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Integrated System for the Development Permit Approval Process in the Housing Industry

By

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A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science

In

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This thesis is dedicated to the everlasting memory of my mother Maya Rani (1945-2003) for her guidance and encouragement throughout my life.

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TABLE OF CONTENTS

LIST OF FIGURES

1 INTRODUCTION

This chapter introduces an integrated system with CAD for the automation of the housing development permit approval process and illustrates the basic approach used to achieve the objectives. The chapter outlines the motivation, the research objectives, the methodology, and the organization of the report, as well as provides a reading guide for the thesis.

1.1 Motivation

The residential construction industry is a significant contributor to Canada's economy. New home building, residential renovations, and other housing construction spending in 1998 exceeded 5% of Canada's GDP. All three components of residential construction investment-- new housing, renovations and acquisition costs-- have shown healthy gains; according to a recent Statistics Canada report, spending totaled $ 17.6 billion in the third quarter of 2003, an 11.1% jump from the third quarter of 2002. New home construction reached $9 billion in the third quarter of 2003, up 8.6% from the third quarter of 2002. Single-family dwellings contributed the most to this increase, growing 5.9% to just over $6 billion (On-Site Canada's Construction Magazine 2004). In Alberta, investment in residential construction increased by 4.8 percent to $ 2.083 billion between the third quarters of 2002 and 2003. In 2003, the City of Edmonton issued 6592 building permits with a value of over $693 millions as listed in Table 1-1 and illustrated in Figure 1-2 respectively.

The shortcomings of the current development permit approval process includes the residential industry's dependence on an individual's abilities to interpret the city bylaws and building codes, and to design a code compliance drawing, makes it error-prone, and time-consuming process. The number of city bylaws exceeds several hundred, and the architect has to memorize all the laws or manually look into the most updated versions of the bylaws and the building code provisions. The designed model together with the development/building permit application form is submitted in paper

form to the city office for approval. Despite the ever-growing technologies, the industry continues to exchange paper-based documents.

Table 1-1: Residential Building Permits Issued in 2003

Residential Industry	Number	Value ($ CAN)
Single family Dwelling	3,653	334,201,100
Semi Detached Dwelling	385	56,645,600
Duplex	0	0
Row Housing	232	64,712,900
Apartments	75	205,040,800
Alteration & Repairs	2,247	32,747,200
Total	6,592	693,347,600

Planning and Development Office, the City of Edmonton

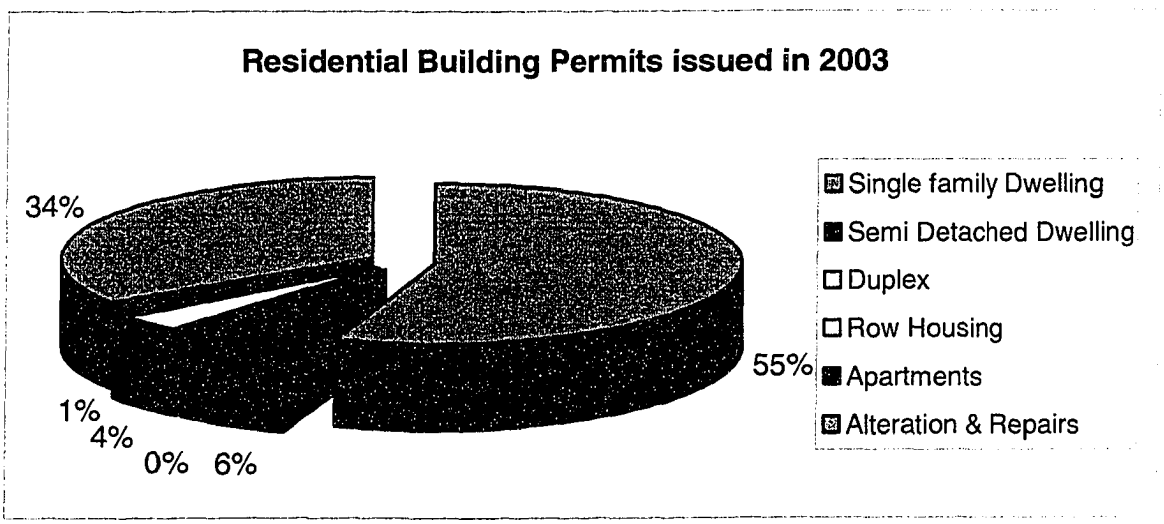


Figure 1-1: Residential Building Permits Issued in 2003

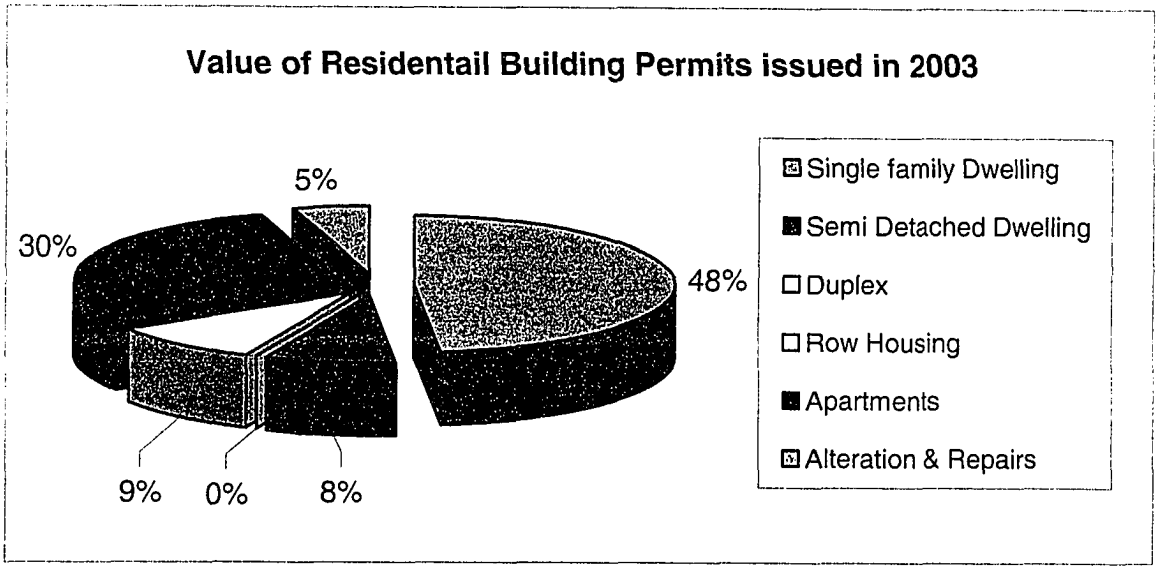


Figure 1-2: The Value of Residential Building Permits Issued in 2003

The approving authorities come across the same procedure as the architect did for discovering the laws that are applicable to the project. The wrong interpretation or omission of these bylaws leads to delay of the development/building permit approval process and cost over runs. Table 1-2 shows the number of non-compliant application sent to the appeal board in the last five years.

Table 1-2: Number of Non-Compliant Applications from 1999 to 2003

Year	Number of SDAB Appeals	Number of Development Applications	% Appealed
2003	408	14,353	2.8%
2002	390	15,415	2.5%
2001	404	13,708	2.9%
2000	480	11,979	4.0%
1999	470	11,555	4.1%

Planning and Development Office, the City of Edmonton

The changes requested by clients to the approved design to meet their family requirements at the sales office are evaluated for their compliance to city bylaws and building code provisions, as well as their effect on the cost and the schedule of the

project. The requested changes are communicated to the architect's office, which generally take 4-6 weeks. Due to the current complex practices of building permit approval process and the communication gap between the sales representative and the Architect/Engineer (A/E); builders are reluctant to allow the prospective homeowners to propose changes to the approved design.

To reduce the processing time for the development permit approval process and to provide sales representative with a tool to evaluate the client's changes with respect to city bylaws and the need for utilization of advanced computer techniques cannot be ignored. Despite the usefulness of advanced techniques, the housing industry remains slow in adapting these techniques. Computer-aided design in architectural practice is still in its infancy and has not yet made a significant impact. Although Knowledge Based Systems (KBS) are capable of automatically checking drawings, these drawing are stilled checked manually between the A/E, the approving authorities and the sales representative. The need to develop an efficient system capable of providing a better CAD environment for drafting, automatically checking drawings with respect to city bylaws and utilizing an automatic checking system by the A/E, the approving authorities and the sales representative for their respective uses is evident and cannot be ignored. The primary advantage of such a system lies in the automatic checking of drawings, storage of the drawing data in a database, accessibility of the drawings data and sharing the checking module between the A/E, the approving authorities and the sales representative. Current system for the automatic checking of building drawings lacks storage capability for the building data in a database and do not provide users with an automated system for the drafting and sharing of the building information.

This research presents a methodology for the development of a integrated system with CAD (ISCAD), which is shared by the A/E, the approving authorities and the sales representative at various stages in the housing project. The methodology integrates CAD with databases, and automates the current practices in the housing project, leading to more efficient communication and lower cost in housing projects. The

proposed methodology has been implemented into a computer prototype system. The developed prototype system consists of two central databases (the building information database and the city bylaws database), the automatic checking module, the information-processing module and integrated building codes assistance module. Visual Basic for Application in AutoCAD is used for the design of the interface while the integration of CAD with the database is established by using Data Access Objects (DAO). Case examples are presented to demonstrate the effectiveness of the various components of the proposed methodology.

1.2 Research Objectives

The framework of this methodology is based on the concept of information-based systems and data sharing supported by a relational database. The proposed methodology not only automates the process but also aims to reduce the informational gap between project participants in the housing industry. The main objectives of this study are the following:

- To propose a methodology for the development of a central repository (IP module and central databases) that can be shared by the participants in the housing industry, i.e. the A/E, the approving authorities and the sales representative for their respective uses.
- To create an intelligent design environment for A/Es integrating CAD with databases.
- To automate the preliminary drafting process in compliance with the city bylaw.

To implement the developed methodology in a "proof of concept" prototype computer system.

1.3 Methodology used to Achieve the Research Objectives

The implementation of the proposed methodology of this research involves four steps as illustrated in Figure 1-3.

Step 1 - Analysis of Current Practices: This focuses on the current practices for the development/building permit approval process; the drafting procedures and information flow between project participants. The analysis is conducted by holding a number of meetings with the participants in the housing industry, i.e. the sales representative, the draftsman and the approving authorities at the city office. Existing redundancies and non-value added activities in the current process were also identified. Knowledge acquisition was achieved through structured interviews with the approving authorities at the Land Development department of the City of Edmonton to understand the current development permits approval process and to interpret the city bylaws applicable to residential buildings. The main focus was on the interpretation of provisions in city bylaw #12800, which is applicable to single story detached residential houses and to understanding the "National Housing Code of Canada 1998 and Illustrated Guide" (NRCC, 1998) which outlines the minimum requirements for the design of building code compliance drawing. Bylaw # 12800 lists the regulations, schedules, and site-specific development control provisions applicable in the City of Edmonton.

Step 2 - Study Phase: This phase focuses on the literature review of the latest developments in the field of automation of CAD, the automated code checking system, integration of CAD with external databases and product modeling.

Step 3 - Implementation: The proposed methodology has been implemented in the AutoCAD environment. Visual basic for application was used to develop the interface in the CAD environment. The databases were developed using Microsoft Access, and the integration of CAD with external databases was established through data access objects (DAO).

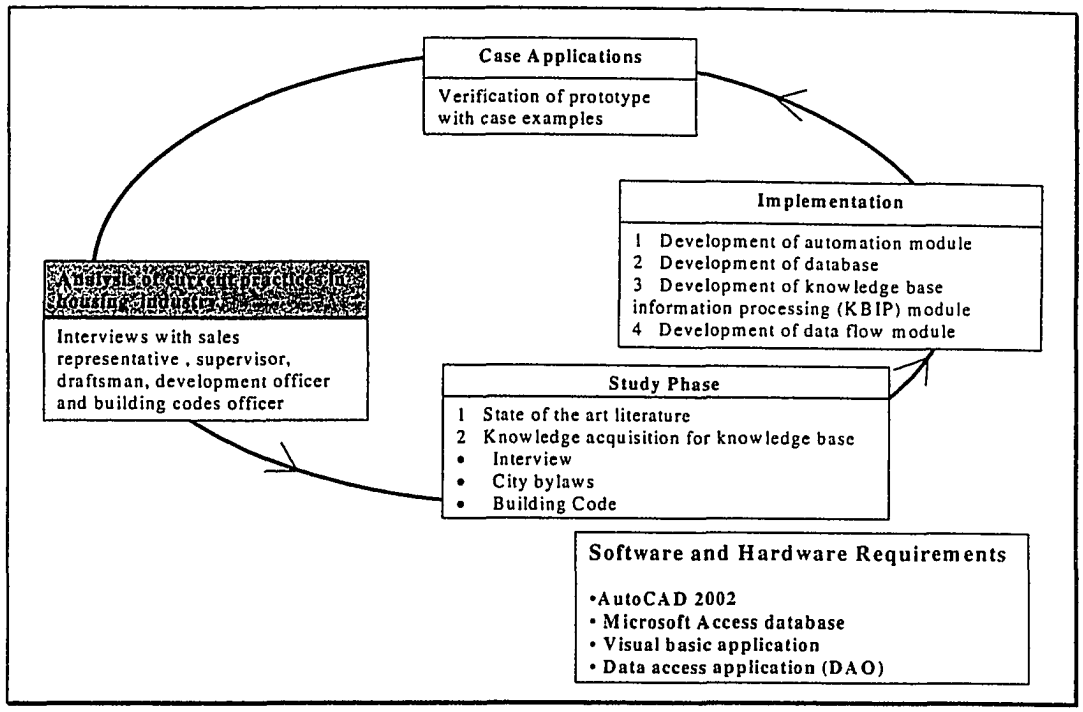


Figure 1-3: Research Plan

Step 4 - Case Applications: The final stage involves the application of the proposed strategy in case examples. The case-based approach allows for the validation and evaluation of the proposed methodology and demonstrates the main features of the developed prototype.

1.4 Thesis Organization

Chapter 1 (Introduction) introduces the thesis by describing its general context (the importance of the residential industry) and the problem addressed (the development /building permit approval process, process for evaluating changes at the sales office). The chapter also discusses the objectives of the research, and the development of the proposed methodology. **Chapter 2** (Literature Review) includes review of the state of the art literature, the current practices for the residential development/building permit approval process and for evaluating the changes requested by clients at the sales office, as well as a description of the techniques for the automatic checking of drawings with an emphasis on a knowledge-based system,

product model databases, and application of the CAD system with database in construction industry. In addition, the chapter also discusses the techniques used for the knowledge acquisition to develop the knowledge-based system. **Chapter 3** (Proposed Methodology) discusses the methodology for the developed prototype. The conceptual design of the system's components, i.e. the automation module, the central databases (the building information database and the city bylaws database), the information-processing module, and the integrated building code assistance module is also explained. **Chapter 4** (Implementation of the Proposed Methodology) describes the implementation of the methodology proposed for developing an integrated system with CAD (ISCAD), which is shared by key players in the housing industry and used in their respective areas. It also explains the design, the hardware and the software requirements and the functions of the developed prototype. A detailed description of this prototype encompassing advantages and limitations is also provided. **Chapter 5** (Case Studies) makes use of up-to-date "real world" case studies to validate and verify the developed system. Case studies are presented in this chapter demonstrating the effectiveness of the developed prototype system. **Chapter 6** (Summary and Concluding Remarks) describes the conclusion, research contributions and recommendations for further research.

2 LITERATURE REVIEW

This includes review of the state of the art literature, the current practices for the residential development/building permit approval process and for evaluating the changes requested by clients at the sales office. In addition, the chapter also discuses the techniques used for the knowledge acquisition to develop the knowledge based system.

2.1 State of the Art Literature Review

The literature review focuses on state of the art developments in the following areas: application of the knowledge based system (KBS) in construction, the integrated CAD system with database, the automatic code checking system, product modeling and general applications of CAD in construction.

2.1.1 Application of KBS in construction

Knowledge based systems and their various application in construction have been widely described in the literature Van der Horst (2004), Heijst et al. (2004), Leeuwen (2002), Lawrence et al. (1995), Sandberg (2003), and Korman (2001). Fasth (2000) outlines the methodology for the development of a knowledge based system, which includes two major steps: 1) knowledge acquisition 2) validation and verification of the developed application. The knowledge acquisition comprises of three stages: knowledge elicitation, knowledge representation, and knowledge encoding. Knowledge elicitation refers to obtaining knowledge from the experts; common techniques of information elicitation include the interviewing of experts and the studying of related literatures. A knowledge representation and its encoding includes gathering of the information from experts and literature review, and its modeling and formalization respectively. Table 2-1 lists a summary of the applications of knowledge-based system, their areas of application and characteristics used in the construction industry.

Table 2-1: Applications of Knowledge Based System used in Construction

No.	Name System	Application Area	Comments
1	BETVAL	Provides advice on the selection of ready mix concrete for the job site.	The system was developed using Insight 2+ and uses IBM PCX or AT computer.
2	CONCEX	Used for quality assurance of concrete at the construction site	Developed using the Rule Master expert system development too.
3	CONCRETE MIX DESIGNER	Provides information on trial mix proportions of concrete.	Developed using Personal Consultant Plus expert system shell.
4	CONTEC	Diagnosis and treatment of deteriorated concrete structures.	Object oriented and rule based expert system shell has been used for the implementation.
5	DURCON	Assists on the selection of concrete constituents durability: corrosion, freeze-thaw, sulfate attack, alkali aggregate reaction	Developed originally in Fortran and Pascal. Later it was converted into Insight expert system shell.
6	ESCON	Rule based expert system designed to model the production of conventional concrete.	ESCON is in development state using the 'Savior' expert system shell.
7	SLABFORM	Designed to assist the designer/planner to select horizontal concrete formwork system..	SLABFORM was developed using the Exsys Professional expert system shell program.

Source: Lawrence et al., 1995

2.1.2 Application of integrated CAD system with database in construction

Researchers has addressed the need for integration of CAD with databases in a variety of different ways ranging from information modeling to knowledge-based interfaces linking several application and multiple databases (Marir, 1998; Cooper, 1998; Yang, 2003; Navon, 1995; and Froese, 1992). The following section focuses on the few attempts made to integrate CAD systems with different applications.

Navon (1995) developed a system called COCSYI (CAM Oriented CAD system) that can automate the integration of design and construction and supports changes in the design procedure. The model is based on the principles of a design feature based system, and predefine parametric and geometric entities with a functional meaning. The designer takes design element from the predefined library of these elements. The model allows automatic extraction of construction-related data from the design database. In the Open System for Construction (OSCON) product model, Marir (1998) integrates the Computer Aided Design (CAD) and relational database management system. The model stores architectural design information in an integrated construction object oriented database that is compliance with industry foundation classes (IFC) and is shared by a range of computer applications. Based on OSCON, AutoCAD creates the instances of the design model and stores them in the distributed object database. An Abstract Design Classes (IFC Building Element) represents an abstraction for each kind of architectural design element and also provides abstraction for the model classes to draw and render in the CAD Environment. In addition, the model has used Virtual Reality Modeling Language (VRML) for remotely interrogating the information stored in the integrated database, visualizing and manipulating the design components in a 3D environment. The client applications, i.e. the esteem, the mentor and the planner, are designed to access and manipulate instances of the specific domain and OSCONCAD design distributed objects through CORBA Object Request Brokers. CAD-B PM, a CAD- Based Project Management Model developed by Zahnan (2000), integrates the CAD design with the central depository of a project information database. It allows the user to separate the design data from the specific CAD package that is used to calculate the productivity and to generate cost estimates for the project. This approach emphasizes the capture of graphical and textual information about the building project and its direct storage to a server based central database. Elzarka (2001) presents a cost-effective approach for developing computer integrated construction (CIC) systems by integrating stand-alone

CAD, spreadsheet, database, and scheduling software packages using Visual Basic for Applications (VBA).

2.1.3 Systems for automatic CAD drawing checking

Much of the research currently carried out in the field of automatic checking of CAD drawing centers on the development of an automatic checking module and the development of the building product model (Turk et al., 1992; Han et al., 1998; and Sulaiman et al., 2002).

