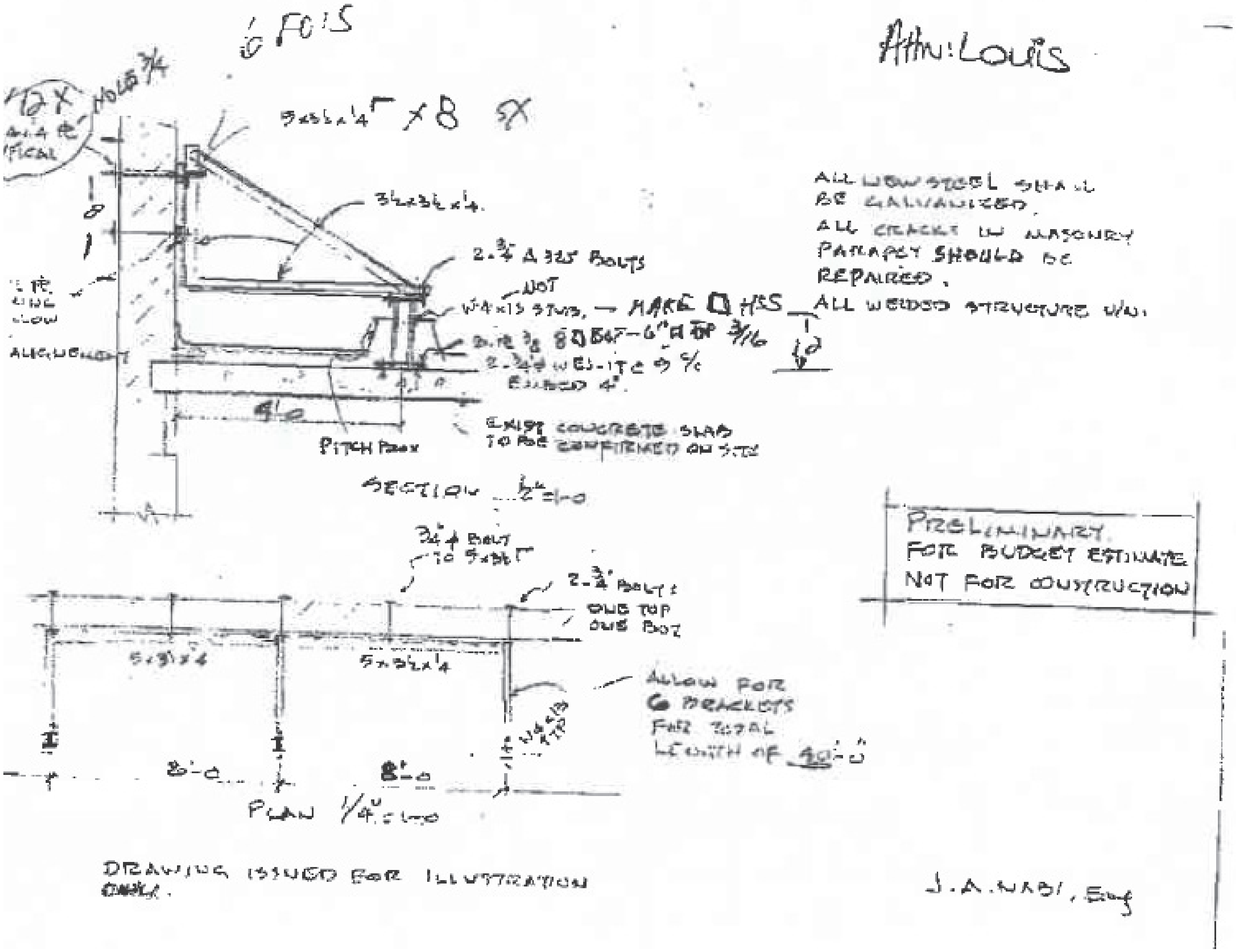
PARAPET WALL REPAIR
SUPPLY AND INSTALL BRACES AS PER DRAWING INO IJM NAB]