Nguyen et al. (2001) presents a computer-based building design framework which emphasizes the engine; this framework is capable of automatically deducing topological information of building components which support various aspects of the building design, such as constructability analysis, construction planning, and building code compliance checking. Han et al (2004) developed "A Client/Server Framework for On-line Building Code Checking" system, which examines the structure and attributes of the product model and the building code model. The building code model, which uses the same structure as IFC product model hierarchy, involves mapping the building code provisions and embedding them in an object-oriented framework in order to analyze a design for code compliance. One building code class can have several instances corresponding to the provisions in the building code. An individual component can be checked against all applicable instances of provisions for that class of building component. The standard product model, i.e. Standard for exchange of product data (STEP), and International Alliance of Interoperability are also used to facilitate the data exchange. The user of the system develops a plan using an IFC compliant CAD package and a specially designed module (AutoCAD-to-IFC translation module) generates the building model class attributes and relationships required by the code-checking program to perform the building code analysis. An AutoLisp routine extracts the IFC information from the enhanced AutoCAD database and converts the information into an IFC Express file, i.e.. IFC Model. The draftsman sends his design to the code-checking program that resides on the remote server. The

code-checking program examines the IFC design data, and groups and re- analyzes the group components to determine the compliance to code provisions. Delis (1995) examine the Automatic Intelligent Fire-Code Checking, in which engineering code requirements are encoded in a knowledge-based expert system that evaluates a design for overall conformity. The system, termed "Fire-Code Analyzer" (FCA), consists of a frame system, a rule system, and a set of geometric algorithms. The frame-based system is used to represent the various three-dimensional objects of an application model and their relations. The rule-based system includes a set of rules in the IF/THEN form, and serves to provide all the necessary information to achieve compliance with codes. A number of geometric algorithms that elicit knowledge from the frame representation of the various building objects are discussed.

2.1.4 Application of Product Models

Researchers have paid particular attention in recent years to methods of describing a building in digital form, i.e. Building Product Modeling (Murat 2001). Several efforts have been made to develop an object oriented building model that contains the necessary geometric, functional and behavioral relationships of building components. There are two international standardization efforts that address the representation of building design: STEP (STandard for the Exchange of Product model data) developed by the International Organization for Standardization; and the Industry Foundation Classes; IFCs are the specifications for a set of standardized object definitions, developed by the International Alliance for Interoperability (IAI). IAI carries out the development at work on the EXPRESS data definition language that developed as an ISO standard within the STEP project. The EXPRESS schemata defined in terms of entities and their attributes offer a standardized format for data exchange. The database is structured denoting sets of objects and objects incorporating physical and non-physical information such as weight, color, electrical and thermal properties, cost, as well as defining how it appears in space. An object also encapsulates procedures that can be used to behave and related to other objects. Rivard (2000) proposed the BENT (Building ENtity and Technology) model, which represents each building

entity as a generic container that encompasses its properties, taxonomy, geometry, composition, relationships, and the design knowledge applied in generating it. Yang (2003) presents a method for IFC-compliant design information modeling for 3D architectural design using IFC technology and the IFC property set extension mechanism. This method comprises the defining of non-standard and project specific design information in extensible and interoperable Psets; the instantiation of these Pset definitions with CAD object information, the generation of IFC compliant product models, and the management of shared product model data across AEC computer applications.

2.1.5 Knowledge elicitation process

Knowledge elicitation refers to how the knowledge is obtained from the expert. The most common methods of information elicitation include interviews with experts and the study of literature reviews. The following section discusses the methods used to elicit the knowledge for the developed prototype.

2.1.5.1 Structured interviews

Experts from the domain, including development officers and building code safety officers, were interviewed to explain the criteria they use to evaluate the compliance of drawings with city bylaws. These experts were also asked for their interpretation of these bylaws. Including the level of variations, variances to the regulations can be approved by the development officers without having to go to the appeal board.

2.1.5.2 Study of city bylaws and building code provisions

This involved the study of the City Bylaw #12800, referred to as the Edmonton Zoning Bylaw, and also known as the Land Use Bylaw by the Municipal Government Act. The "National Housing Code of Canada 1998 and Illustrated Guide" (NRCC, 1998), which sets the minimum requirements for the design of building code compliant drawings required for self-contained, single-detached, and semi-detached houses, was also investigated.

2.1.6 Development requirements in the City of Edmonton

The Edmonton Zoning Bylaw, also known as city bylaw #12800, governs developments in the City of Edmonton. Land belonging to the City of Edmonton has been classified into 39 zones, 2 direct control provisions and 14 overlays, each of which has its own purpose and characteristics. A zone as defined in the Edmonton Zoning Bylaw is a specific group of listed Use Classes and Development Regulations, which regulate the use, and development of land within specific geographic areas of the city. According to the bylaws, no person can commence, or cause or allow to be commenced, or carry on, or cause or allow to be carried on, a development without a Development Permit issued under the provisions of the development classes of the city bylaw. For any development, an approved development permit, a document stating that the proposed development has been reviewed against the provisions of Edmonton Zoning Bylaw, is required. The development permit is not required for minor developments; some activities, which do not necessitate an approval, are listed below:

- Farm buildings, other than those used as dwellings;
- A single storey accessory building not greater than 10.0 m^2 in floor area;
- Interior alterations and maintenance to a residential building, provided that such alterations and maintenance do not result in an increase in the number of dwellings within the building or on the site, nor in a change of the Use Class or the introduction of another Use Class;
- Interior alterations and maintenance to a non-residential building, including mechanical or electrical work, provided that neither the Use Class nor the intensity of the Use Class is changed, nor that another Use Class is added;
- The erection of any fence, wall or gate not exceeding 1.85 m in height provided that the erection of such structure does not contravene any provision of this or any other bylaw of the City of Edmonton.
- The parking or storage, or both, of any uninhabited recreational vehicle in a residential zone, where such parking or storage fully complies with the regulations of objects prohibited or restricted in residential zones of this bylaw;

- Landscaping, where the existing grade and natural surface drainage pattern is not materially altered, except where Landscaping forms part of a development which requires a Development Permit;
- Minor structures not exceeding 1.8 m in height which are ancillary to residential uses, such as a barbecue, dog house, lawn sculpture or bird feeder.
- Demolition of a building or structure where a Development Permit has been issued for a new development on the same site, and the demolition of the existing building or structure is implicit in that permit.
- The temporary use of a portion of a building or structure for which a Development Permit has been granted under this bylaw, for the marketing of the building or structure; and
- The erection of an uncovered deck that is located entirely within a rear yard, and which has a height of less than 0.6 m, and which is accessory to a residential structure.

Developments are classified in two categories: 1) Class A - Permitted Development and 2) Class B - Discretionary Development (for definitions see Appendix B). The majority of projects requiring building permits, which is approval for the construction of new buildings, additions, interior or exterior alterations to buildings, demolitions, relocating buildings or construction alterations for the purpose of changing the use of a building, also require a development permit. The following projects require both development and building approval: Commercial Change of Use and/or Interior Alterations, New House or Additions (e.g. Garages, Sunroom, Veranda), Detached Garage, Uncovered Deck, Shed Permit.

2.1.6.1 Requirements for building permit application for a house

A development permit and a building permit are required for the construction of all new houses and additions to houses. When considering a new house or an addition to an existing building, it is necessary to research in the property for easements, rights of way or other instruments. Information on these items is found in the land title office.

Additions to houses require the applicant to obtain the permits separately depending on the extent of construction. When making an application for the permits for a new house, the applicant must provide the following drawings and information:

- The municipal address and/or the legal description (lot, block, plan) of the property.
- Three (3) copies of a site plan showing where the buildings are located on the property.
- Three (3) sets of construction plans drawn to a minimum scale of 1:100 (1/4 inch = 1 foot) with dimensions.

2.1.7 Introduction to Alberta Land Titles

The Alberta Land Titles Office is responsible for keeping the records, and transactions related to subdivision plans, and for providing a quick and accurate search for land records in the province. A subdivision plan approved by several authorities such as the local municipal subdivision approval authority is submitted to the Land Titles Office. After the final check for compliance with statutory requirements performed by the Surveys Technologists at Land Titles, the plan is registered with the Alberta Land Titles Automation (ALTA) system. The land subdivided in a city, town, village or acreage subdivision is identified by a new legal description defining the land by plan number, block number and lot number (PBL). The ALTA system systemically generates a plan number for the plan. Plan numbers are now seven digits, with the first two digits designating the year and the third digit designating the Land Titles Office, Calgary being number 1 and Edmonton being number 2. For example, the plan numbered as 7510001 was the first plan registered in 1975 by the Calgary Land Titles Office.

In 1999, the Land Titles Office introduced an electronic system to replace the existing Surveys registration system; it provides advanced facilities such as electronic submission, examination, registration, storage and dissemination of all survey plans in the province, which exceeds 250,000 plans. A web-enabled Spatial Information

System (SPIN) delivers survey plans, survey control marker data, original township plans, and a wide variety of other land related information allowing either parameter-based searches, or graphic, map-based searches of the plan and other land databases. The Alberta Registries & Consumer Services on-line Survey Plan Index (SPIN) system allows province wide search, view, and download of registered plans of survey in TIF image form. All survey plans in the province are searchable either by direct key in of the plan number(s), or by legal description (Alberta Township Survey - ATS) or graphically through viewing and zooming in on the cadastral mapping of the province. Copies of registered plans can be obtained from one of the Land Titles Offices located in Calgary and Edmonton by quoting the plan number and are available on paper, reproducible film or in digital format on either diskette or CD-ROM.

2.2 Current Practices for New Residential Building Project

The construction of a new house (housing project) passes through four phases: 1) preparation and submission of a development/building permit application by the architect/engineer (A/E); 2) the approval and issuing of building permits at the city office; 3) construction of the approved design; and 4) the selling of the house to its prospective owner. Figure 2-1 illustrates the current practices followed for a housing project.

The preparation and submission of the building permit application includes the drafting of the new house drawings and the submission of the building permit application, which includes the application form, site plan and construction plans. The site plan shows the dimensions of the proposed project site, the location of the proposed building, and the existing facilities (power line, gas line, sewer line etc.) on the site. The construction plans for the proposed model include floor plans and elevations of the designed model. The site plan and the construction plan for the proposed model are drawn in compliance with city bylaws and building codes provisions. For drafting the proposed model, A/E identifies the city bylaws and building code provisions applicable to the new house. The number of city bylaws

exceeds several hundred, and the architect has to either memorize the bylaws or manually look for the most updated versions of the bylaws and building code provisions, which makes the drafting of a drawing a time consuming process and one which may result in a non-compliant drawing. Drawings are expected to serve experts from different area of interest as the main medium of integration (Eastman et al. 1998). In addition, the information provided in the drawings is non-systematic, lacking fixed standards to represent the information in the drawings, and therefore drawings cannot be viewed as model drawings.

A hard copy of the CAD drafted design is submitted to the city office for approval of the development/building permit. During the development/building permit approval process, the development officer checks the compliance of the site plan with city bylaws and the safety officer checks the construction plan's compliance with building code provisions. A development officer reviews the application using the regulations of the Land Use Bylaw and issues a Zoning Bylaw Compliance Certificate, which is a Compliance Certificate indicating that a building(s) located on a Site is (are) located in accordance with the Yard regulations of this Bylaw and the Yards specified in the Development Permits which may have been issued for the site. A Building Code Safety Officer reviews the application to prepare the building permit. The Alberta Building Code regulates the construction methods, and materials used, the occupancy, and the equipment for the housing project, which provide for the health and safety of the occupants. The approving authorities go through the same process as the A/E did for assessing the applicable city bylaws and building code provisions. The aforementioned code checking, which requires knowledge of the regulations, awareness of changes, a good understanding of the design process and most importantly skillful personnel is completed manually (Delis, 1995). The non-compliant drawings are rejected and follow the steps of modification according to city laws before being resubmitted for a building permit. If the application is refused, the applicant may appeal the development officer's decision to the Subdivision and Development Appeal Board.

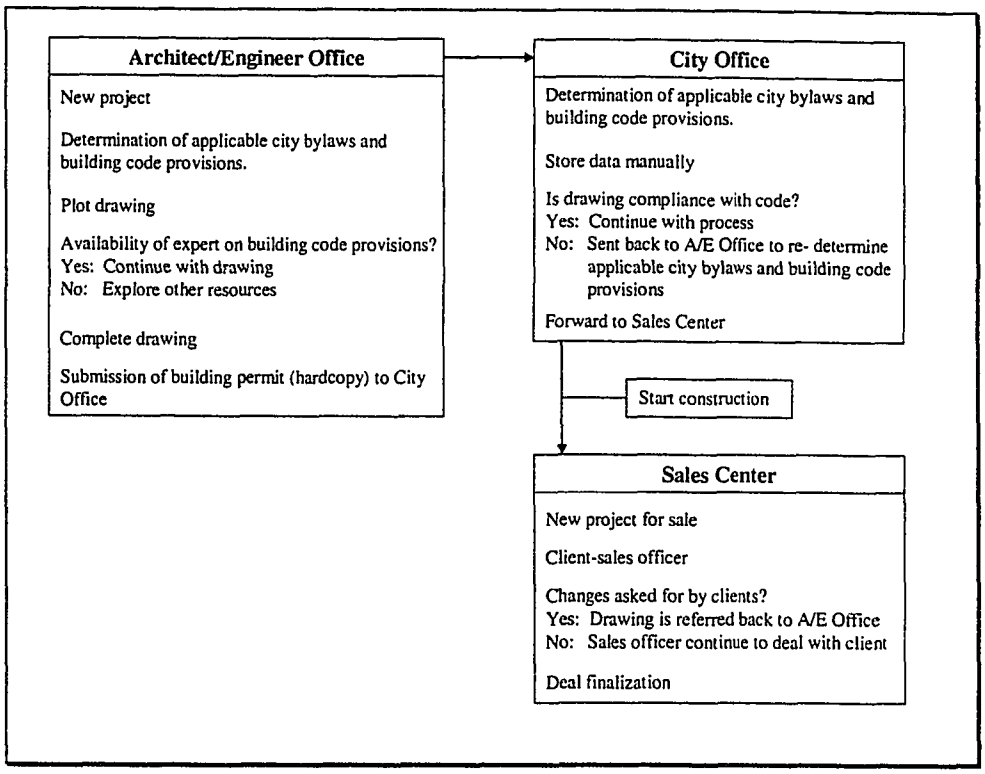


Figure 2-1: Current Practices

The approved building permit leads the way for the start of construction, and the blue prints of the approved model are sent to the sales representative to sell the approved model. Clients at the sales office might demand changes to fulfill their requirements. The most important criteria for evaluating these changes is their compliance with city bylaws and building code provisions, while others include methods by which changes will be implemented and their effect on cost and scheduling. The sales representative, not necessarily an engineer by profession, may find it difficult to answer the queries of prospective owners (clients) regarding the changes made to meet his family needs. In the current system, the requested changes are sent to the architect's office in documented form, and A/E undergo the same process to check their compliance with city bylaws and building code provisions as he did during the design of the project. The sales representative can pursue the proposed deal only after receiving a response from the A/E's office.

Generally, it takes 4-6 weeks to get a response from A/E's office and the City office. Due to this complex, tedious, and time consuming process, most builders are reluctant to allow changes to ongoing projects.

Most of the activities included in the process described above are redundant since the same information stored in the drawings is extracted repeatedly during different phases of the project. By reducing the redundancy, unnecessary time, cost, and errors associated with each phase may be eliminated. In addition, the non-standardized method of presenting information, the submission of hard copies of documents leads to data re-entry, which might consequent in inaccuracies. The issue of integration of the various stages involved in the residential building project has become more critical than ever. There is a need for a greater automation of the building permit process as a whole to bridge the gap between society's demands and the residential industry's supply.

3 PROPOSED METHODOLOGY

This chapter describes the proposed methodology for the development of a integrated system with CAD, which is shared by key players for their respective uses in the housing industry, i.e. the A/E, the approving authorities, and the sales representative. The chapter also describes the system components of the developed prototype.

3.1 Proposed Methodology

The previous chapter described the current practices in the development/building permit approval process for a new house that necessitate the need for capturing and storing drawing information in a database for future use. The research presents a methodology for an automated development permit approval process, which focuses on the development of a integrated system with CAD (ISCAD) and its utilization by the A/E, the approving authorities, and the sales representative at various stages in the housing project. Doing so involves the development of an Information-Processing module (IP), an automation module, a building information database, and a city bylaw database.

The proposed technique presents a new approach for the housing industry, one that allows for automation of the development permit approval process and improves the communication between project participants in a housing project, while maintaining the accessibility of both traditional and advanced computer tools. According to the Edmonton Zoning Bylaws, principal and accessory buildings can be constructed inside the specific boundaries of a site, which have minimum offsets from other existing buildings or facilities. The boundary is known as a building pocket. The details for the proposed buildings and existing facilities are provided by the A/E, leading to the completion of a site plan. Upon the completion of the drawing in specific layers, the drawing data is extracted and stored in a central database. The extracted information is attached to specific objects (polyline) with specific layers, which are recognized using the Visual Basic for Application in AutoCAD. The information, which involves the lot

shape, the site's characteristics, the building's characteristics (height of a new house and attached or detached garage), and design-drawing specifications, is stored in a central database that can be updated as new information becomes available. The information stored in the database is shared by the A/E, the approving authorities, and the sales representative and can be accessed at any time. The approving authorities check the compliance of the site plan drawing with the city bylaws and issue the development permit. If changes are made to the drawing, the data is updated in the central database and changes made to the drawing are checked for their compliance with city bylaws. The benefits of the electronic sharing of project information include the minimization of errors, security and data integrity across the functional applications, as well as improved process efficiency, thus enhancing communication between project team players. Figure 3-1 illustrates the method proposed to develop the proposed methodology.

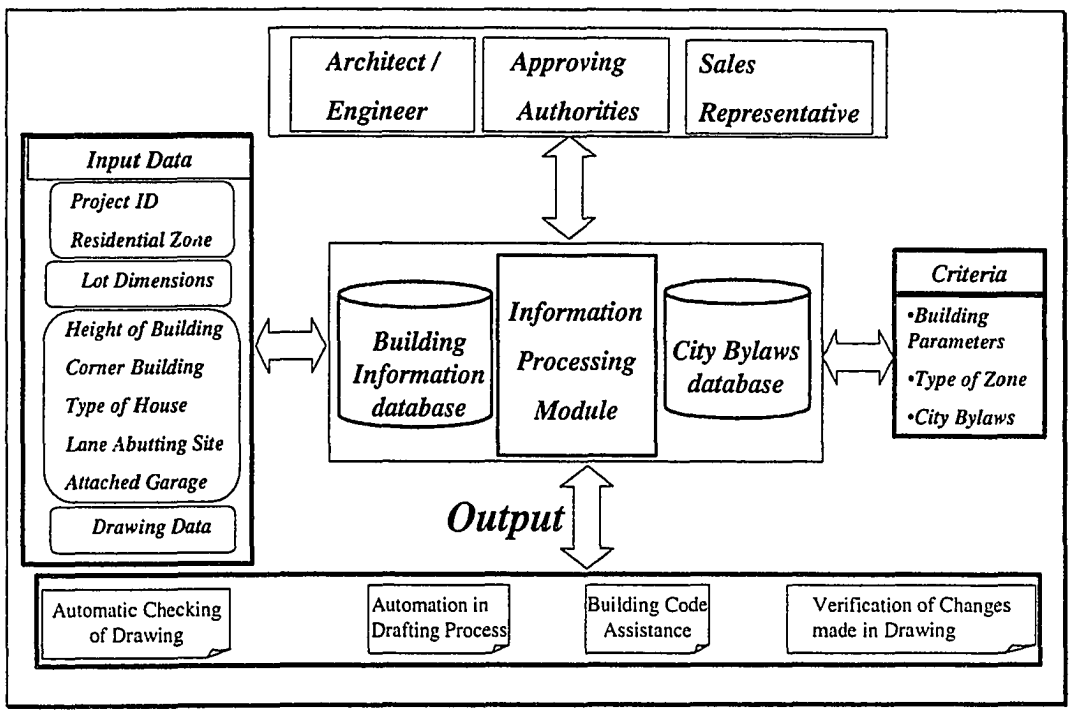


Figure 3-1: Proposed Methodology

3.2 Process Flow in the Proposed Methodology

The construction of a new house follows a four-stage process: preparations of the building permit application, its approval, construction of the house, and the selling of the approved design model. Three of these stages: preparations of the building permit application, its approval, and the selling of the approved design model, are carried out in three different environments: 1) the CAD environment, 2) the city office environment and 3) the sales office environment respectively. Figure 3-2 shows the process flow in CAD Environment. Figure 3-2 shows the process flow in the CAD environment.

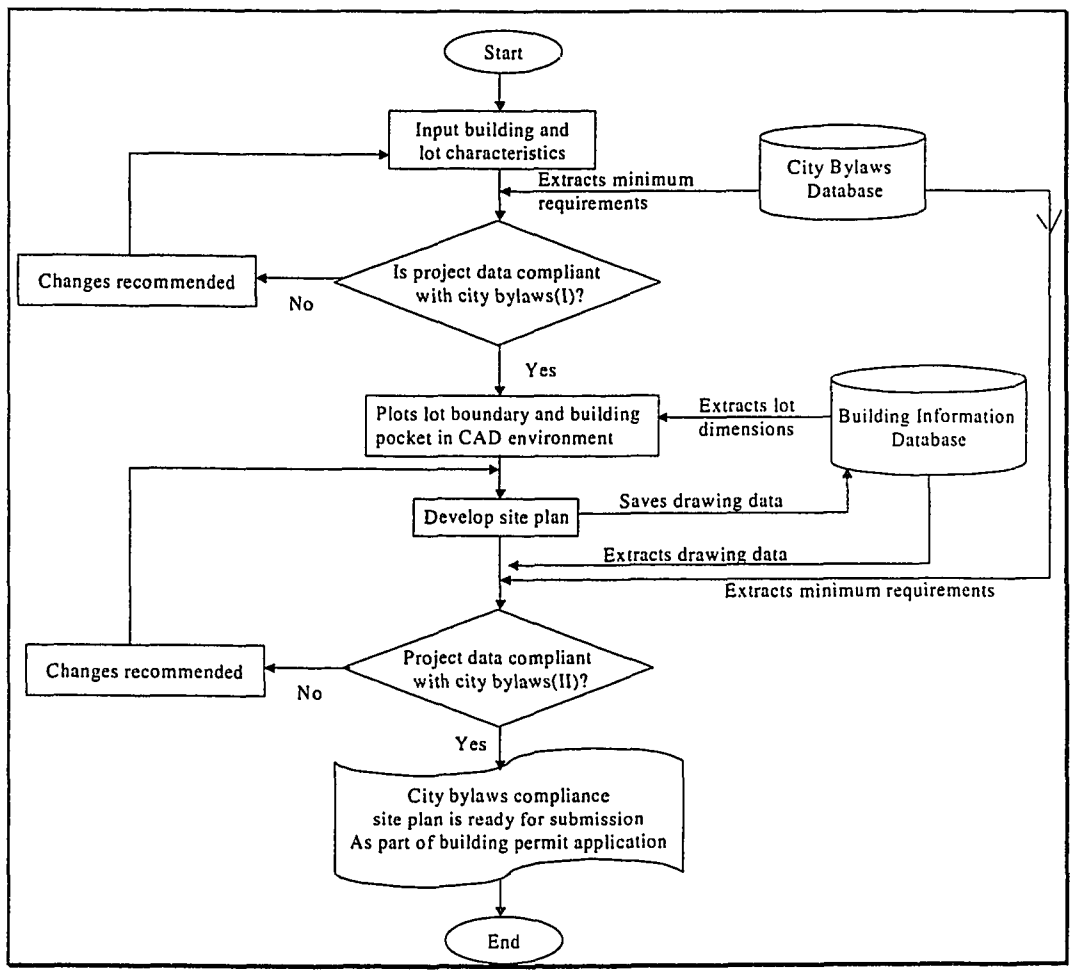


Figure 3-2: Process Flow in the CAD Environment

Note: City bylaws(I) checking checks the minimum requirements for minimum site width, site depth requirements for the residential zones, also described as checking the feasibility of project. City bylaws(II) checking checks the minimum yard and area requirements provisions.

The data flow within the system represents the flow of information between the following processes: the storing lot data into a central database, checking the feasibility of the project, drafting of the building pocket compliance with city bylaws in the CAD environment, extraction of the drawing data, storage of the drawing data in the database, checking the site plan drawings with reference to the city bylaws, and the labeling of the site plan drawing.

For the development permit approval process, the approving authority accesses the site plan information from the central database and checks the site plan with respect to the city bylaws. The aforementioned code checking is completed in which non-compliant objects in the drawings are highlighted, and the development permit is issued instantly. In the sales office environment, the sales representative accesses the instances of the approved design model stored in the central database. Clients at the sales office might demand changes to fulfill their requirements. These changes in the CAD drawing are completed and are updated in the central database. Figure 3-3 illustrates the process flow in the sales office environment.

The updating of the changes is completed in two steps: 1) extraction of the data and 2) updating the database. The compliance of the changes made in the drawing is verified instantly, a process that involves a comparison of the drawing characteristics, stored in the building information database and the minimum requirements stored in the city bylaws database. The highlighting of the non-complying parts provides instant answer for its compliance to the city bylaws.

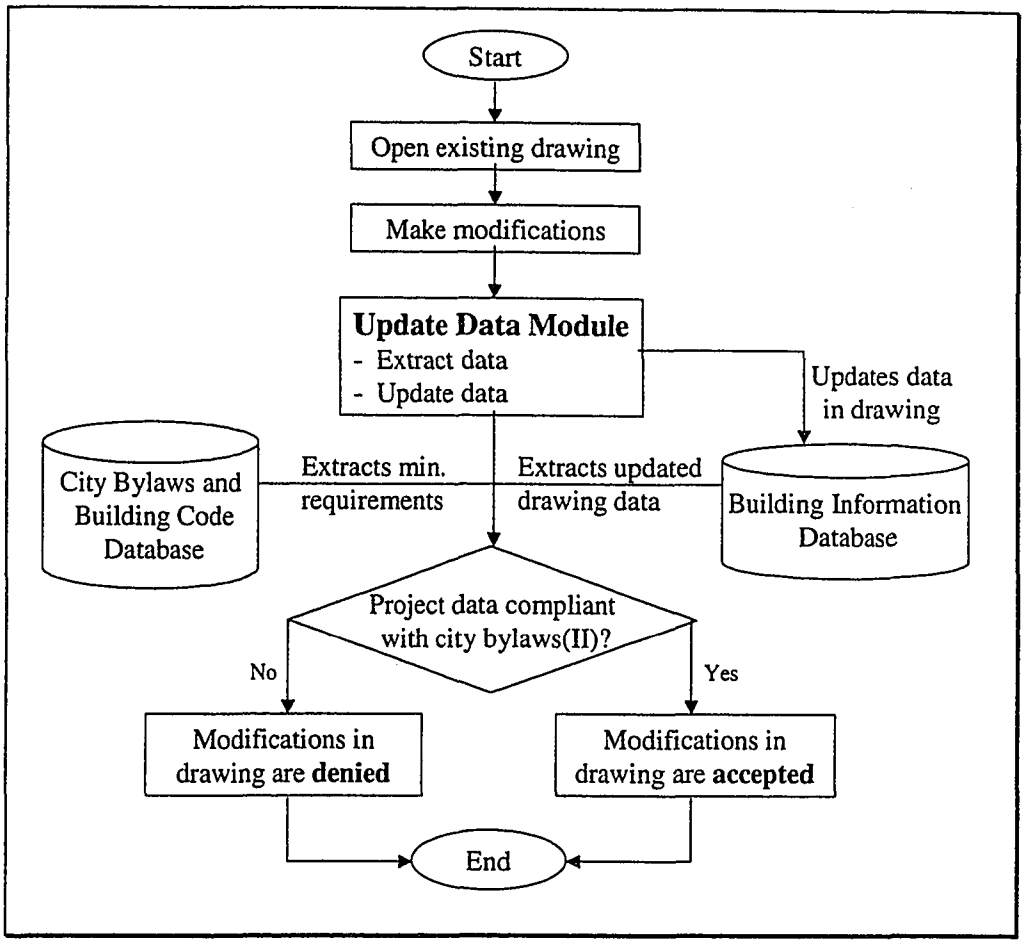


Figure 3-3: Process Flow in the Sales Office Environment

The integration of the processes mentioned in the section 3.2 provides an efficient method for generating a drawing that is compliant with city bylaws; later the system can be used for the verification of changes requested for a particular design. This research involves the development of an error-free system that automates the development permit approval process and provides a tool to the sales officer to verify the changes requested by his/her client. Figure 3-4 illustrates the system components developed in the proposed methodology, which consists of main components: automation module, extraction module, integrated building code assistance module, and IP module.

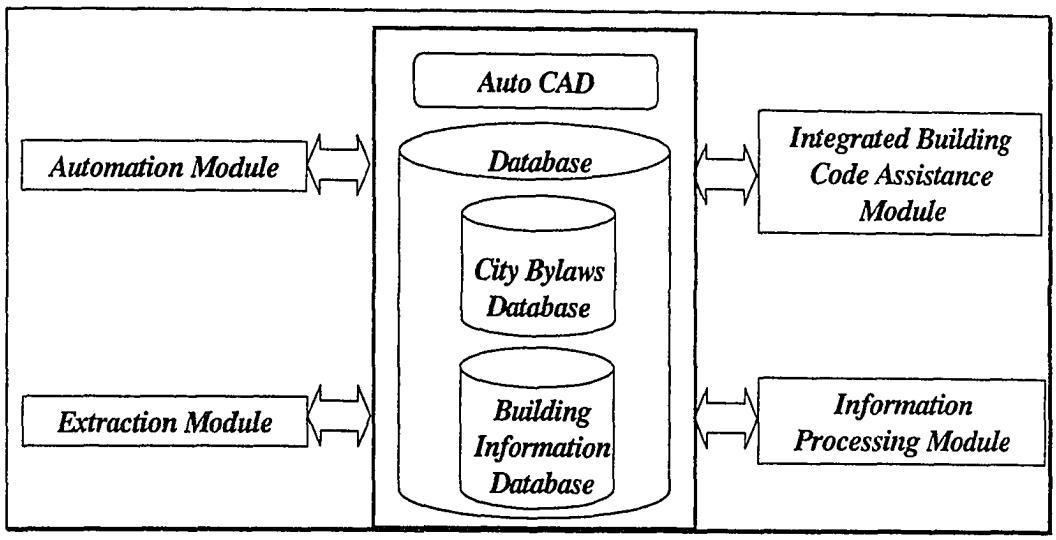


Figure 3-4: System Main Components

3.3 System Central Databases

The two databases have been created to meet the requirements of the end user and to improve the performance functions such as instant data flow between end users. Storing data in database has many advantages: changes in city bylaws provisions are achieved by making changes in instances of city bylaws stored in the database and the participants of a project (the architect, the sales representative, the approving authorities) can access the project data electronically. The development of the databases goes through three main phases: 1) requirements, collection and analysis; 2) the conceptual database design; and 3) implementation of the conceptual design. The requirement collection and analysis of the database were written based on the end user requirements and the functions of the prototype. The result of this step was a concisely written set of user requirements. The data flow diagram techniques were used to determine the functional requirements of the application. The implementation of the conceptual design was achieved through the logical database design and the physical database design. The logical database design involved the implementation of the database using a commercial database. The databases were designed using MS ACCESS, and the conceptual schema was transformed from the level data model to an implementation data model. The result is a database schema in the implementation

data model of the MS ACCESS environment. In the physical database design, the internal storage structure and file organization for the database were specified.

3.3.1 Building Information database

The building information database considers three criteria for the storage of data: 1) the data required in the building permit application form; 2) the city bylaws requirements for the checking of the site plan; and 3) storage of lot data (angles and distances for each side of lot). An applicant's personal data such as the project's owner, the applicant's business name, the contact person and project related information such as the legal address, and the project address are all required for the building permit application form. The second set of criteria, i.e. the city bylaws requirements for checking of the site plan include project's characteristics such as the type of residential zone, the height of building, and the type of land use. Based upon the classification of lot shape, the lot data (distances and angles for each side of the lot) is stored in the building information database.

The conceptual design of the database provides a comprehensive description of the database requirements, highlighting its entities and their respective relationships. The development was carried out using an entity relationship (ER) diagram as shown in . The ER diagram consists of entities, relationships, and attributes, and serves two purposes: effective dataflow throughout the prototype as per requirements and reference for the developer to ensure that all the requirements are modeled without any conflicts between entities and relationships. Entities are basic objects with an independent physical or conceptual existence. The proposed database consists of seven entities: 5 physical entities (project, building etc.), and 2 conceptual entities (i.e. pie shape and plot shapeI). The following section gives a brief outline of the attributes and relationships between entities in the building information database. Weak entities such as pie shape, and plot shapeI store the lot data in the database.

Attributes are the particular properties of the entity type. This database uses different types of attributes such as composite, simple, single value, multi value, derived and

key attributes. The composite attributes such as a lot's legal address, ProjectID, and the applicant's address are a combination of smaller parts, each smaller part having an independent meaning. The project conditions, applicant's personal data, and the characteristics of the building shown in drawing are stored through the use of simple or atomic attributes. Multi-value attributes are used for different lot shapes. Derived attributes are used to calculate the side yard and area of the lot. The key attribute that distinguishes the entities is, in some cases a combination of several attributes. One composite attributes concerning the project is added to the project entity; the key attributes of other entities are derived from it. Relationships: The developed database consists of two types of relationships: 1) ternary relationships such as the relationship between the project, site and building entities and 2) identifying relationships such as the relationship between the residential building project and building permit applicant, as shown in .

3.3.2 City Bylaws database

The City Bylaws database stores the instances of city bylaws provisions for residential zones. The storage of city bylaws instances in the database makes it easy to incorporate future changes in city bylaws. In this prototype, the city bylaws database consists of instances of provisions applicable in four residential zones: 1) the single detached residential zone (RF1); 2) the residential small lot zone (RSL); 3) the low density infill zone (RF2); and 4) the planned lot residential zone (RPL). The instances of provisions in four residential zones are listed in one table having 28 attributes; atomic and null valued attributes are used to store these instances. The attribute "zone name" is primary key of the table.

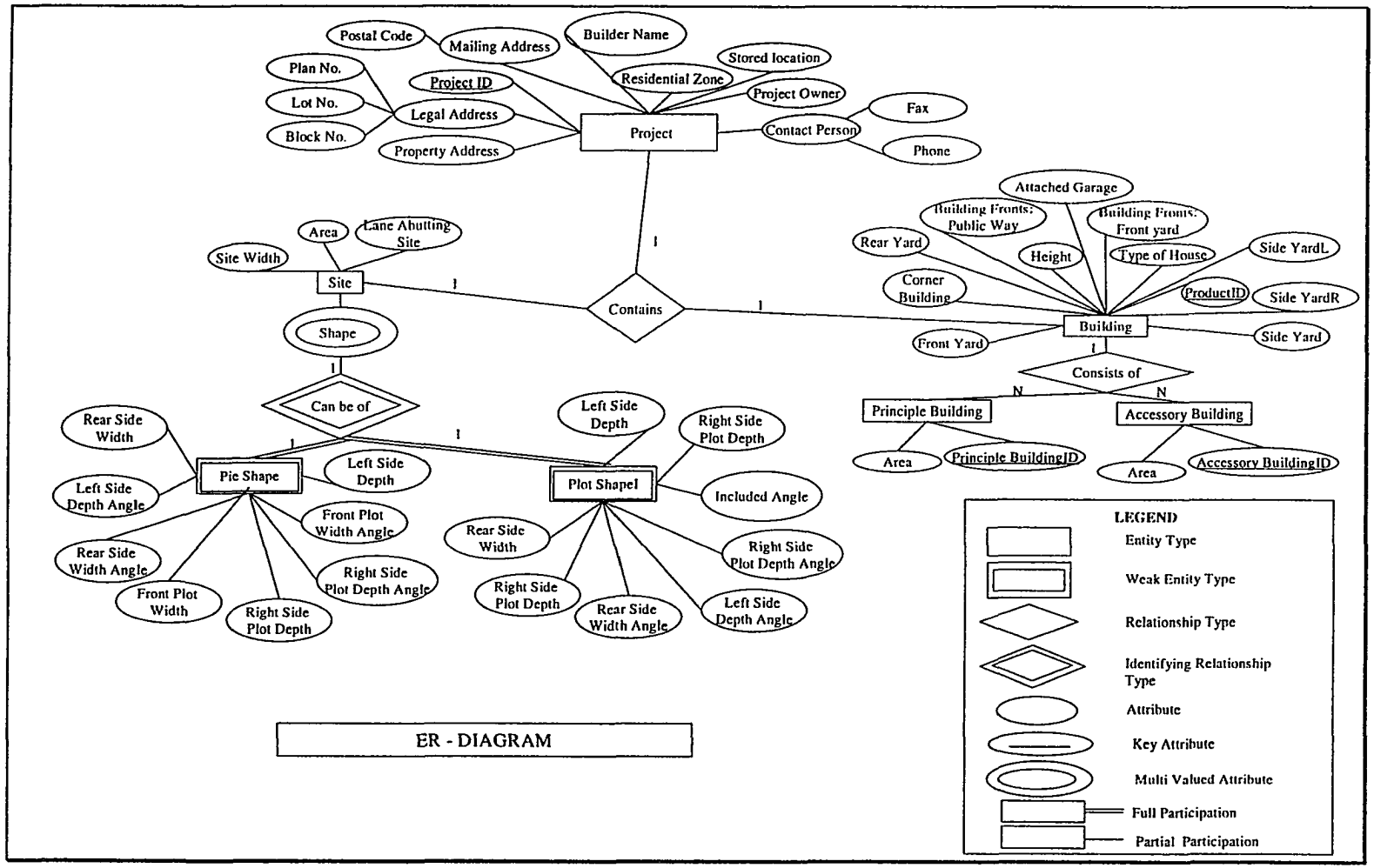


Figure 3-5: ER Diagram for the Building Information Database

3.4 Storing of Lot Data

The proposed system consists of a comprehensive database that contains information about all lots in the city registered in the Alberta Land Title Office. The lots have been classified into two categories: 1) lots for which the building and development permits have been approved and 2) lots for which the building permits are not approved yet. In addition to information about the projects for which the building permits have been approved, the database also contains lot data (the length and angle of each side of a lot) for each lot for which a building permit is not approved yet. The information about the building on a lot is populated later, as the design of the proposed model progresses. The ProjectID, which is a combination of the plan, block and lot number (PIB), recognizes each project in the building information database. The Land Titles of Alberta office keep records for all registered lots. For this research, two subdivision plans having plan number 0226762 and 7722037 (Attached in Appendix A) were downloaded from the SPIN web site. The plan view of the lot site shows the side distances and side bearings of lot, which exists in the subdivision. Figure 3-6 shows the distances and bearing of the lot having plan number 7722037, block number 3 and lot number 4; the ProjectID for the building Information database is 772203734.

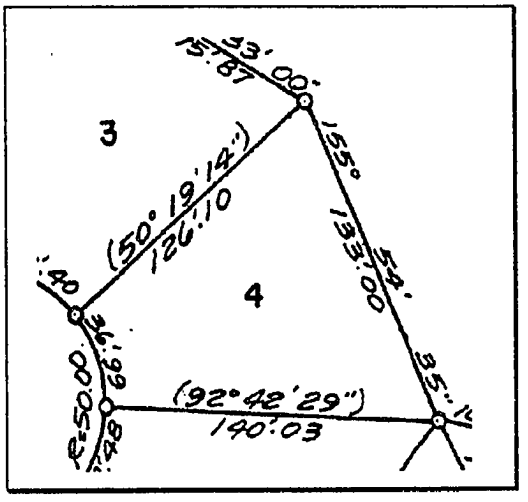


Figure 3-6: Lot Representation in the Subdivision Plan

3.4.1 Classification of lot shapes

The lots in the subdivision plan have been classified based upon lot shapes, and the subdivision plan consists of variety of shapes. These shapes vary from simple such as rectangular, pie to others that are a combination of lines and arcs. A new approach has been used to classify lot shapes; the line in the lot shape is coded as 1 while an arc is coded as 0. The name of the shape starts from the start point of the right side of the lot and runs anticlockwise; Figure 3-7 is coded as 1110. Lot data in the database is stored based on the lot's shape; each lot's shape has a separate table in the database, and attributes of table are a function of a lot shape. From the study of downloaded subdivisions, the lots for single detached houses have been classified into 10 categories; it is also observed that 60-65% of all lot shapes are either category 1111 or 1110.

Table 3-1: Classification of Lot Shapes

No.	Shape Name	Comments
1	1111	Rectangular, trapezoidal, parallelogram and other four sides shape, covered in the prototype
2	11110	Not covered in the prototype
3	111100	Not covered in the prototype
4	11110	Not covered in the prototype
5	1110	Covers three side and arc as front side, covered in the prototype
6	1111000	Not covered in the prototype
7	11111	Not covered in the prototype
8	11101	Not covered in the prototype
9	111110	Not covered in the prototype
10	111000	Not covered in the prototype

3.4.2 Storage of lot data in the central database

The lot shown in Figure 3-7 is composed of three lines and an arc. Sides of a lot can be a line, an arc, or a combination of both. The azimuth of the line with respect to north and its length (either in metric or imperial system) describe the line while the properties of an arc are represented by its length, its radius, and its central angle.