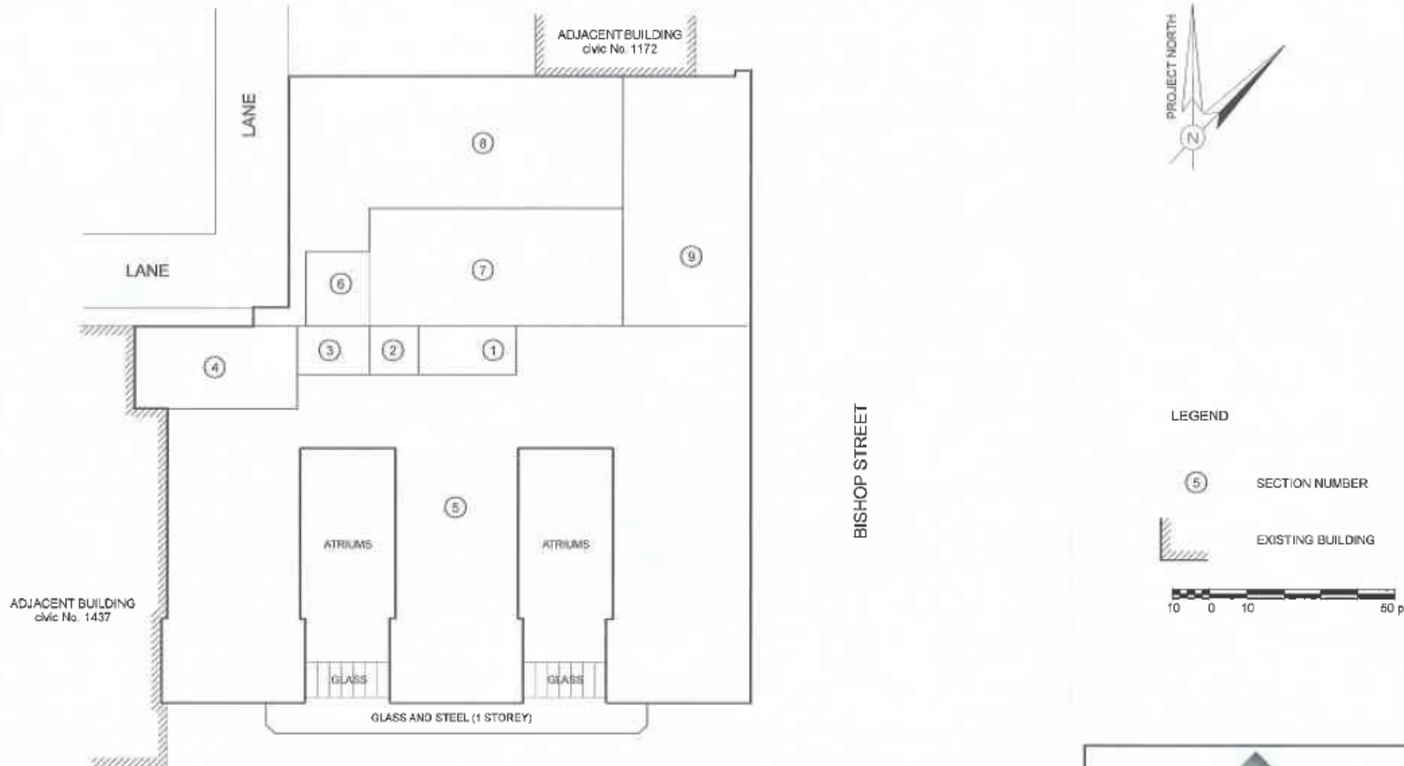
TOTAL $ 10300.00
TPS $ 721.00
TVQ $ 826.58

TOTAL	$11847.58



16PCS
2'0"
2-3/4 A325 BOLTS
4X4X.188X12" STUB (6PCS)
4'-0
PITCH POCKET
EXIST CONCRETE SLAB TO BE CONFIRMED ON SITE
SECTION 1/2"=1-0
ALL NEW STEEL SHALL BE GALVANIZED.
ALL CRACKS IN MASONRY PARAPET SHOULD BE REPAIRED.
PRELIMINARY.
FOR BUDGET ESTIMATE
NOT FOR CONSTRUCTION
$1675.00
LOT
ALLOW FOR 6 BRACKETS FOR TOTAL LENGTH OF 40'-0"
8'-0
8'-0
PLAN 1/4"=1-0
DRAWING ISSUED FOR ILLUSTRATION ONLY