Figure 3-8 shows the Figure 3-7 lot when it is seen from its frontage; it consists of four sides: the right side; the rear side, the left side, and the front side, named AB, BC, CD, and DA from the right side, moving in an anticlockwise direction.

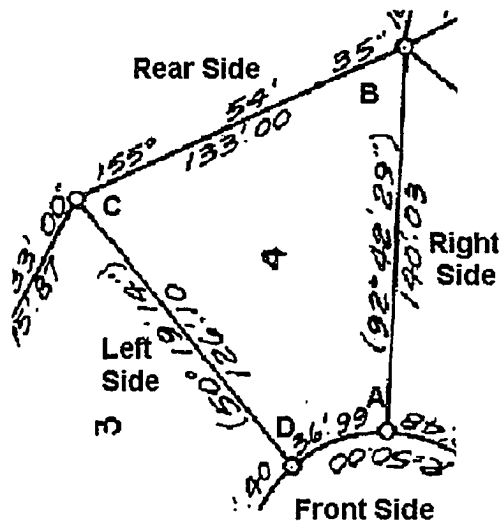


Figure 3-8: Lot Front View

The angle stored in the database is the azimuth angle for a line starting from the start point, i.e. AB, BC, and CD respectively. If the given azimuth in the subdivision plan is for the reverse direction (BA), it is converted to back azimuth by using the equation shown below.

Table 3-3 lists the title name, side name, its graphic element, length and the azimuth of the side of the plot shown in Figure 3-7.

Back Azimuth = Azimuth ±180----------Equation 1

Case 1-------If azimuth <180, back azimuth = azimuth +180

Case2--------If azimuth >180, back azimuth = azimuth -180

Table 3-3: Lot Data for 1110 Shape Type

Title Name	Side Name	Graphic Element	Length (ft)	Angle (degree)	Radius (ft)	Arc Length (Ft)
AB	Right Side	Line	140'. 03	92d42'29"	N.A.	N.A.
BC	Rear Side	Line	133'. 00	335d54'35"	N.A.	N.A.
CD	Left Side	Line	126'. 10	230d19'14"	N.A.	N.A.
DA	Front Side	Arc	N.A.	N.A.	50'. 00	36'. 99

3.5 Extraction of Data

The concept of the data extraction is based on the idea that the components of a proposed model are drawn using specific objects (polyline) with specific layers, objects in the drawing are recognized using the Visual Basic Application in AutoCAD and the properties of the drawn objects are extracted. Layers are like overlays on which various types of information is kept; they are an efficient tool for organizing the drawing. Upon the completion of the drawing in specific layers, the drawing data is extracted and stored in the central database. Figure 3-9 illustrates the process developed for extraction of data from the CAD drawing.

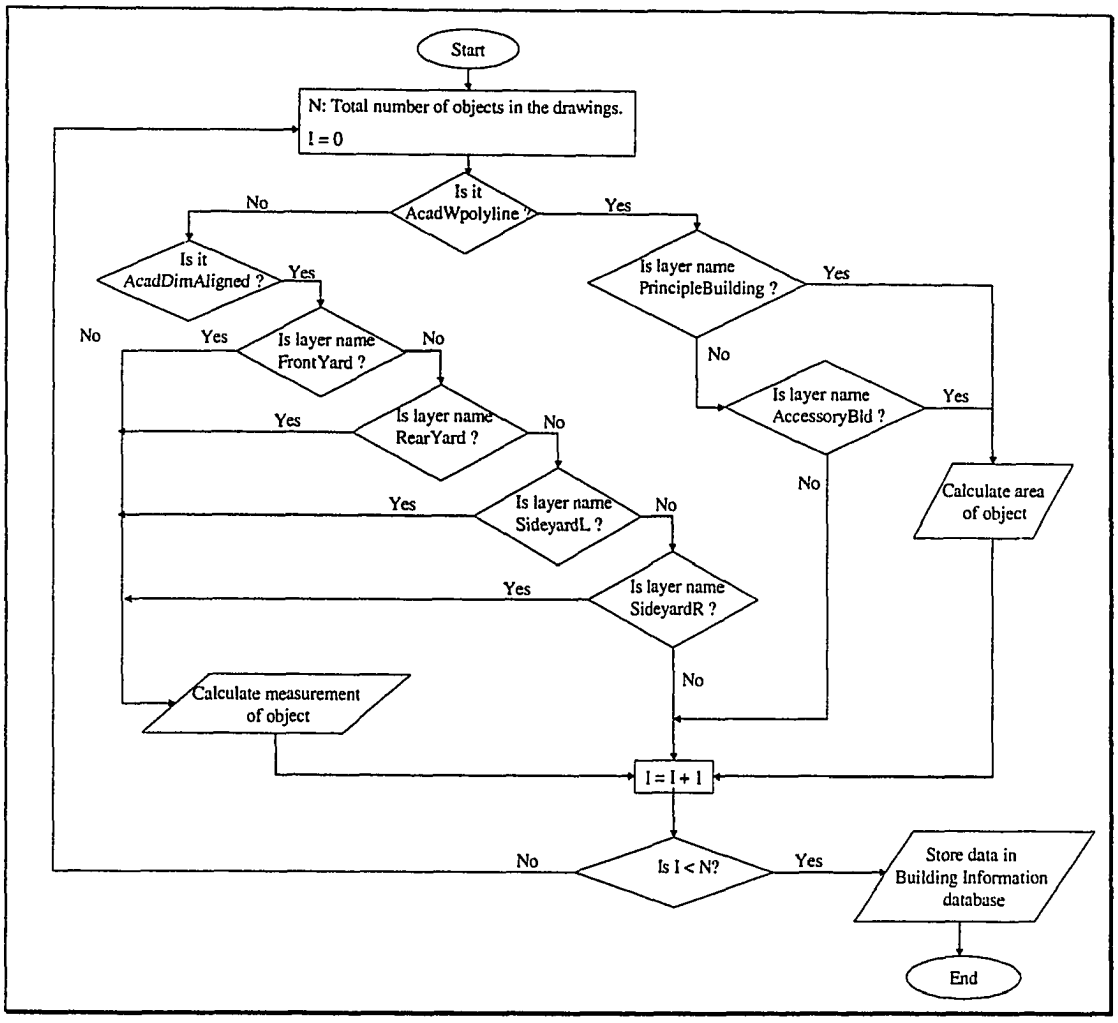


Figure 3-9: Data Extraction Process

3.6 Information Processing (IP) Module

The objective of the IP module is to evaluate the feasibility of the proposed project, calculate the minimum yard requirements and check the compliance of the site plan drawing to city bylaws. The IP module is placed in a central repository, which is shared by the A/E, the approving authorities at the city office, and the sales representative at the sales office as shown in Figure 3-1. The instant accessibility of the IP module to participants in the housing industry not only automates the development permit application process but also eliminates the redundancies involved in the process.

3.6.1 Evaluation of the feasibility of a housing project

The feasibility of the project is determined by checking the project's characteristics with the minimum required specifications of the specific residential zone (for definitions see Appendix B). Residential zones are the specific area where the construction of the single detached, semi detached, duplex, and secondary suit housing projects is permitted. Table 3-5 lists the characteristics of six residential zones from city bylaws #12800 which highlights the name, general purpose, uses (permitted and discretionary), minimum and maximum requirements for the City of Edmonton residential zones. Each zone is unique and there is significant variation of requirements in each zone. The minimum requirements such as minimum site area, minimum site width, and minimum site depth and maximum height for a new house are a function of the residential zone and the type of house. For example, the minimum site area requirement for a single detached residential zone is 360 m^2 /dwelling while the area requirement for a planned lot (RPL) residential zone is 270 m^2 /dwelling.

3.6.2 Calculation for side yards

According to the Edmonton Zoning Bylaw, a building of house can be constructed in the specific area on the lot, i.e. the proposed building must have minimum required offsets from existing buildings or facilities. These minimum required offsets are a function of the type of zone, the height of the building, and the characteristics of the lot such as whether it is a corner building, has an attached or detached garage, and has a lane abutting the site. This section focuses on the effect of the aforementioned listed factors for yard calculation.

Table 3-5: Characteristics and Requirements of Edmonton Residential Zones

Residential Zone Characteristics					Minimum Requirements				Maximum Allowable Site Coverage		
No.	Name of Residential Zone	Purpose	Permitted Use	Discretionary Use	Site Area	Site Width	SD (m)	MAHght	PBAC (%)	ABAC (%)	TAC (%)
1	RF1	Provide SDH primarily	SDH	RSC, SemDH, DH, SS	360 m2 /dwelling	12.0 m	30.0	10.0 m	28	12	40
2	RSL	Provide smaller lot SDH with attached garage	SDH	RSC, SemDH, DH, SS	360 m2 /dwelling	10.4 m, 9m for pie shaped lot	30.0	10.0 m			45
3	RF2	Retain SDH while allowing sensitive infill at a slightly higher density	SDH	RSC, SemDH, DH,SS	360 m2 / SDH,300 m2 / DH or semDH,100 m2 / SS	7.5 m for each DH or semDH, 12.0 m for each SDH with or without SS	30.0	10.0 m)	28	12	40
4	RPL	Provide smaller lot SDH while allowing greater flexibility for infill developments	SDH	RSC	270 m2, 258 m2 when 8.6 < site width< 9.0 m	9.0 m, 8.6 m for up to 30% of the RPL sites within a registered plan of subdivision	30.0	10.0 m	35	17	47
5	RF3	Provide primarily SDH and semDH while allowing small scale conversion and infill redevelopment	DH, SS, SemDH, SDH	RSC, AH, RH, DH & SS other than in permitted areas	360 m2 / SDH,300 m2 / DH or semDH, 200 m2 / RH, 150 m2 RH internal dwelling,100 m2 / SS, 800 m2 /AH or SRH	7.5 m for each DH or SemDH, 12.0 m for each SDH with or without SS, 6.0 m for each RH end dwelling, 5.0 for each RH internal dwelling, 20.0 m for each AH	30.0	10.0 m (	28	12	40
6	RF4	To provide primarily semDH	SemDH, SDH	RSC,DH	360 m2 / SDH, 225 m2 / DH or SemDH, 100 m2 / SS and 300 m2 / DH or semDH within the boundary of MNbhd	7.5 m for each DH or SDH, 12.0 m for each SDH with or without SS	30.0	10.0 m (	28	12	40

Table 3-7: List of Legends used in Table 6

Legend			
RSC	Residential Sales Center	SRH	Stacked row housing
SDH	Single detached housing	MNbhd	Mature Neighborhood
SemDH	Semi Detached Housing	SD	Site Depth
DH	Duplex housing	MAHght	*Maximum allowable height*
SS	Secondary suit	PBAC	Principle building area coverage
AH	Apartment housing	ABAC	Accessory building area coverage
RH	Row housing	TAC	Total Area Coverage

3.6.2.1 Effect of the height of the building

The height of the proposed house plays an important role in the size calculation of the building pocket. The measurement of the height of a house is a function of the type of roof used for the construction. Figure 3-10, shows the height calculation for various roofs.

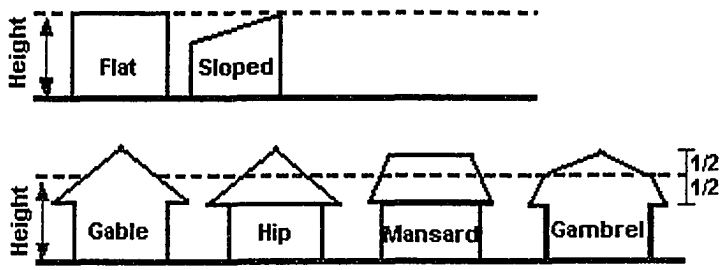


Figure 3-10: Roofs Shape Effect on the Height of the House

The height requirements do not affect the front yard and the rear yard, while side yard (side yardL and side yardR) requirements are a function of the height of the building. The minimum side yard requirement is 2.0 m if the height of the building is more than 7.5m; otherwise it is 1.2 meters, as listed in Table 3-9.

Table 3-9: List of the Effect of the Building Height on Side Yards

Height of House	Minimum Side Yard Requirement
< 7.5 meters	1.2 meters
>7.5 meters	2.0 meters

3.6.2.2 The effect of a building on a corner

On a corner lot, building of a house fronts one of two possible sides: 1) front yard and 2) flanking public roadway as shown in Figure 3-11. In the case of building fronts the Front yard (Right side corner building in Figure 3-11), the minimum side yard abutting the flanking public roadway is 20% of the site width to max of 4.5m. The other minimum side yard is 2.0 and 1.2 meters depending on the height of the building. The building fronting the flanking public road way (Left side corner building in Figure 3-11), have the minimum side yard abutting the flanking road way is 4.5 meters while other minimum side yard is 2.0 and 1.2 meters depending on the height of building For corner building, minimum front yard requirement remains same while for rear yard it is 4.5 m instead of 7.5 as in case of non-corner lot. Table 3-12 shows the minimum rear yard and side yard requirements in case of corner building.

Table 3-12: Corner Building Effect on the Side Yards

		Height of Building	Min. Required Rear Yard	Min. Required Side Yard Abutting the Public Roadway	Min. Required Other Side Yard
Building Fronts	Front Yard	> 7500	4500	20% of site width	2000
	Front Yard	< 7500	4500	20% of site width	1200
	Public Roadway	> 7500	4500	4500	2000
	Public Roadway	< 7500	4500	4500	1200

Note: All dimensions in millimeters.

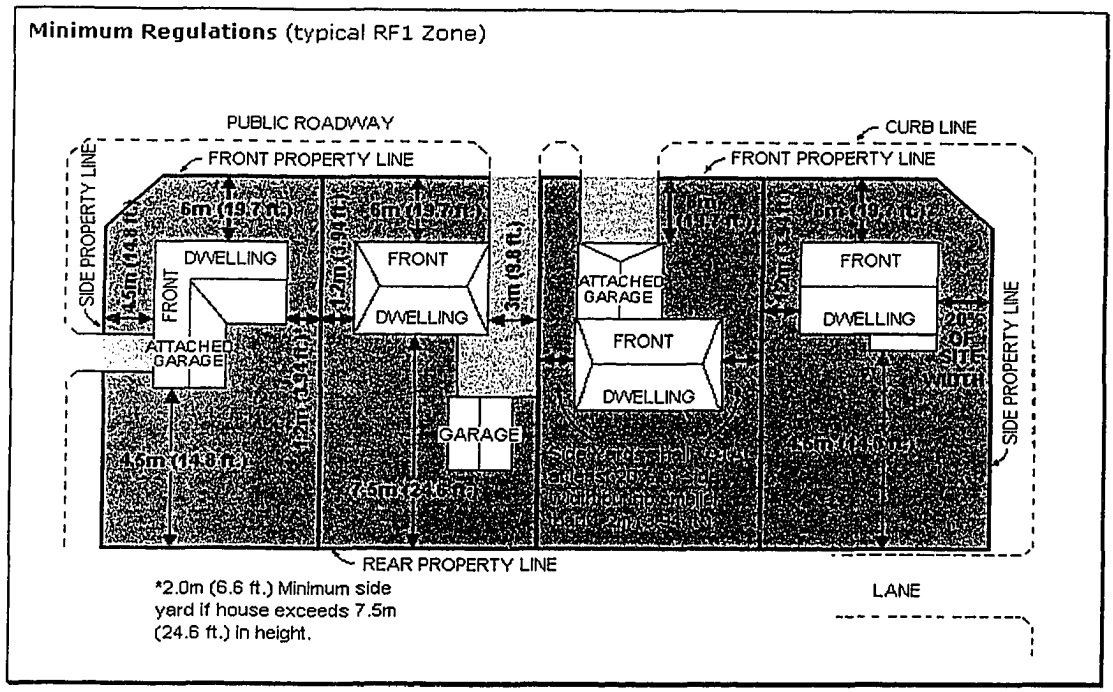


Figure 3-11: Minimum Yard Requirements for RF1 Zone

3.6.2.3 Effect of lane abutting the site

The lane is an alley, which provides an access to a garage from the rear side of the lot. For lots having characteristics such as a lane abutting the site or the proposed building is a detached garage, one of the sideyards has to be 3.0 meter to meet the vehicular access requirements. Detached garages are independent structures separated from the living portion of the residence. The front yard and rear yard are not affected by lane criteria. Table 3-14 shows the combined effect of the lane, the attached garage and the height of the building for the side yard calculations.

Table 3-14: The Effect of Lane Abutting the Site on the Yards Requirements

		Attached Garage	Height of Building	Min. Required Side Yard (only one side yard)	Min. Required Other Side Yard
Lane Abutting the site?	No	No	> 7500	3000	2000
	No	No	< 7500	3000	1200
	Yes	No	> 7500	4500	2000
	Yes	No	< 7500	4500	1200

Note: All dimensions in millimeters.

3.6.2.4 Total side yard rule

The other important rule governing the calculation of the side yard is that total side yard (Side YardL + Side YardR) should be at least 20 % of the site width. The following examples illustrate the total side yard rule. Table 3-16 lists the site and building characteristics used for the given examples.

Table 3-16: Case Example Parameters

	Site Characteristics				Building Characteristics
	Attached Garage	Lane Abutting Site	Corner Building	Site Width (mm)	Height of Building (mm)
Example 1	No	No	No	8000	13000
Example 2	Yes	Yes	No	7000	13000

Note: For definitions of above used terms see Appendix B.

Example 1

Solution:

Minimum Front Yard = 6000mm, Minimum Rear Yard = 7500 mm

Effect of Height: As the height of the proposed house is 8000 mm, so minimum side yards on each side will be 2000mm i.e. SideYardL=2000 mm, SideYardR = 2000 mm

Effect of Corner Building: Not Applicable

Effect of Lane: As the site building characteristics shows that the proposed house is a house with detached garage; no lane is abutting the site. So one of the side yards must be 3000 mm. So in this it has two solutions:

1) SideYardL = 3000 mm, SideYardR = 2000 mm
2) SideYardL = 2000 mm, SideYardR = 3000 mm

Total Side Yard Rule: The sum of both side yards should be at least 20% of site width.

Total side yards = 2000 + 3000 = 5000mm

$$20\% \text{ of site width} = \frac{20 \times 13000}{100}$$

= 2600 mm

Since 5000 > 2600, so in this case total side yard rule is not governing factor and side yards will be such that sum of the side yards should be minimum 5000mm.The solution used by the prototype to develop the building pocket is listed below.

Minimum Front Yard = 6000mm, Minimum Rear Yard = 7500mm
SideYardL = 2000 mm, SideYardR = 3000 mm

Example 2

Solution:

Minimum Front Yard = 6000mm, Minimum Rear Yard = 7500 mm

Effect of Height: As height of the proposed house is 7000 mm, so minimum side yards will be 1200mm i.e. Side YardL = 1200 mm, Side YardR = 1200 mm

Effect of Corner Building: Not Applicable

Effect of Lane: Not Applicable.

Total Side Yard Rule: The sum of both side yards should be at least 20% of site width.

Total side yards = 1200 + 1200 = 2400mm

$$20\% \text{ of site width} = \frac{20 \times 13000}{1000}$$

= 2600 mm

Since 2400 < 2600, here total sum rule governs the side yards and side yards will be such that sum of the side yards should be minimum 2600 mm. Table 3-18 lists the solutions used by the prototype to develop the building pocket for example 1 and 2.

Minimum Front Yard = 6000mm, Minimum Rear Yard = 7500
SideYardL = 1200 mm, Side YardR = 2600 –1200 = 1400 mm

Table 3-18: Yard Dimensions Calculations

	Front Yard	Rear Yard	Side YardR	Side YardL
Example 1	6000	7500	3000	2000
Example 2	6000	7500	1400	1200

Note: All dimensions in millimeters.

3.6.3 Checking the compliance of site plan drawing to city bylaws

Existing CAD systems do not provide advanced functions for the automatic checking of design and drafting errors in drawings. If the knowledge for checking site plan drawings is implemented into computers, CAD systems could automatically check for design and drafting errors. The logic for checking the errors in drawing is based upon rule-based system and is written by using Visual Basic for Application (VBA). The following section describes a method for systematically checking the site plan for a new house.

The developed system checks the site plan for site coverage for principal and accessory buildings and side yards calculations. The regulations for the development of house in the Edmonton Zoning Bylaw are function of following factors:

- Type of residential zones
- Building characteristics such as height of the building and attached or detached garage
- Site characteristics such as lane abutting the site and corner lot.

Based on input conditions, 24 possible cases of site conditions are developed and values of side yards are determined. Table 3-20 lists calculated values for front yard, rear yard, Side YardL, and Side YardR. Based upon project conditions, case number is selected and minimum requirements for that case are fired which are passed to automation module for drafting the building pocket.

Table 3-20: The 4 Cases Used for the Calculations of the Side Yards

Case	Site Conditions						Minimum Yard Values in RF1 Zone			
No.	CB	AG	LA	X30	X31	Height	M.F.yard	M.r.yard	S.YardL	S.YardR
1	T	T	T	T	F	>7500	6000	4500	2000	20%SW - SYL, 2000
2	T	T	T	T	F	<7500	6000	4500	1200	20%SW - SYL, 1200
3	T	T	T	F	T	>7500	6000	4500	4500	20%SW - SYL, 2000
4	T	T	T	F	T	<7500	6000	4500	4500	20%SW - SYL, 1200
5	T	T	F	T	F	>7500	6000	4500	20%SW	2000
6	T	T	F	T	F	<7500	6000	4500	20%SW	1200
7	T	T	F	F	T	>7500	6000	4500	4500	20%SW - SYL, 2000
8	T	T	F	F	T	<7500	6000	4500	4500	20%SW - SYL, 1200
9	T	F	T	T	F	>7500	6000	4500	20%SW	2000
10	T	F	T	T	F	>7500	6000	4500	20%SW	1200
11	T	F	T	F	T	>7500	6000	4500	4500	20%SW - SYL, 2000
12	T	F	T	F	T	>7500	6000	4500	4500	20%SW - SYL, 1200
13	T	F	F	T	F	>7500	6000	4500	20%SW, 3000	2000
14	T	F	F	T	F	<7500	6000	4500	20%SW, 3000	1200
15	T	F	F	F	T	>7500	6000	4500	4500	2000
16	T	F	F	F	T	<7500	6000	4500	4500	1200
17	F	T	T	N.A.	N.A.	<7500	6000	7500	1200	20%SW - SYL, 1200
18	F	T	T	N.A.	N.A.	>7500	6000	7500	2000	20%SW - SYL, 2000
19	F	T	F	N.A.	N.A.	<7500	6000	7500	1200	20%SW - SYL, 1200
20	F	T	F	N.A.	N.A.	>7500	6000	7500	2000	20%SW - SYL, 2000
21	F	F	T	N.A.	N.A.	<7500	6000	7500	1200	20%SW - SYL, 1200
22	F	F	T	N.A.	N.A.	>7500	6000	7500	2000	20%SW - SYL, 2000
23	F	F	F	N.A.	N.A.	<7500	6000	7500	1200	20%SW - SYL, 3000
24	F	F	F	N.A.	N.A.	<7500	6000	7500	2000	20%SW - SYL, 3000

Note: Side yard R = 20%SW - SyardL, 2000 indicates that Side YardR is equal to 20 % of total side yard minus left side yard, but calculated Side YardR must be equal or more than 2000.

Table 3-22: List of Legends used in Table 12

Legend's	
CB: Corner Building	X30 = Building fronts the front yard
Mf yard: maximum front yard	X31 = Building fronts the public road way
M r yard: Maximum allowable rear yard	AG: Attached Garage
S yardL: Side yard left	LA: Lane abutting the site
20%SW = 20% of site width	S yardR: Side yard right
Height: Height of the proposed house	

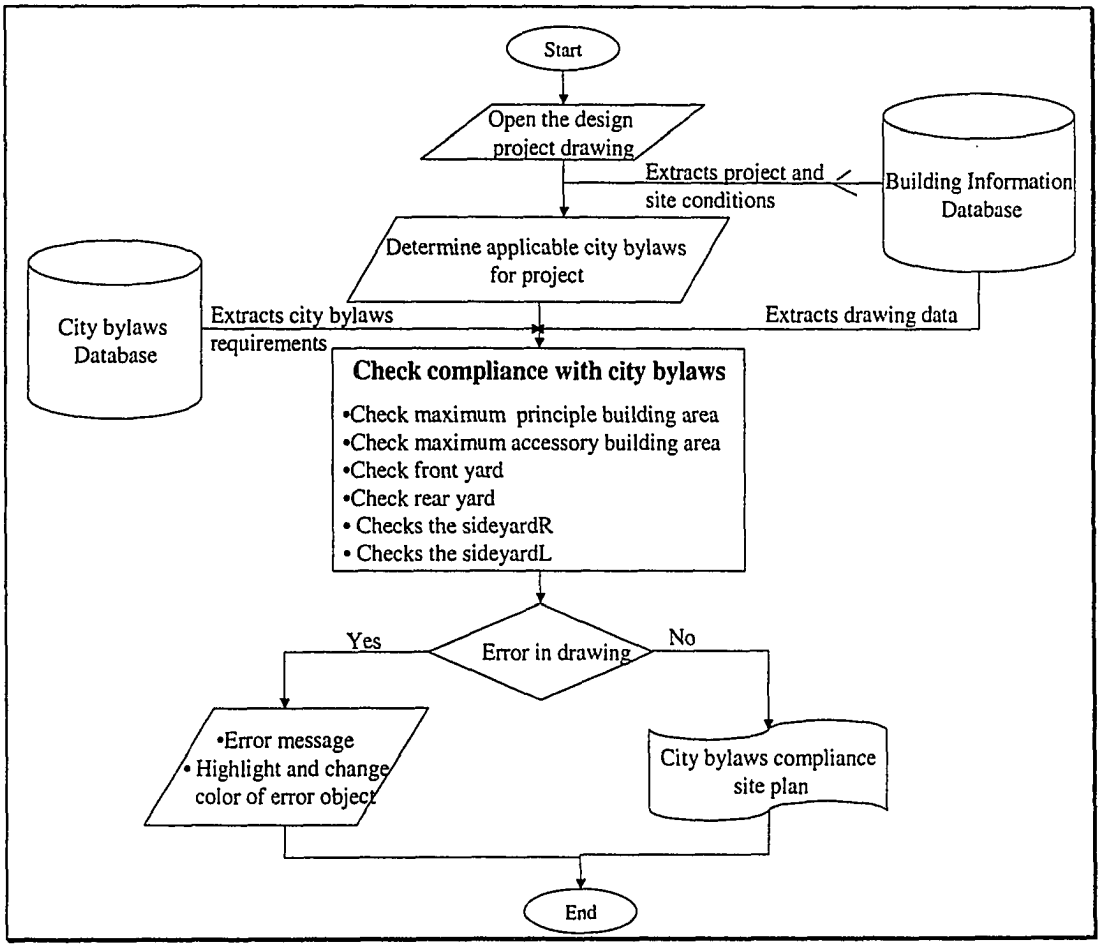


Figure 3-12: Site Plan Checking Process

In the proposed methodology, the calculated minimum requirements are used for two purposes: 1) to provide input data to the automation module, which develops city bylaws compliance building pocket, and 2) to check the yards of the site plan. The

checking of site plan is a comparison of features of the drawings and city bylaws minimum requirements. During the process, instances of the minimum requirements of city bylaws are extracted from the city bylaws database while drawing characteristics are stored in the building information database. illustrates the site plan checking process.

3.7 Integrated Building Codes Assistance Module

The main focus of this research is the automation of the development permit approval process based on city bylaws. However, preparation of construction plans need to be compliant with the National Building Codes of Canada (NBC). Integrated Building Code Assistance provided in the prototype is based upon the National Housing Code (NHC) of Canada 1998 and Illustrated Guide. The National Housing Code and Illustrated Guide (NRCC,1998) presents the "National Building Codes of Canada 1995" requirements for self-contained, single detached, semi detached housing with self-explanatory illustrations. The guide is divided into 16 divisions corresponding to 16 parts of NHC 1) Start-up; 2) Foundation; 3) Floor Framing; 4) Room and Space Dimensions; 5) Means of Egress; 6) Fire Safety and Control; 7) Wall System; 8) Roofing; 9) Windows, Skylights and doors; 10) Fireplaces, Chimneys and Flues; 11) Insulation, Air Barriers Systems and Vapor Barriers; 12) Mechanical System; 13) Plumbing and Electrical facilities; 14) Interiors Finishes; 15) Exterior Finishes; and 16) Garages and Carports. The NHC contains the extracts from the NBC 1995 that apply to housing and is best on illustrations.

Residential buildings must be designed and constructed to to provide the required amount of space to suit the intended use of all rooms and allow adequate headroom to suit typical uses of room,to accommodate people, furniture, and appliances while still allowing movement within a room or space, and to form the basis of the prescribed minimum requirements in the code. It is also intended that all dwelling units contain certain types of room for specific purposes. Every dwelling unit must have at least one separate bathroom and space for a function such as sleeping, the preparation and

eating of meals, and a living area must be allocated with the minimum required ceiling height, floor area and dimensions. Ceiling heights, floors area and minimum dimensions are measured between finished surfaces. Minimum floor area does not include closets or built in bedroom cabinets unless stated otherwise. Two or more adjacent areas are considered to be a combination room if the wall dividing them occupies less than 60% of the separating plane. Figure 3-14 illustrates these conventions as they apply to the code.

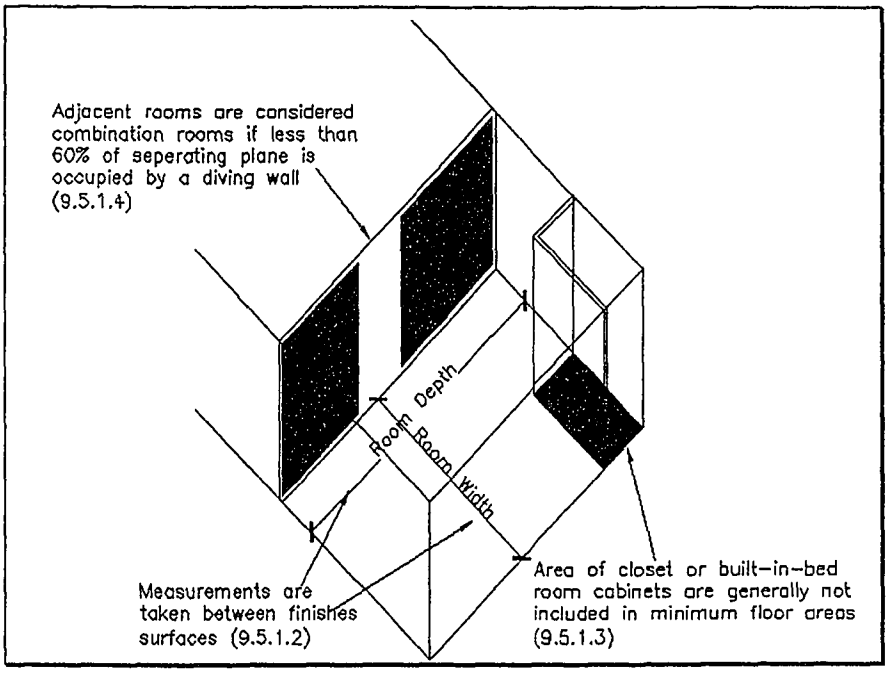


Figure 3-14: Requirements for Dimensions & Areas for Rooms and Spaces

The developed system provides assistance on "Room and Space Dimensions" division which lists the minimum ceiling height, floor area and dimensions required for variety of intended uses. The code requirements for minimum ceiling heights, floor areas and dimensions are illustrated in Figure 3-15 through Figure 3-17.

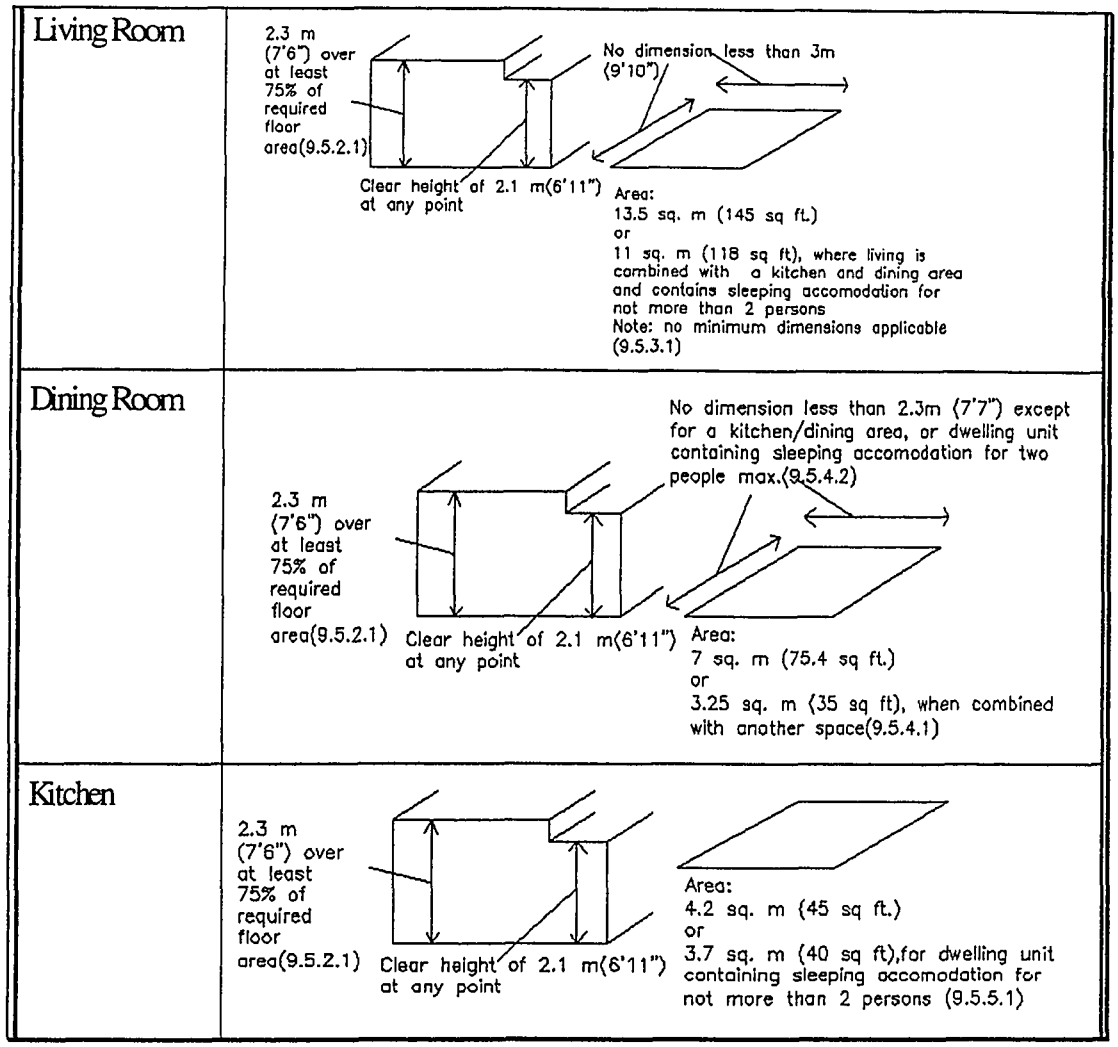


Figure 3-15: Room Minimum Requirements: Height, Space and Dimensions (1/3)

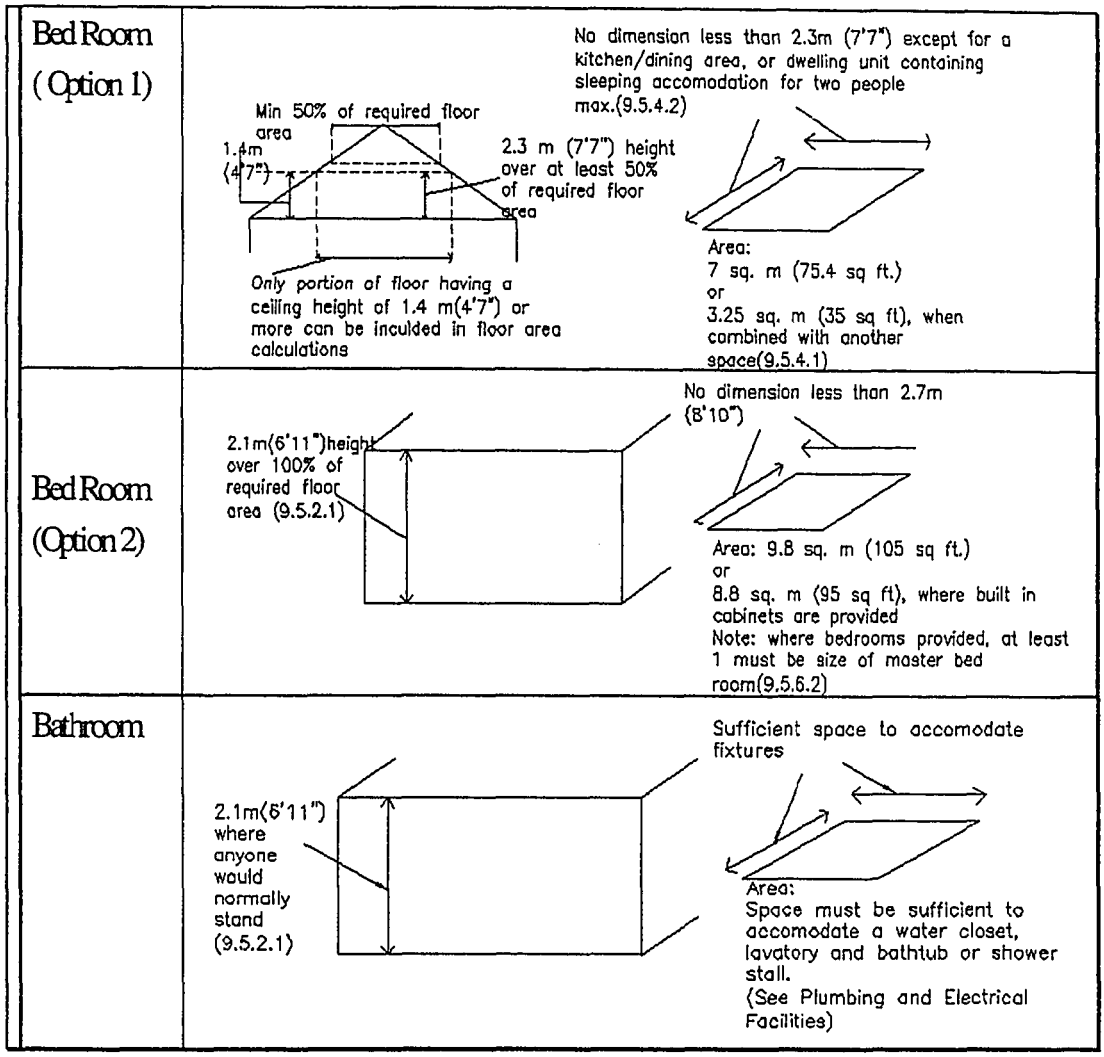


Figure 3-16: Room Minimum Requirements: Height, Space and Dimensions (2/3)

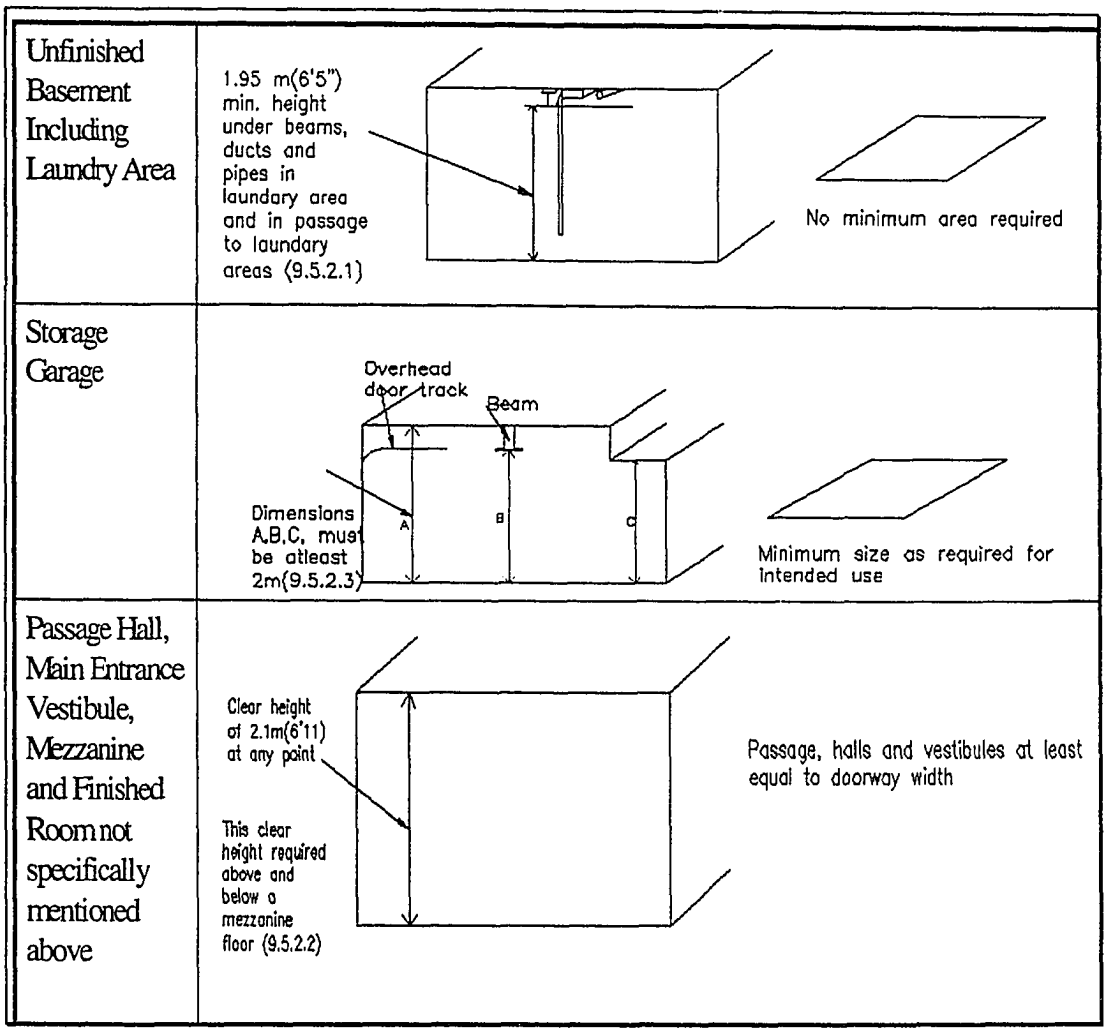


Figure 3-17: Room Minimum Requirements: Height, Space and Dimensions (3/3)

The minimum requirements as shown above are drawn in CAD drawings, which are stored on depository (hard drive). A query system is developed based on Space Name and User requirements, i.e. query for space, query for dimensions, query for both space and dimensions. Based on combinations of queries, the CAD drawing representing the minimum requirements is accessed from the repository.