Attn: Louis
ALL NEW STEEL SHALL BE GALVANIZED.
ALL CRACKS IN MASONRY PARAPET SHOULD BE REPAIRED.
ALL WELDED STRUCTURE
2-3/4" A 325 BOLTS
NOT
MAKE HSS
EXIST CONCRETE SLAB TO BE CONFIRMED ON SITE
PITCH POCK
SECTION
3/4" BOLT TO 5x3 1/2"
2-3/4" BOLTS ONE TOP ONE BOT
ALLOW FOR 6 BRACKETS FOR TOTAL LENGTH OF 40'-0"
8'-0
PLAN 1/4" = 1-0
PRELIMINARY.
FOR BUDGET ESTIMATE
NOT FOR CONSTRUCTION
DRAWING ISSUED FOR ILLUSTRATION ONLY.
J. A. NABI, Eng



NOTE:
ALL BUILDING INFORMATION HAS BEEN TAKEN FROM PLAN PREPARED BY "T.T. KATZ, QUEBEC LAND SURVEYORS" DRAWING No. 102, FILE 27171, DATED JANUARY 29, 2001 AND PROVIDED BY THE CLIENT.

INSPEC-SOL
ENGINEERING SOLUTIONS

4010205 CANADA INC.
LEVEL 1 PROPERTY CONDITION ASSESSMENT
OFFICE TOWER
1425 RENE-LEVESQUE BOULEVARD WEST, MONTREAL, QUEBEC

ROOF SECTION PLAN

DRWN: L.N. / M.H.	SCALE: 1"=30'	REF. No: M021799-G1
CHKD: C.V.	DATE: JULY 23, 2007	DRWING No.: M021799-G1-1

A P P E N D I X II

Replacement Reserve Cost Table

INSPEC·SOL

Reference No. M021799-G1

REPLACEMENT RESERVE COSTS

1425 Rene Levesque Blvd West, Montreal, Quebec

Item No.	Item	Expected Useful Life (EUL) (yrs)	Remaining Useful Life (RUL) (yrs)	Quantity	Unit	Unit Cost	Total Cost	Immediate Costs	Replacement Reserve Costs Investment horizon													Total Cost
									2007 Year 1	2008 Year 2	2009 Year 3	2010 Year 4	2011 Year 5	2012 Year 6	2013 Year 7	2014 Year 8	2015 Year 9	2016 Year 10	2017 Year 11	2018 Year 12	2019 Year 13	Years 1 to 13
2.2.4.	**Site Conditions**																					
2.2.4.1.	Topography	Varies	Varies	n/a	n/a	n/a	$0.00															$0.00
2.2.4.2.	Storm Water Drainage	Varies	Varies	n/a	n/a	n/a	$0.00															$0.00
2.2.4.3.	Access and Egress	Varies	Varies	n/a	n/a	n/a	$0.00															$0.00
2.2.4.4.	Asphalt Paved Surfaces - Deferred Maintenance	Varies	Varies	n/a	n/a	n/a	$0.00															$0.00
2.2.4.5.	Flatwork	Varies	Varies	n/a	n/a	n/a	$0.00															$0.00
2.2.4.6.	Landscaping and Appurtenances	Varies	Varies	n/a	n/a	n/a	$0.00															$0.00
2.2.4.7.	Recreational Facilities	Varies	Varies	n/a	n/a	n/a	$0.00															$0.00
2.2.4.8.	Exterior Stairs	Varies	Varies	n/a	n/a	n/a	$0.00															$0.00
2.3.2	**Building Structure**																					
2.3.2.1.	Foundation Walls - Parging	Varies	Varies	n/a	n/a	n/a	$0.00															$0.00
2.3.2.2.	Frame	Varies	Varies	n/a	n/a	n/a	$0.00															$0.00
2.3.2.3.	Slab-on-Grade	Varies	Varies	n/a	n/a	n/a	$0.00															$0.00
2.3.3.	**Building Envelope**																					
2.3.3.1.	Exterior Walls - Repointing and sealing	Varies	Varies	n/a	n/a	n/a	$10,000.00		$7,000.00	$3,000.00												$10,000.00
2.3.3.2.	Window Repairs: Re-caulking and Replacement	Varies	Varies	n/a	n/a	n/a	$3,200.00		$3,200.00													$3,200.00
2.3.3.2	Roof Basin Repairs	Varies	Varies	n/a	n/a	n/a	$5,800.00		$5,800.00													$5,800.00
2.3.4.5.	Roof - Parapet Repairs	Varies	Varies	n/a	n/a	n/a	$9,500.00		$9,500.00													$9,500.00
2.3.4.5.	Roof - Flashing repairs	Varies	Varies	n/a	n/a	n/a	$45,000.00		$45,000.00													$45,000.00
2.4 & 2.5	**Electrical, Mechanical and Vertical Transport**																					
2.4.1.	Electrical	Varies	Varies	n/a	n/a	n/a	$0.00															$0.00
2.4.2.	HVAC - Repairs and Maintenance	Varies	Varies	n/a	n/a	n/a	$0.00															$0.00
2.4.2	HVAC - Balancing	Varies	Varies	n/a	n/a	n/a	$0.00															$0.00
2.4.2.	HVAC - Provision for the replacement of Major Components	Varies	Varies	n/a	n/a	n/a	$0.00															$0.00
2.4.3.	Plumbing	Varies	Varies	n/a	n/a	n/a	$0.00															$0.00
2.6.	**Life Safety, Fire Protection Systems**																					
2.6	Repairs and Replacements	Varies	Varies	n/a	n/a	n/a	$0.00															$0.00
2.7.	**Interior Finishes**																					
2.7.	None	Varies	Varies	n/a	n/a	n/a	$0.00															$0.00
	TOTALS (Uninflated)						$73,500.00	$0.00	$70,500.00	$3,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$73,500.00
	Inflation Factor						**Inflation Rate Factor**	3%	1.00	1.030	1.061	1.093	1.126	1.159	1.194	1.230	1.267	1.305	1.344	1.384	1.426	
	TOTALS (Inflated)								$70,500.00	$3,090.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$73,590.00

Investment horizon	13
Total Gross Leasable Area (GLA) (sq.ft.)	182,295
Cost per Square Foot per Year (Uninflated)	$0.03
Cost per Square Foot per Year (inflated)	$0.03

Notes:

LS = Lump Sum

Immediate Costs, where applicable, are not included in Capital Reserve Total

All Egress and Facilities issues are considered as Immediate Repairs

The actual square footage or linear footage for repair work must be verified by additional detailed investigation

APPENDIX III

Out-of-Scope Issues

INSPEC•SOL

OUT OF SCOPE ISSUES

In the context of the ASTM E-2018-01: "Standard Guide for Property Condition Assessments" (Baseline Property Condition Assessment Process), an ***Out of Scope Issue*** is defined as "Any aspect the condition of the subject building that cannot be readily ascertained during a walkthrough investigation." General and specific Out of Scope Issues for Level I Property Condition Assessments, as reported by **Inspec-Sol**, are as follows:

General Issues:

- Our mandate did not include non-destructive or destructive testing, openings of roofing systems, wall assemblies or other enclosures, or testing of mechanical, electrical or life-safety systems.
- Our mandate did not include verification or engineering calculations of the building or component design.
- The assessment of the mechanical and electrical systems was strictly visual to determine the type of system, age and aesthetic condition. Operating conditions of the actual equipment was determined through review of available logbooks, interviews with Site contacts and maintenance personnel. No physical testing or intrusive investigative techniques were used.
- It should be noted that the mandate did not include a review of the National Building and Fire Codes or compliance of the property to these codes.
- It should be noted that our verification for the presence of organic bacterial growth organisms, commonly referred to as mould during our walkthrough visit of the Property, was strictly visual and limited to exposed surfaces. No physical testing or intrusive investigative techniques were used.
- Costs estimates for repairs presented in this report are not based on quantity surveys or detailed engineering calculations and are intended only for global budgeting purposes.
- Determining the extent of infestation or remedy for treatment, pertaining to any type of pests such as wood damaging organisms, rodents, or insects.

Specific Issues:

Topic	*Out of Scope Issues*
Site Conditions	▪ Operating conditions of any manholes or utility pits. ▪ Condition of any items on the property that are extraneous to the property (e.g. Hydro-Quebec transformers, transmission poles and lines, etc.). ▪ Confined or crawl spaces will not be entered, although observations will be made from the point of entry, if possible.