4 IMPLEMENTATION OF PROPOSED METHODOLOGY

This chapter describes the implementation of the methodology proposed for developing an integrate system with CAD, which is shared by key players in the housing industry (the A/E, the approving authorities, and the sales representative) and used in their respective areas. It also explains the design, hardware and software requirements and functions of the developed prototype. A detailed description of this prototype encompassing advantage and limitations is also provided.

4.1 Prototype Design

The Integrated System with CAD (ISCAD) is a prototype for automating the development permits approval process; it provides significant gains in productivity and accuracy over current practices. The prototype is centered on the concept of development of central repository (information processing module and central databases), which is shared by the A/E, the approving authorities, and the sales representative and employed in their respective areas. It consists of a user-friendly CAD interface, an automation module, a IP module and two databases: 1) Building Information Database, and 2) City Bylaws Database as shown in Figure 3-4. AutoCAD is linked with the databases using data access objects (DAO), which stores drawings and project information. Automation in the CAD environment for the purpose of drafting is achieved by customizing AutoCAD, which takes care of routine and repetitive operations making them simpler in an automated manner. For automation in CAD, visual basic for application (VBA) is utilized to automate the design of lot size. The building codes clauses for design of a house are explained in the integrated building code assistance module, which provides a better drafting environment. To facilitate the comprehension of features within the application, a series of captured screens are used to illustrate the developed prototype. The following section explains the implementation of the components of the developed prototype.

4.2 Development of Databases

Project information, drawing data and instances of city bylaws are stored in the two databases. The tables of the databases are accessible to the system designer but hidden from the end user. One significant advantage of storing data in an external database is that it makes project data easily available to all participants in the housing industry. The following section explains the implementation of the databases used in the prototype.

4.2.1 Development of building information databases

This aims at developing the database schema utilizing the ER-diagram by mapping its entities, relationships, and attributes within DBMS. The proposed data model as presented in the ER diagram supports seven entities and their relationships. Each entity and each relationship has been structured and its related attributes have been added. Figure 4-1 shows the tables and their relations used in the building information database. Each entity is assigned its data type (text, numeric etc.), its constraints, and its data integrity functions. Each table has its own key attribute(s) or foreign key(s). For example, Project table has 18 different attributes describing the project, its owner, its legal address and ProjectID, which identifies each project stored in the database. Similarly all entities and relationships are mapped into tables. These relations are actual links that have been defined in the Microsoft Access. The bold key indicates the primary key in a table, and a connector line between two tables indicates a relationship. The main table in the database is the Project table, shown in Figure 4-2. The construction project must have one site, so the Site table is weak entity of the Project table. Site's shape attribute is multi value attribute, so two table: pie shape and plot shapeI, are dependent on the Site table. The new houses have buildings on site, which are categorized in two types: 1) principle buildings and 2) accessory building. So the building table has one to many relationships with both Accessory Building and Principle Building table. Each table has its own function. The following is a description of each table in the database, listed in alphabetical order.

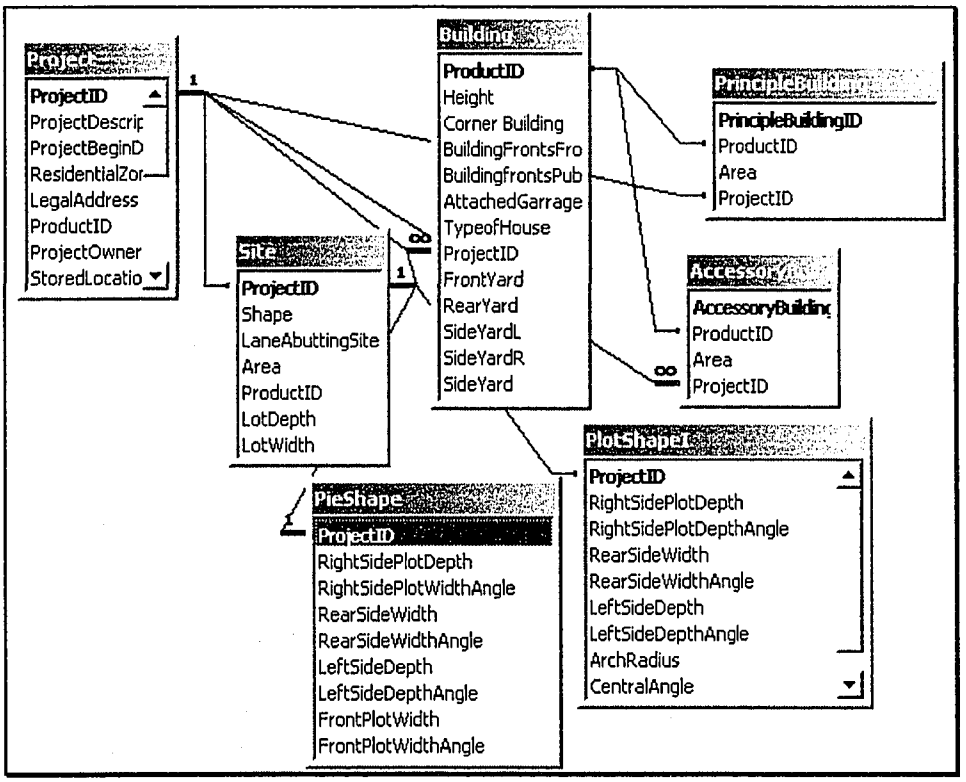
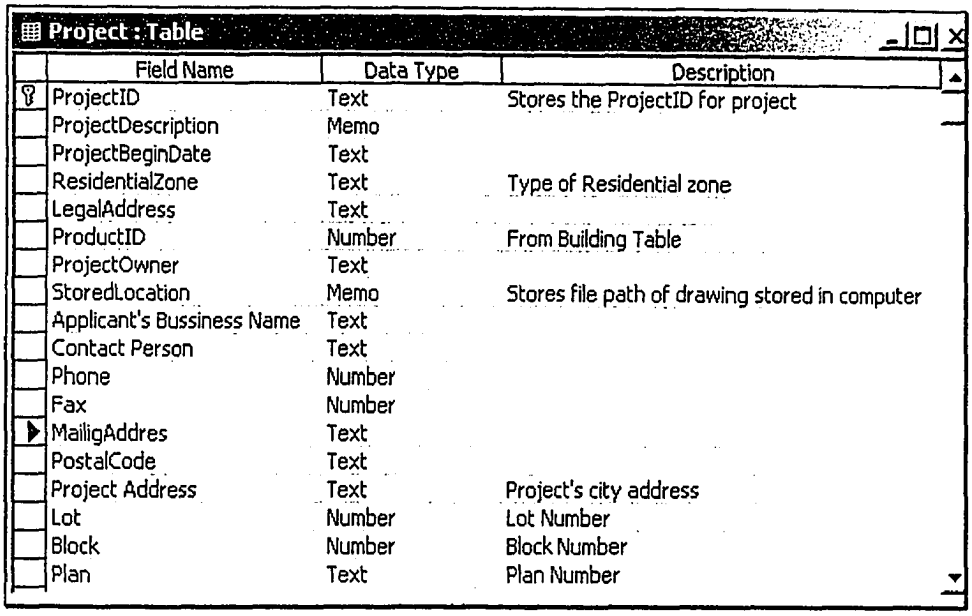


Figure 4-1: Mapped Entities in Access Database

4.2.1.1 Tables in the Building Information database

Project: This table has primary key ProjectID, which is a combination of plan, block and lot number, and stores project information such as project owner, legal and city addresses. It links to the Building table by storing its primary key. Building permit applicant data such as contact person and fax number is also stored. Other relevant information such as the residential zone of the proposed house and its stored location (path of saved drawing) is also stored in the table. Figure 4-2 lists the attributes and their data type for the project table.



Project : Table

Field Name	Data Type	Description
ProjectID	Text	Stores the ProjectID for project
ProjectDescription	Memo	
ProjectBeginDate	Text	
ResidentialZone	Text	Type of Residential zone
LegalAddress	Text	
ProductID	Number	From Building Table
ProjectOwner	Text	
StoredLocation	Memo	Stores file path of drawing stored in computer
Applicant's Bussiness Name	Text	
Contact Person	Text	
Phone	Number	
Fax	Number	
MailigAddres	Text	
PostalCode	Text	
Project Address	Text	Project's city address
Lot	Number	Lot Number
Block	Number	Block Number
Plan	Text	Plan Number

Figure 4-2: Data Type for Project Table's Attributes

Building: Similar to the project table, building table contains the characteristics of the building proposed for the site; these characteristics are divided in two categories of attributes: 1) non-derived attributes, and 2) derived attributes. The user at the start of the project enters non-derived attributes such as height, corner building, building fronts, and type of house. Derived attribute such as SideYard is sum of two attributes i.e. SideyardL and SideyardR. The ProjectID links the table to the Project table.

Site: This table is a weak entity and is dependent on the ProjectID. It stores site characteristics having both derived and non-derived attributes i.e. area and lot width. PieShape & PlotShapeI: tables store the lot data of shapes 1111 and 1110 respectively. The lot shapes are values of multiple attributes of attribute shape belonging to the site entity. ProjectID identifies the lot shape tables, a weak entity of the Site table. As discussed in the methodology, shape 1111 represents the rectangular, pie shaped, wedge shaped and other four sided lot shapes. PieShape and PlotShapeI consist of 9 and 8 attributes respectively, which represents the measurements and angles of each shape.

Principle Building & Accessory Building: This table stores the area of the site used for the construction of principle and accessory buildings respectively. Both tables have primary key, which is derived from the ProjectID.

4.2.1.2 Queries in the Building Information database

The flow of information from the Building Information database is divided in three categories: 1) from CAD environment to database; 2) from database to CAD environment; and 3) updating data. Figure 4-3 illustrates the flow of information throughout the prototype. The Building Information database consists of 11 parametric queries, which fulfills various functions in the prototype.

Table 4-1 shows the list of queries developed in the prototype, which are activated by DAO.

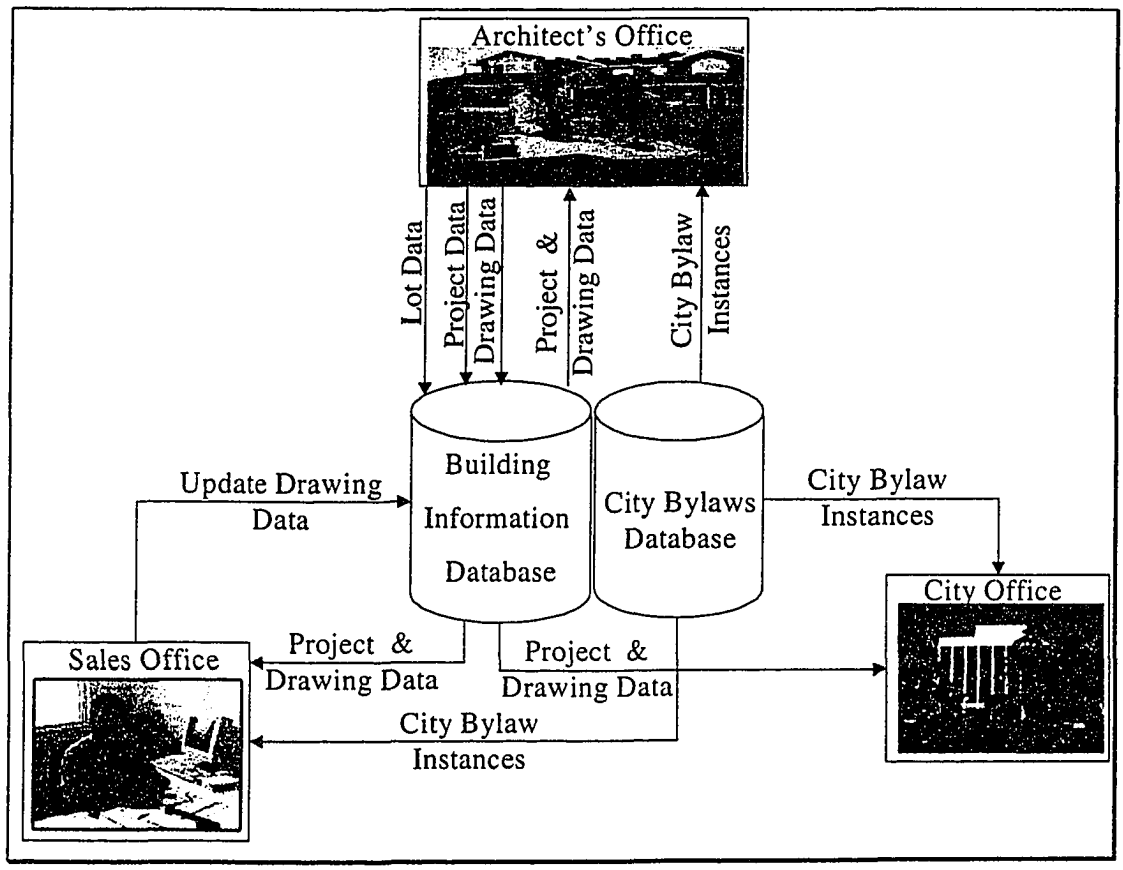


Figure 4-3: Data Transactions in the Prototype

Table 4-1: List of Queries in the Building Information Database

No.	Type of Query	Name of Query	Function of Query
1		ShapeQuery	Determines the lot shape
2	Select Queries	PieShapeQuery	Determines site and building characterstics,yard values for 1111 lot shape
3		PlotShapeIQuery	Determines site and building characterstics,yard values for 1110 lot shape
4		BuildingHeight	Determines the height of the proposed house
5		PieShapePlotData	Determine the lot data for lot shape 1111from BID
6		ShapeIPlotData	Determine the lot data for lot shape 1110 from BID
7		FindLocation	Extracts the paths of saved drawing from BID
8		LabelQuery	Determines data from BID and information is labelled in site plan
9	Update Queries	ProjectData	Stores the extracted drawing data in the BID
10		SiteConditions	Populates the site/building characterstics at the start of the project
11		UpdateQuery	Updates the extracted drawing data in the BID

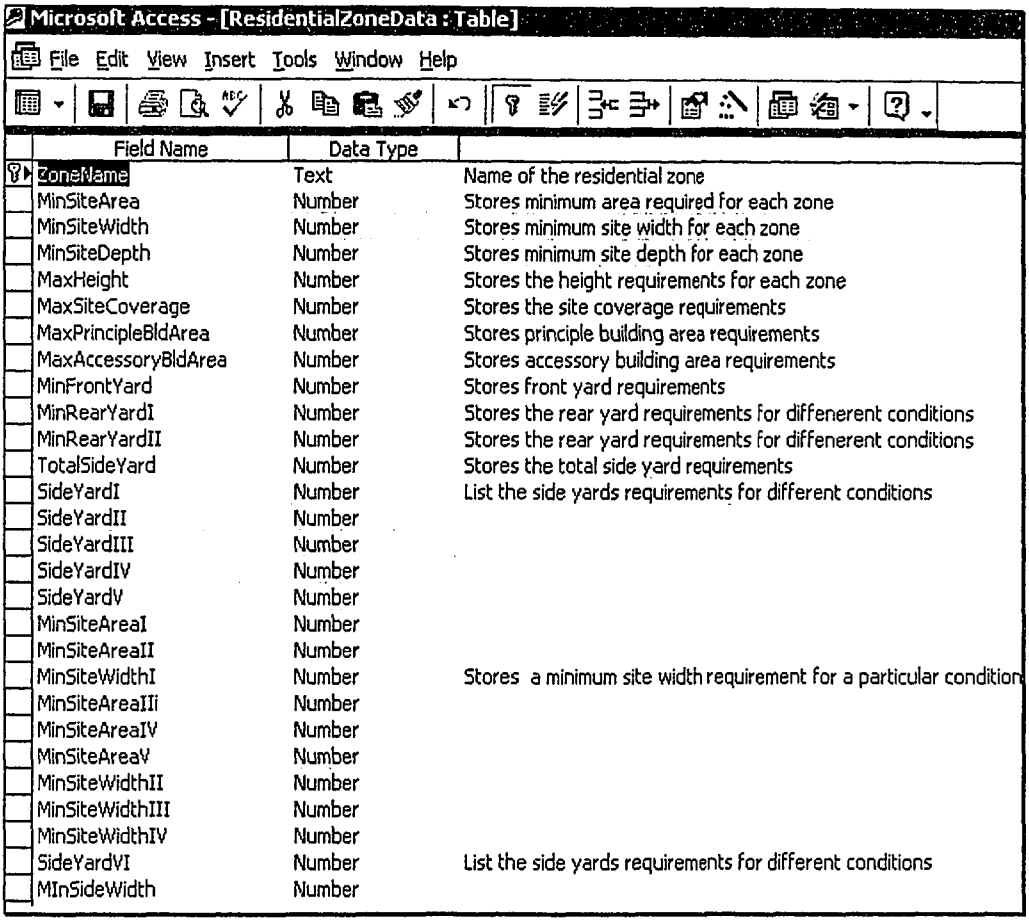
Note: BID represents the building information database.

The AddNewData function creates new instances for project in the building information database; it create the ProjectID for Project, Building, Accessory Building and Principle Building tables and also stores lot data in the shape table, depending upon shape of the lot. The attributes describing the site and building characteristics are kept blank; Update queries such as ProjectData and SiteConditions populate the database as A/E progresses in the site plan design. Select queries are used to extract the data from the building information database.