Topic	*Out of Scope Issues*
Building Structure	▪ Our mandate did not include coring of the slab-on-grade and retrieval of samples of the granular foundation. We, therefore, cannot confirm the presence or absence of pyrite bearing aggregate or other materials, which could alter the condition of the slab. ▪ Determination of previous substructure flooding or water penetration unless reasonably visible or if such information is provided. ▪ Seismic and wind load considerations, or calculation of any load design requirements.
Building Envelope	▪ Walking on pitched roofs, or mounting any roof with inadequate access, general or localised instability, or any other perceived safety issue. ▪ Accessing wall details or windows on a building's upper floors. Observations will be limited to vantage points that are on-grade or from readily accessible balconies or rooftops. ▪ The evaluation of the roof membrane systems did not include cut tests to verify the composition of the systems, for the presence of moisture below the membrane surface, or the compatibility of the different components. ▪ Commenting on elements confined within the wall or roof assemblies, such as masonry anchorage, insulation, etc. No cut tests or other openings were carried out. ▪ Checking for the presence of phenolic foam insulation in the roof cross-section.

Topic	*Out of Scope Issues*
Electrical and Mechanical Systems	▪ Review of drawings or construction documents related to these systems. ▪ Measurement to verify the capacity, adequacy, or efficiency of the system. ▪ Removal of panel or device covers. ▪ EMF (electromagnetic field) issues. ▪ Issues concerning tenant-owned equipment. ▪ Issues concerning process-related equipment. ▪ Review of drawings or construction documents related to these systems ▪ Observations of flue or vent connections. ▪ Observations of interiors of flues, vents, ducts and chimneys. ▪ Issues concerning tenant-owned equipment. ▪ Issues concerning process-related equipment. ▪ Verification of pipe sizes or other design issues. ▪ Verification of any underground systems. ▪ Verification of the earth fill around soil absorption systems (SAS), field piping or distribution boxes of septic field systems. ▪ Determining adequacy of pressure and flow rate.
Vertical Lift Systems	▪ Examination of cables, sheaves, controllers and motors. ▪ Entering elevator pits or shafts.
Life Safety Systems	▪ Determining National Fire Code hazard classifications. ▪ Determining the fire rating of assemblies. ▪ Verification of sprinkler head density. ▪ Determining or reporting sound transmission ratings. ▪ Determining or reporting fire spread ratings or flammability issues.

APPENDIX IV

Glossary of Selected Terms

BUILDING SCIENCES

SELECTED GLOSSARY OF TERMS

Acoustical sealant: a sealant with acoustical properties used to seal joints in the construction of sound rated ceramic tile installations.
Alligator cracking: a series of inter-connecting cracks on an asphalt surface caused by failure of the asphalt under repeated traffic loading.

Backer rod: bar used to seal wide gaps and joints before caulk is applied, reducing unwanted air leakage.
Baluster: the small vertical supports in a balustrade.
Balustrade: a railing consisting of balusters and a top rail.
Baseboard: trim placed at the join of the floor and wall planes.
Batten: a continuous piece of square-sawn lumber to which sheet metal panels can be attached; also, a wood or metal covering strip, to conceal joints from view and from the weather.
Bearing plate: a flat plate, intended to spread load from a column to the foundation, to provide for fastening and to permit levelling of the column base.
Bleeding: the extrusion of adhesive, cement paste, creosote, or resins from building components.
Blisters: small rounded or elongated raised areas of roof membrane which are filled with air.
Bridging: blocking between joists used to distribute loads and stiffen frames.
Brick veneer: a facing of brick laid against a structural wall but not bonded to the wall and which bears no load other than its own weight.
Buckle: in structural terms, failure by deflection.
Bowing: longitudinal deflection of a piece of lumber, pipe, rod, or the like, usually measured at its center.

Caulk: to seal joints or cracks with a mastic material.
Camber: the upward curve of a surface or beam, usually invoked to offset deflection or induce drainage.
Casing; wood trim around doors and windows.
Chalking: oxidation of paint over time due to weather.
Cladding: a non-load-bearing skin forming an exterior wall.
Clear span: horizontal unsupported distance between bearings.
Control joints: see Expansion joints.
Compression: the state of being pressed or condensed by forces.
Condensation: the formation of water out of moisture vapour because of reduced temperature.
Conduit: a metal or plastic tube that allows wires to be threaded through construction systems.
Corrugate: to bend sheet material into a series of parallel folds to produce a regular pattern of furrows and ridges.
Course: a horizontal row of masonry units.
Creep: deformation of a material under stress.
Crazing: fine, random cracks or fissures caused by the shrinkage which may appear in a surface of plaster, cement paste, mortar, or concrete.
Cribbing: an assembly of heavy wooden members to retain earth.
Cutout: a piece removed to create a small opening.
Curtain wall: a non-load-bearing envelope wall hung on the external structural frame of a building.
Curing: maintenance of humidity and temperature of the freshly placed mortar or grout during some definite period following the placing or finishing, to assure satisfactory hydration.

Damp-proofing: the exclusion of water in its vapourized form.
Decking: system used to form a wood or metal horizontal platform.
Defect: a natural or machining fault that detracts from the serviceability or appearance of a piece of material.
Deflection: downward displacement of a beam or truss because of loading.
Delamination: the separation of layers of glued or bonded materials.
Dry rot: a type of wood decay caused by a fungus.
Durability: characteristics of materials that determines how long they will last under expected conditions of service.

Efflorescence: a powdery gray-white salt residue brought to the surface of masonry by the action of moisture.
Esthetic (aesthetic): having primarily to do with appearance.
Expansion joint: a location where construction systems are interrupted to permit movement of the building.
Epoxy adhesive: an adhesive system employing epoxy hardener portions.

BUILDING SCIENCES

SELECTED GLOSSARY OF TERMS

Face: the surface exposed to view.
Fieldstone: naturally occurring uncut blocks of stone.
Flagstone: large, thin, irregularly shaped pieces of slate or shale laid flat as paving stones.
Flange: the peripheral plates along the outermost edges of the central web of a steel beam.
Flashing, base: that part of the flashing system that connects the horizontal roof or waterproof membrane to the adjacent vertical wall or parapet.
Flashing, cap: a continuous piece of metal, snapped on to complete a weatherproof system at edges, ridges, or expansion joints in roof system.
Flue: a (usually) vertical duct or vent for hot gasses and smoke.
Flush: two components having surfaces lying within one plane.
Frieze: a decorative horizontal band on a building surface.

Gable: the upper triangle area formed by the sloping roof at the end of a building.
Girder: a horizontal or slightly inclined main beam.
Glazing : the process of securing glass panels into prepared door or window frames.
Grade beam: a horizontal foundation that transmits loads to vertical piles.
Grout: a mixture of cement, fine sand and water used to fill minor voids in concrete or masonry work.

Hanger: a metal or plastic device used to suspend building components.
Header: a masonry unit laid horizontally with its length perpendicular to the wall plane; also, the horizontal frame member at the top of an opening.
Heave: The localized upward bulging of the ground due to expansion or displacement caused by phenomena, such as frost or moisture absorption. May also occur due to the production of secondary sulphate based by-products due to the oxidation of pyrite present in granular fill.
HVAC: heating, ventilation, air-conditioning.

Insulation: any material that will not easily conduct energy in the form of heat, sound or electricity.

Jamb: the vertical side of any opening.
Joint: the point of contact between two components.
Joist: horizontal structural member supporting decks and floors.

Laminate: to apply a thin layer on the top of another.
Landing: an intermediate rest platform in a flight of stairs.
Lintel: a horizontal member used to distribute forces above an opening.
Longitudinal crack: a crack in asphalt surface that runs parallel to the “laydown” direction.
Louver: a slatted ventilation opening.

Mastic: oil-or cement-based paste used to fill minor holes and cracks in buildings.
Membrane: a thin pliable sheet or layer of (usually waterproof) material used as a liner in parts of buildings.
Mildew: a whitish fungal coating, often appearing on damp paper or plaster surface.
Molding: trim or ornamental cover.

Offset: a change in vertical plane.
Overhang: the distance a joist or chord extends beyond the bearing point.