4.2.2 Implementation of the City Bylaws database

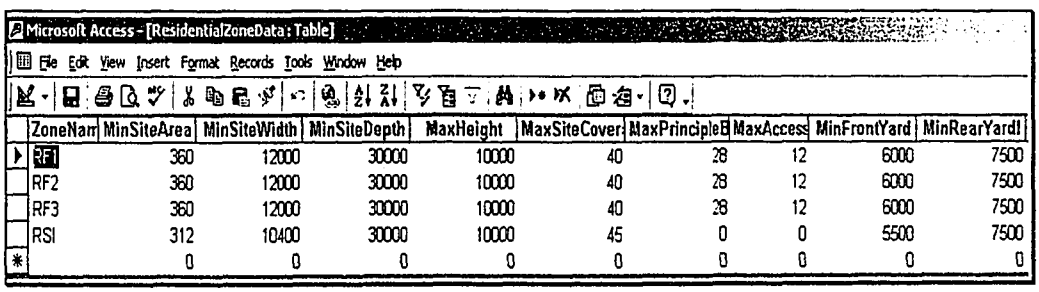
The City Bylaws database stores the instances of the city bylaw provisions, which are stored in the ResidentialZoneData table. The 28 attributes of the table stores the

minimum requirements for the site width, the side yard, the height etc. in four residential zones. Figure 4-4 lists the name and description of the attributes of the ResidentialZoneData table. Figure 4-5 is captured screen of the sample of instances of the ResidentialZoneData table. The Database RF1query is used to extract the instances of city bylaws from the City Bylaws database.



Field Name	Data Type	
ZoneName	Text	Name of the residential zone
MinSiteArea	Number	Stores minimum area required for each zone
MinSiteWidth	Number	Stores minimum site width for each zone
MinSiteDepth	Number	Stores minimum site depth for each zone
MaxHeight	Number	Stores the height requirements for each zone
MaxSiteCoverage	Number	Stores the site coverage requirements
MaxPrincipleBldArea	Number	Stores principle building area requirements
MaxAccessoryBldArea	Number	Stores accessory building area requirements
MinFrontYard	Number	Stores front yard requirements
MinRearYardI	Number	Stores the rear yard requirements for diffenerent conditions
MinRearYardII	Number	Stores the rear yard requirements for diffenerent conditions
TotalSideYard	Number	Stores the total side yard requirements
SideYardI	Number	List the side yards requirements for different conditions
SideYardII	Number	
SideYardIII	Number	
SideYardIV	Number	
SideYardV	Number	
MinSiteAreaI	Number	
MinSiteAreaII	Number	
MinSiteWidthI	Number	Stores a minimum site width requirement for a particular condition
MinSiteAreaIIi	Number	
MinSiteAreaIV	Number	
MinSiteAreaV	Number	
MinSiteWidthII	Number	
MinSiteWidthIII	Number	
MinSiteWidthIV	Number	
SideYardVI	Number	List the side yards requirements for different conditions
MInSideWidth	Number	

Figure 4-4: List of Attributes of the ResidentialZoneData Table



ZoneNam	MinSiteArea	MinSiteWidth	MinSiteDepth	MaxHeight	MaxSiteCover	MaxPrincipleB	MaxAccess	MinFrontYard	MinRearYardI
RF1	360	12000	30000	10000	40	28	12	6000	7500
RF2	360	12000	30000	10000	40	28	12	6000	7500
RF3	360	12000	30000	10000	40	28	12	6000	7500
RSI	312	10400	30000	10000	45	0	0	5500	7500
	0	0	0	0	0	0	0	0	0

Figure 4-5: Sample Instances of the ResidentialZoneData Table

4.3 Storing of Lot Data in the ISCAD System

Figure 4-6 shows a captured screen from the Integrated System with CAD for storage of lot data in the central database. The New Project tab shown in Figure 4-6 contains three frames: Search ProjectID, Project Data and Store Lot Data. The mouse click on the Search Existing Project button in the Search ProjectID frame accesses the building information database and verifies the existence of lot data in the database. A mouse click on the Search Existing Button activates the ProjectData query in the building information database and makes the search for the Project ID entered by user.

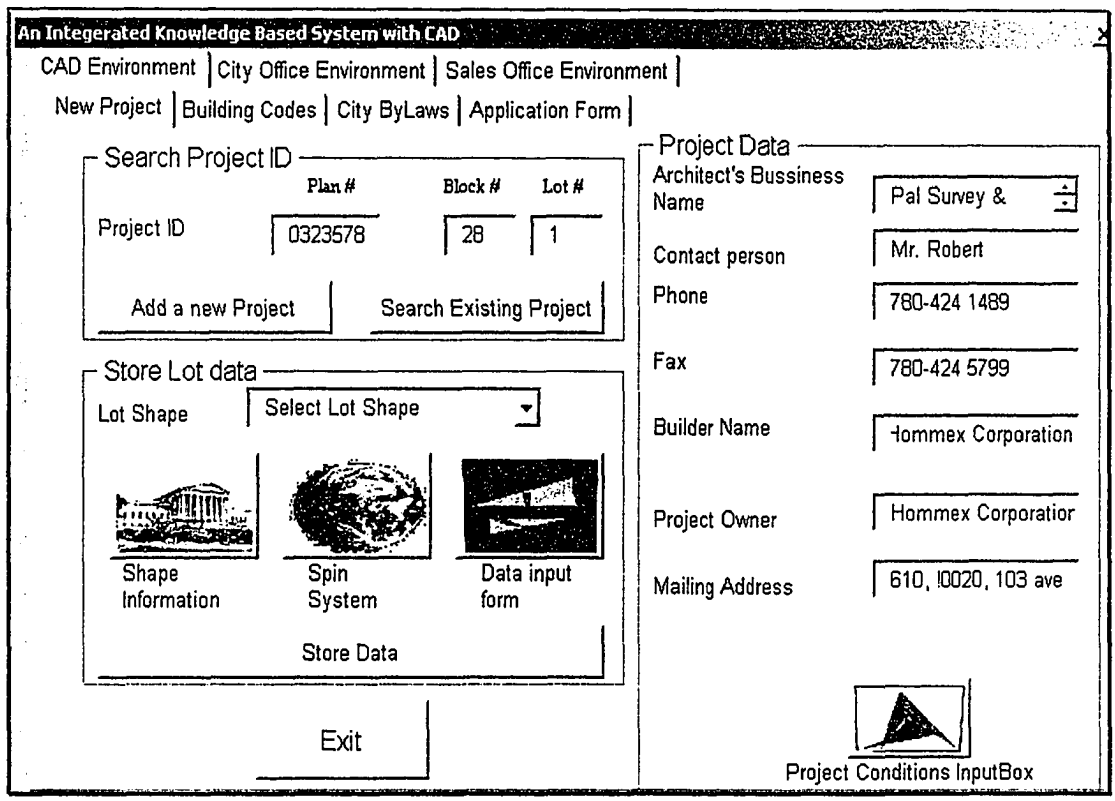


Figure 4-6: Interface for Lot Data Entry Process

If the database does not store the lot data, a message emerges on the screen, then the user needs to store the lot data in the database. Selecting the Add a New Project button displays the Store Lot Data frame, as shown in Figure 4-6. The Spin System button launches a web link to the spin system website, which displays the preliminary details (shape of lot, corner building) of the proposed site. The shape information button

provides details about the lot shape which function in the developed prototype. The mouse click on the Shape Information button displays the shapes available in the prototype. The captured screen of available lot shapes is shown in Figure 4-7.

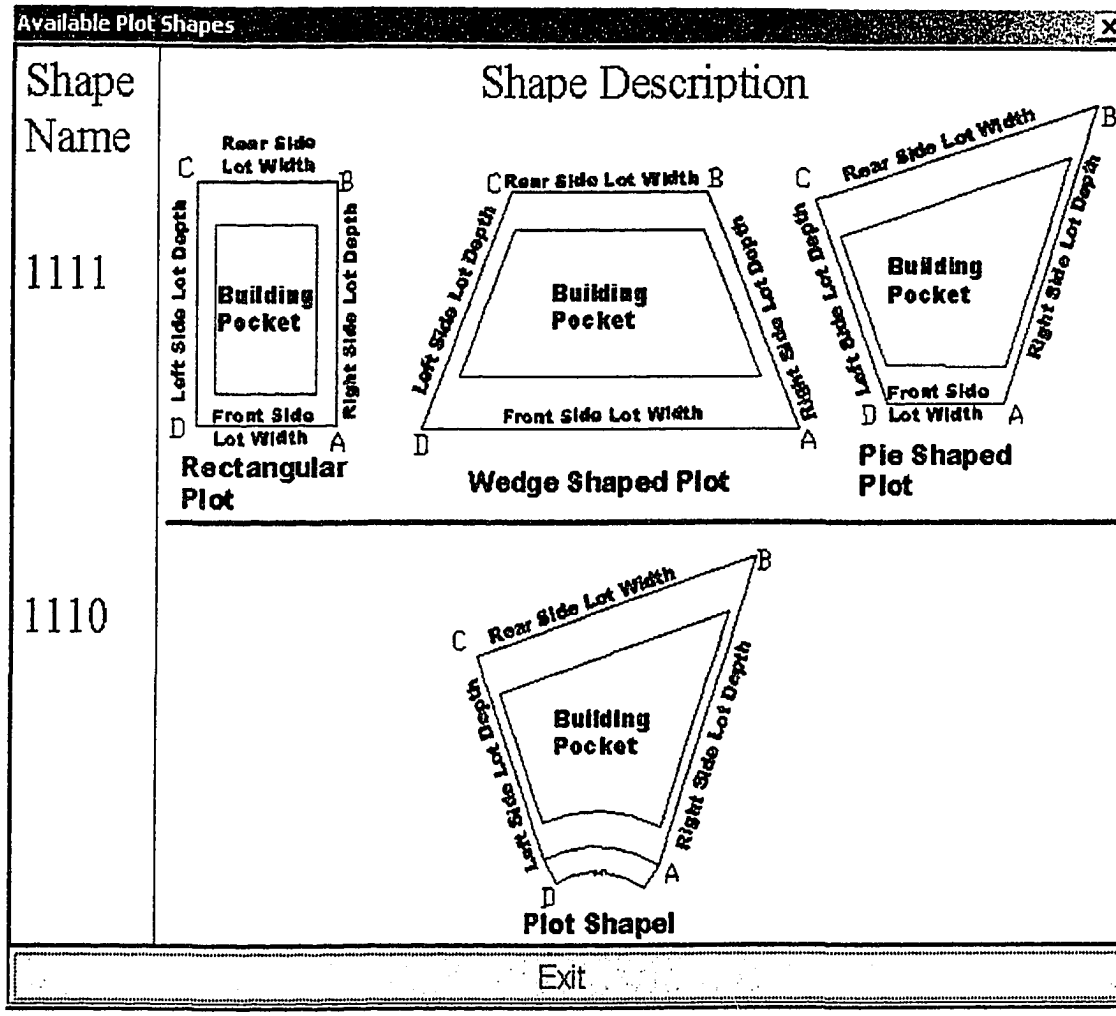


Figure 4-7: Available Lot Shapes in the Prototype

The combo box Lot Shape lists the shapes available in the prototype. When "lot shape" from the lot shape combo box is selected and the Data input form button is clicked, the data input form for the selected shape is displayed. Figure 5-2 shows the input data form for the shape 1110, which is composed, of three sides and an arc at the front side of the lot, as shown in

Figure 3-8. The bearings and length of the three sides are stored in text boxes. All bearings are full circle bearing measured from the north and are stored with an accuracy of seconds. The length of each side is entered in a textbox corresponding to the side. The mouse click on the OK button activates the Add NewProject function, which creates a new ProjectID in the project table of the building information database. Corresponding ID are also created for other tables. Other attributes of the table remain blank; these are populated later as the drafting of drawing progresses. The lot data is stored in a table based on the lot shape. Figure 4-8 shows the input data form for shape 1111, which refers to four sided shapes including rectangular, pie, wedge and other four sided lot shapes.

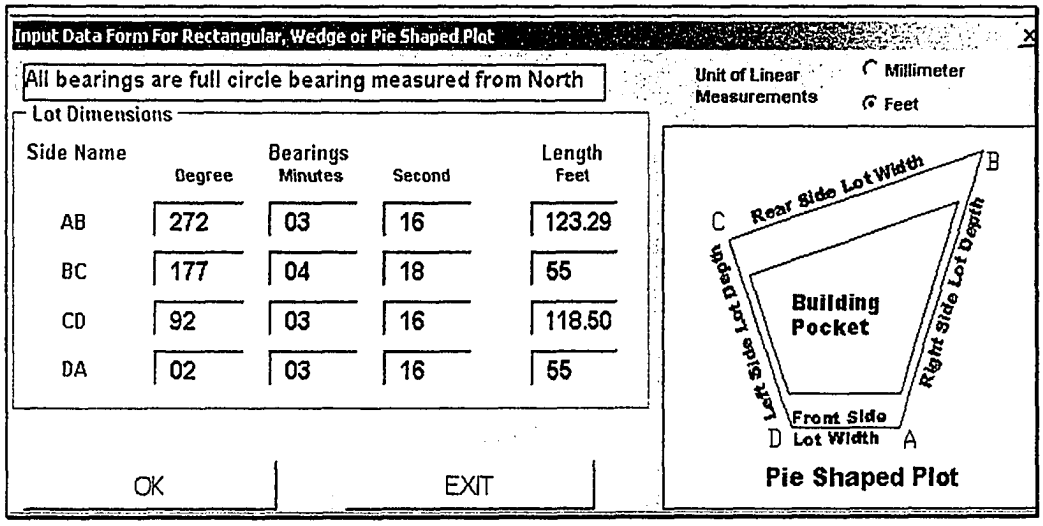


Figure 4-8: Input Data Form for Lot Shape (type 1111)

4.4 Implementation of the Automation Module

The automation module provides facility to the architect to accelerate the preliminary drafting process; it draws the preliminary lot boundary and city bylaws compliance-building pocket automatically in the CAD environment. AutoCAD is customized for optimal use by designing a user interface, toolbars and pull-down menus, which have advantages such as fewer time consuming tasks, automation of the repetitive tasks, ease of use, allowing less skilled operators to handle design load, and more faster and

accurate designs which adhere to standards. The section given below explains the procedure for storing input data in the building information database from the subdivision plan.

Drawing of lot size in AutoCAD: This is achieved by the automation module; it starts drawing from the starting point (arbitrary point 0,0,0) and draws the right side of the lot. The end point of the right side is considered to be the start point for the rear side, and the rear side of the lot is drawn. Other lot sides, such as the left side and the front side, are drawn in the anticlockwise direction. The lot shape is drawn in the closed polyline represented by distinguished layer, the parameters such as the site width and area of the lot are calculated, these are used for verification of the city bylaws.

Drawing of the building pocket: Based upon the project conditions, the IP provides parameters such as side yardR, rear yard, side yardL and front yard. The dimensions of lot size and calculated yards are used as input for the VBA module designed for automatic drawing of the building pocket. The offsets are drawn of the right side and rear side at distances side yardR and rear yard respectively. The intersection of theses two offsets gives one corner of the building pocket; other corners of the building pocket determined by finding the intersecting points of offsets for other sides in an anti clockwise direction. The automation module draws the building pocket in the Bldpocket layer. The building pocket is converted into polyline and the area of the building pocket is determined. Specific layers, i.e. Principal building, Accessory bld, Front yard, Rear yard, Side yardR, Side yardL and Bldpocket, are created automatically and are used in developing the site plan.Table 4-3 lists the functions and their purposes developed in the automation module.

Table 4-3: List of Functions used in the Automation Module

No.	Function Name	Comments
1	Selectedshape	Based upon shape, site dimensions are collected from the building information database, these are input for the drawing of the lot shape
2	PieorWedgeShapedPlot	Plots four sides for lot shapes (1111) in CAD Environment
3	PieShapedBldPocket_Draws	Draws building pocket incompliance with city bylaws for lot shape 1111 in the CAD Environment
4	PlotShapel_Dimensions	Labels drawing dimensions automatically
5	PlotShapel_Draw	Plots four sides for lot shape (1110) in CAD Environment
6	PlotShapelBldPocket_Draw	Draws building pocket incompliance with city bylaws for lot shape 1110 in the CAD Environment
7	Label	Extracts the data from the building information database and labels the CAD drawing

4.5 Implementation of IP Module

As discussed in the methodology section, IP module is placed in central repository, which is used by the A/E, the approving authorities at the city office and the sales representative at the sales office. IP module performs three functions: 1) evaluates the feasibility of the proposed house; 2) calculates the minimum required yards; and 3) checks the compliance of site plan drawings to city bylaws. The primary advantage of the IP module is its instant accessibility to the participants in the residential industry; it will automate the building permit application process and will also eradicate the redundancies involved in the process.

Evaluating the feasibility of a housing project: This involves verifying features of the proposed model with the minimum city bylaw requirements before starting the drawing in CAD environment. The minimum requirements checked by IP in this section are function of the type of land use and the residential zones; the parameters verified in the section are: 1) the height of the proposed building; 2) the site area; 3)

the width of site; and 4) the depth of site. The requirements for the aforementioned criteria are listed in Table 3-5.

Calculation of side yards: The input data of building conditions such as attached garage (yes/no), lane abutting the site (yes/no), frontage of building (either in front yard or public road way), and height of the proposed building are collected from the user input data form. This set of conditions constitutes a case and is based upon the case minimum requirements for yards are determined. Table 3-20 lists the possible cases of new housing project with minimum requirements.

The IP module checks the city bylaws in the site plan drawing and highlights the non-compliant objects in the drawing. The IP module consists of three types of function developed in Visual Basic Language: 1) the 24 cases of possible site conditions; 2) city bylaws provisions defined in the form of functions; and 3) function to identify the objects in the drawing, to change their color and to highlight the objects. The city bylaws provisions for front yard, rear yard, principle building, accessory building and side yards are encoded in the form of the function. Based on the project conditions, the IP module selects one case out of 24 cases and the required functions describing the minimum requirements are activated. Next, the drawing data, which is collected from building information database, is compared with the minimum requirements of the city bylaws. If any non-compliant part is found, then the function is activated which highlights and changes the color of the non-compliant object to magenta. The functions such as FrontYardError and RearYardError identify the objects in the drawing based upon the layer used by the designer. The changes in the properties of objects such as the change of color to magenta and the highlighting of objects indicate an error in the objects.

Table 4-5: List of Functions Used in the IP Module

No.	Function Name	Comments
1	CitybylawsCheckingII	Collects site conditions and based upon case (24 cases), min values of front yard, rear yard, side yard are allocated; this becomes input for the drawing of the building pocket
2	CitybylawsChecking	Contains 24 cases and, based upon input conditions(Case), checks drawing for city bylaws
3	RearYardError	Selects the rear yard line from drawing and highlights the rear yard in the drawing.
4	PrincipleBuildingError	Selects the principle building polyline from drawing and highlights it.
5	AccessoryBuildingError	Selects the accessory building polyline from drawing and highlights it.
6	SideyardRError	Selects the accessory sideyardL line from drawing and highlights it.
7	SideyardLError	Selects the accessory sideyardR line from drawing and highlights it.
8	PrincipleBuilding-AreaError	Ensures that site coverage does not exceed 40% of total site area
9	PrincipleAreaI	Ensures that the site coverage does not exceed 28% of total site area
10	CornerRearYardChecking	Ensures rear yard not less that 4500
11	AccessoryAreaChecking	Ensures area under accessories does not exceed 12%
12	Extraction	Identifies the object and extracts data from CAD drawing

4.6 Integrated System with CAD

ISCAD is a proof of concept prototype developed for automation and checking of a drawing for compliance with city bylaws based upon methodology outlined within this thesis. The developed prototype consists of two central databases (the Building Information database and the City Bylaws database), the Automation module, the Information-Processing module, and the Integrated Building Codes Assistant module. The following section presents: 1) design requirements; 2) functionality of the

prototype; 3) hardware and software used for the prototype; 4) system components; and 5) system advantages and limitations.

4.6.1 Design requirements

The current practices and limitation outlined in chapter 2 exposes the wastages and redundancies existing in the development permit approval process and indicate a need for the development of an integrated system. The efforts in developing the "proof of concept" were suited to the requirements of the housing industry for a development permit approval process. The basic components and features within the application are based on the requirements that emerge from the traditional processes of preparation, submissions and approval of the development permit for a new house and as well as selling of that house to its prospective owner. Although limited in scope, the integrated system is a model that meets core processes integration requirements. Another requirement is a central database that holds the project data, drawing data and city bylaws instances. The design requires:

- Development of a better drafting environment.
- Automation of the drafting procedure.
- Storage of city bylaws instances in a database that can be easily modified.
- Development of an automatic CAD checker for site plans.

4.6.2 Functionality of the prototype

The system's functions are directly aimed at eradicating the limitations of current practices in the housing industry, as discussed in chapter 2. The solution to existing problems leads to automation, building codes assistance and automatic checking of drawings for compliance with city bylaws.