Panel: a flat board, plate or pane inserted into a frame.
Parapet: a low wall projecting above the roof level.
Parging: a single application of masonry cement used to cover minor blemishes in concrete or masonry walls; also used to line brick chimney vents.
Parquet: small wood block flooring laid in basket-weave or other mosaic patterns.
Partition: a non-load bearing wall separating two areas of a building.
Peeling: the separation of adhesive from glued surfaces.
Permeability: ability to permit (or resist) the passage of water.
Pier: a vertical portion of wall between openings, also a free-standing short or stubby column.

Pitch: slope or angle.
Plumb: vertical.
Ponding: the accumulation of water in low areas of nominally flat roof decks or paved areas.
Popping: the loosening of cover over concealed nail heads caused by thermal or moisture movement in framing.
Porous: a surface permeable by water or air.
Potholes: bowl shaped holes of various sized in an asphalt surface.
Precast unit: concrete formed, poured and cured in a location other than its final location.
Pyrite: a widespread iron sulphide mineral often associated with heaving and sulfatation of concrete due to the formation of sulphate based secondary by-products, on oxidation.

Ramp: an inclined plane.
Ridge: the uppermost edge of a roof plane; the upper apex between two adjoining roof planes.
Riser: the vertical component of a step, intended to prevent the feel from slipping beyond the tread.
Rout: to gouge with a cutting tool.

Scaling: pitting of surfaces after repeated exposure to freezing and thawing.
Sealants: products used to seal joints that have been packed with weatherproof materials.
Sealers: waterproof products used to coat or prepare surfaces or areas to inhibit moisture penetration.
Shear: the tendency of forces to cause a transverse fracture across a member.
Sheathing: usually rough wood or plywood boarding used to enclose a space and impart structural integrity to a wood or metal frames, such as a floor wall or roof.
Siding: overlapping long, narrow and thin boards of wood or metal attached horizontally or vertically to the outside of buildings to improve weather protection and appearance.
Sill: the lowest horizontal part of any opening through the wall.
Soffit: the exposed underside of any building surface.
Spalling: breaking away of surface in flakes or chunks.
Splits: tears that extend through roof membrane layers.
Step crack: a pattern of cracks in brick or concrete block veneer, often following mortar joints, which form as a result of foundation settlements.
Storey: the usable portion of a building between one floor and the one above it.
Strength: the characteristic of a material that determines its ability to resist or impart forces.
Substrate: the surface beneath a finishing layer or coating.

Tension: forces tending to stretch or elongate an object.
Terrazzo: a mixture of cement paste and marble chips, ground and polished after curing.
Thermographic scan: an infrared survey carried out on a roof system to determine areas of heat loss and potential roof leaks.
Threshold: see sill.
Topping: a thin layer of fine concrete laid on top of and bonded to a thicker substrate of structural concrete.
Transverse crack: a crack in an asphalt surface that runs across (perpendicular or diagonal to) the "laydown" direction.
Tread: the horizontal component of a step.
Trim: long, narrow strips of shaped and finished wood, metal, or plastic used to conceal joints of building components.
Truss: a structural frame, usually part of a roof structure.

Valley: the line where two inclined planes of a roof surface meet and to which water will be directed.
Vapor Barrier: material used to prevent the passage of vapour or moisture into a structure or another material, thus preventing condensation within them.
Veneer: a thin layer of wood, masonry, or metal applied for primarily cosmetic effect.

Warp: a significant and unwanted deviation from an intended true plane.
Waterproofing: the exclusion of water in its liquid form.
Web: the central vertical plate between outer beam flanges.
Weep holes: small spaces left in mortar joints or concrete walls to permit moisture escape.
Wythe: in masonry, width, usually the width of one brick, as is a wall or veneer one wythe thick.

APPENDIX (D)

Canada Inflation Rate Within 20 years (1991 – 2010)

Consumer Price Index, historical summary
(1991 to 2010)

Year	All-items	Change from previous year
	2002=100	%
1991	82.8	5.6
1992	84.0	1.4
1993	85.6	1.9
1994	85.7	0.1
1995	87.6	2.2
1996	88.9	1.5
1997	90.4	1.7
1998	91.3	1.0
1999	92.9	1.8
2000	95.4	2.7
2001	97.8	2.5
2002	100.0	2.2
2003	102.8	2.8
2004	104.7	1.8
2005	107.0	2.2
2006	109.1	2.0
2007	111.5	2.2
2008	114.1	2.3
2009	114.4	0.3
2010	116.5	1.8
Average		2.00