- The CAD integrated prototype application automatically draws the lot size, and a building pocket in compliance with city bylaws and labels drawings.
- Building code requirements, as illustrated in "National Housing Code of Canada 1998 and Illustrated Guide", are provided to A/E during the drafting of drawings.

- The system compares the data of the proposed model stored in the building information database with minimum requirements stored in the city bylaws database and non-compliant objects in the drawing are highlighted and an error message appears on screen.

4.6.3 Hardware and software requirements

The implementation of the system in the "proof of concept" utilizes the following specific software applications: AutoCAD 2002 (Architectural Desktop 3.3), Microsoft Access, Visual Basic Application in AutoCAD, and Data Access Objects. The main objective of application choice was to choose the specific applications that are most readily available to small builders so that all can be benefited. AutoDesk's AutoCAD is the most commonly used software for drafting purposes in the residential industry. The choice for strong and powerful DBMS results in a choice of Microsoft Access. Visual Basic for Applications is designed specifically to provide development capabilities inside an off-the-shelf application. AutoCAD provides full support for VBA with the release of R14 and can be customized to meet user requirements and integrated with other VBA-enabled applications; this providing additional functionality and program improvement, leading to reduction of time consuming tasks, automation of repetitive tasks, query-links between applications, program features enhancement, low-cost options replacement, and the use of verification tools. VBA's ability to link various programs together allows a user to share or access information, making detailed queries and easily generates custom report. DAO is an application program interface (API) available with Microsoft Visual Basic; it allows a programmer to request access to a Microsoft Access database. DAO is Microsoft's object-oriented interface with databases encapsulating Access's Jet functions; it can also access other Structured Query Language databases. In other words, choice of applications is not a restriction within the implementation.

4.6.4 Prototype description

An Integrated Based System with CAD is an automatic CAD drawing check system developed according to the methodology discussed in the previous chapter. In addition, it also provides a better CAD environment for drafting a drawing, and also integrates the processes carried out in architect/engineer's office, city office and sales office environment. ISCAD is linked to both AutoCAD 2002 and Microsoft Access through Data Access Objects, and is supported by a user-friendly interface developed in AutoCAD VBA. Three tabs describe three environments: 1) the CAD environments; 2) the city officer environment; 3) the sales office environment. Each tab has sub tabs that call up entry forms and processes carried out in each environment. The following section describes the processes carried out in each environment.

4.6.4.1 CAD environment

In the developed prototype, the CAD Environment tab provides functions that are involved in the preparation of development of a permit for a new house and its submission to the city office. This menu has four sub tabs: 1) New Project; 2) Building Codes; 3) City Bylaws; and 4) Application Form. The end user of this environment is the architect/engineer.

New project tab have two functions, the addition of new lot data in the building information database and the drafting of a site plan for a new house. The user i.e. A/E enters the ProjectID which is PIB. Seven text boxes allow the project data to be entered; this information is required in the building permit application form. A mouse click on the Project Conditions input box button displays the Input Site Condition Form, as shown in Figure 4-9. The site conditions and characteristics of the new house are entered here. The controls behind the mouse click event ensure that lot data is stored in that database and users have provided all the required information in input boxes.The Input Site Condition Form asks for information about the residential zone and the type of the land use and as well as the building and site characteristics. The

Residential Zones combo box presents residential zones in which a house can be constructed and the combo box presents six options for residential zones: 1) Single Detached Residential Zone (RF1); 2) Residential Small Lot Zone (RSL); 3) Low Density Infill Zone (RF2); 4) Planned Lot Residential Zone (RPL); 5) Low Density Development Zone (RF3); and 6) Semi Detached Residential Zone (RF4). The Type of land use combo box tells the user possible types of houses in specific zones. For example Single Detached Residential Zone (RF1) gives permission for the following types of house: Single detached housing, Residential sales center, Semi detached housing, Duplex housing, and Secondary suits. Building Characteristics, a frame in the Input Site Condition Form, enquires about the characteristics of the proposed house. This frame contains the Check Box Yes, a check box to determine the attached garage option, and a text box for the height of the new house. Site Characteristics, another frame, contains two check boxes and one option button. Two check boxes labeled yes in the frame determine corner building and lane abutting the site option respectively. Clicking on the Draw PlotSize button starts the sequence of processes: storage of project data in the database, evaluation of feasibility of the project, drawing of the lot size in AutoCAD, calculation of side yards, and drawing of the building pocket. Before starting theses processes, coding behind the Draw PlotSize button ensures that the user has entered residential zones, type of house, and height of the building for the new house. Figure 4-9 is a captured screen of Input Site Condition Form.

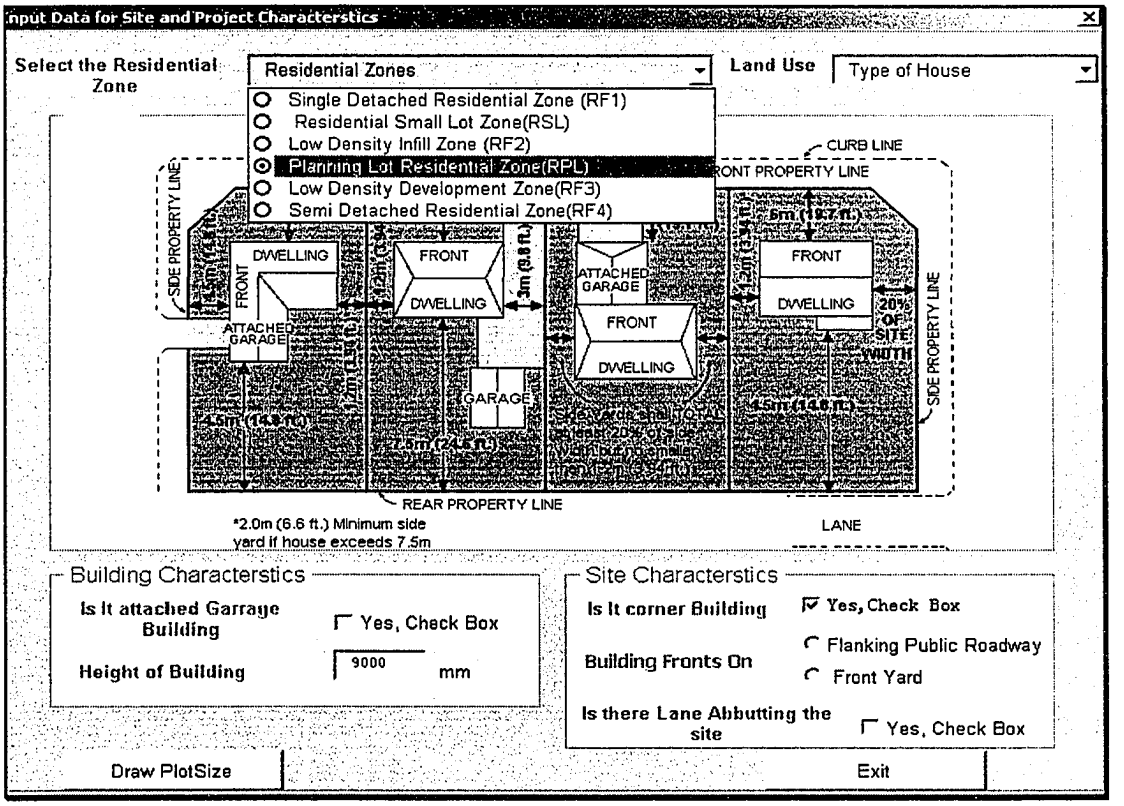


Figure 4-9: Building and Site Conditions Input Data form

Storage of project data in a database: This involves the storage of project data, site and building characteristics in the building information database. As explained in the methodology, each lot in the database is allotted a ProjectID and its building components instances are kept blank; these are populated as the design proceeds. The SiteConditions query developed in the building information database is accessed using DAO objects, which populate the blank instances of the given project. Evaluation of the feasibility of the project involves checking the new project for requirements such as minimum height, minimum site width, and minimum area in residential zones. The IP module evaluates the project and if the new project's characteristics do not meet the requirements, an error message is displayed on screen and user cannot proceed with the design project. Drawing of lot size in AutoCAD is the drawing of lot size in the AutoCAD environment. The Automation module, which is VBA coding, is used to draw the lot size automatically. Calculation of side yards is one of the main functions of the IP module. Based on project conditions, which are extracted from the building

information database, IP selects one case and calculates the minimum yards requirements. Drawing of the building pocket is similar to the process of drawing of lot size. The calculated yard values are passed to the automation module, which draws the building pocket in AutoCAD in compliance with city bylaws. Figure 4-10 illustrates the process carried out for the development of the building pocket.

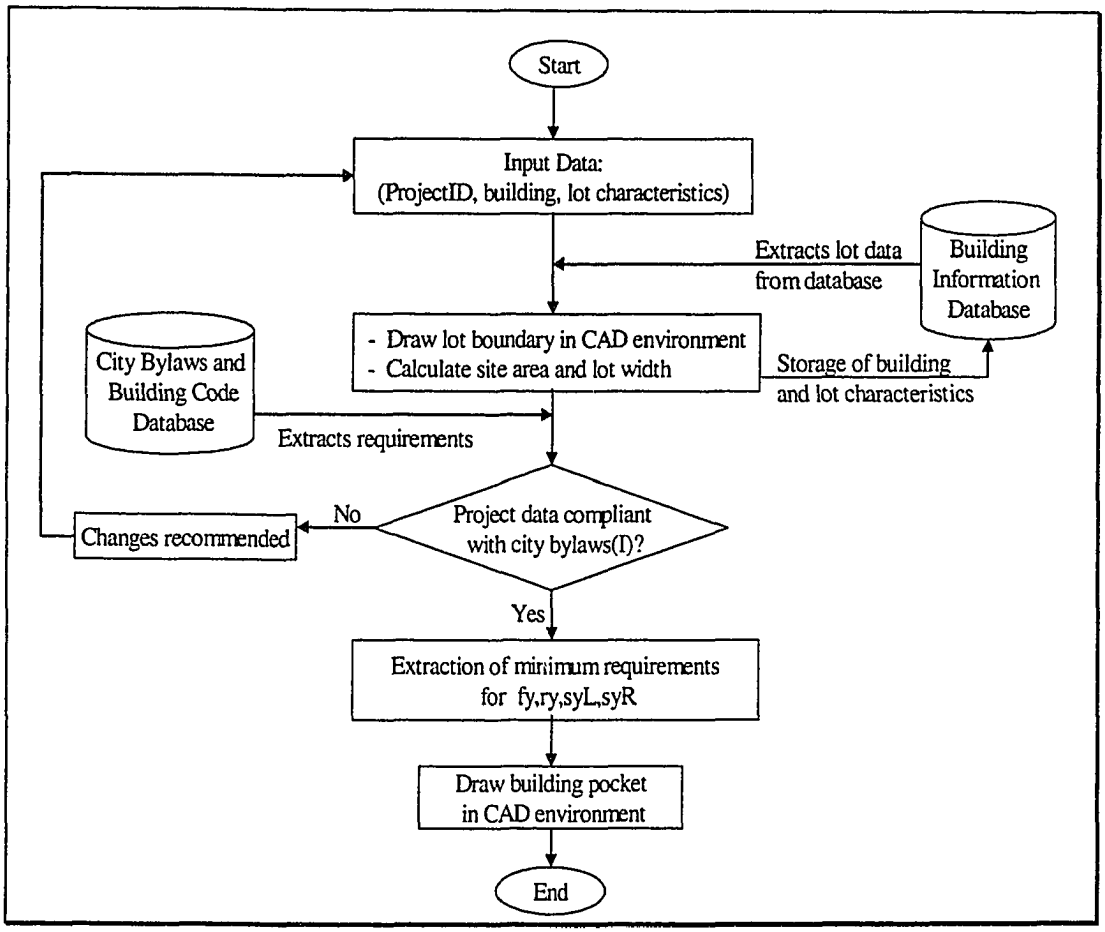


Figure 4-10: Processes Used to Determine the Building Pocket Dimensions

Note: For definition of city bylaws (I) checking see figure 3.2

Completion of Drawing: This involves completing the site plan, which identifies the buildings and other features in relation to the property boundaries. The site plan provides lot and building setback dimensions, property corners, and information on all accessory buildings, such as the size and location of garages, tool sheds, and the location of easements, utility locations, North direction indicator, lot area, existing structures on site, and surface drainage. The site coverage is divided into two

categories, principal building area and accessory building area, and is shown in Principal building and Accessory bld layers respectively using polyline in the AutoCAD environment. The aligned linear dimensions of front, rear, and side yards are created in Front yard, Rear yard, Side yardR, and Side yardL layers to show building set back dimensions.

The Building Codes tab, as shown in Figure 4-11, contains 16 sub tabs, corresponding to the 16 divisions of the housing guide. The Room and Space Dimensions tab provides minimum requirements of ceiling height, floor area, and the dimensions required for a variety of intended uses. The Room or Space Name combo box stores a list of nine intended uses of space such as living room, dining room, storage room, and garage. The combo box Find lists the name of criteria for which a user might want to perform a search. It lists three types of criteria: height of the room, floor area, room dimensions and both. The click event on the Run Query button activates the code behind it, which selects one case from 26 cases and loads the corresponding CAD drawing in the interface. The picture frame loads the Building Codes illustrated drawings, which are stored in the computer disk.

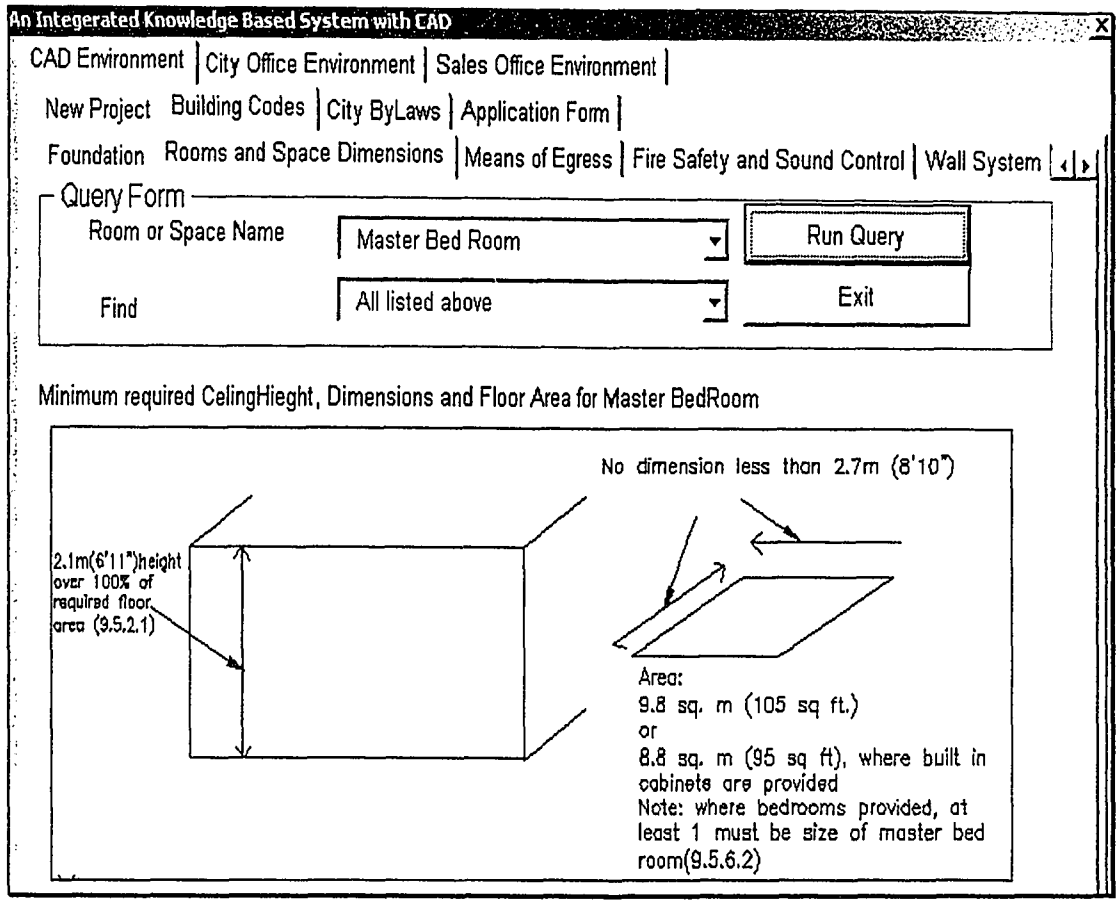


Figure 4-11: Illustrated Building Code Interface Module

The City Bylaws tab, as shown in Figure 4-12 performs the following functions: opening of existing drawings in AutoCAD environment, storing of CAD Data in the building information database, checking of site plan to city bylaws and labeling of the CAD drawing. The button Link to City of Edmonton website navigates a City of Edmonton's website in a new window citing city bylaws applicable to a new house. In the frame Checking of City Bylaws, the site plan drawing is checked; this involves extraction of drawing data, storage of drawing data in the building information database, and checking of the site plan drawing data. The activation event of the form leads to a search in building information database and all ProjectID stored in the database are displayed in the ProjectID combo box. The user selects a ProjectID and clicks on Store Data button. The code behind the button ensures the storage of the drawing before saving the data. If the drawing is not stored, a message is displayed to

the user regarding storing the drawing. The storing of data involves three processes: opening the site plan in the AutoCAD environment, extracting data, and storing it in the building information database.

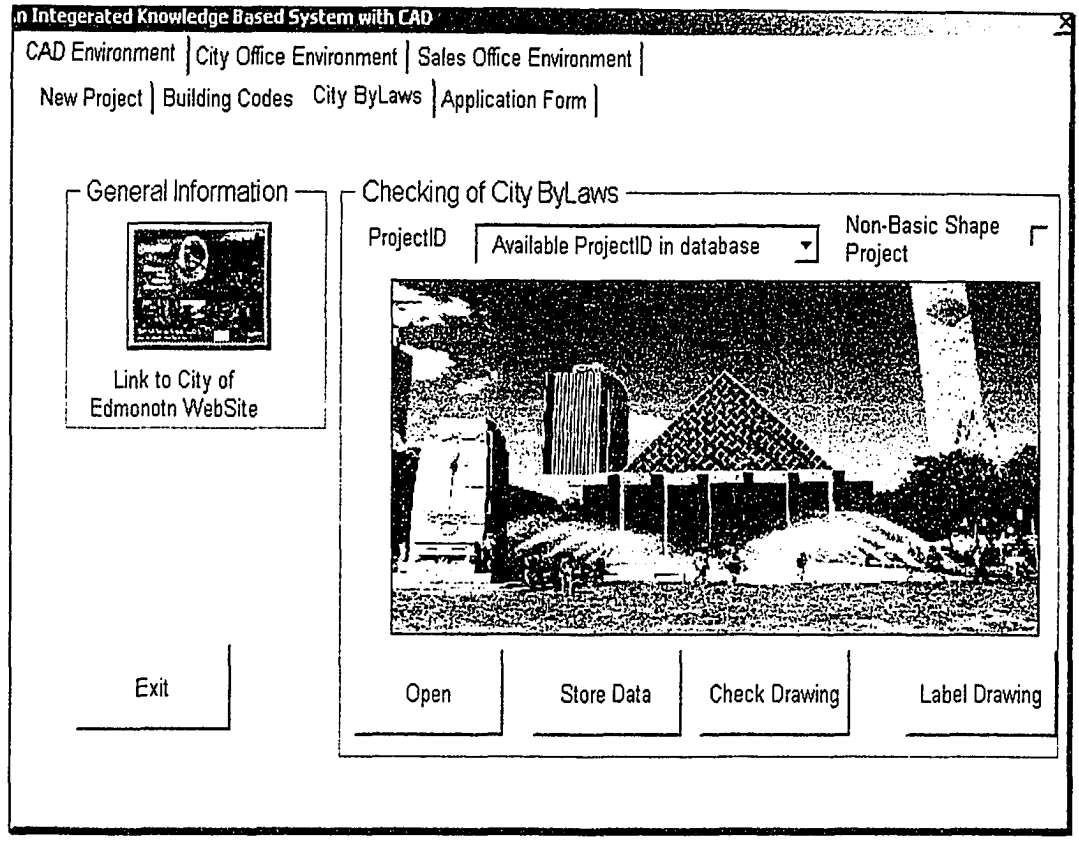


Figure 4-12: City Bylaws Tab Interface

Opening the site plan in the AutoCAD environment: This process is activated by a click event on the Store Data button. The query FindLocation, extracts the path of the saved site plan from the building information database and this path is passed to the open function, which opens the selected project in the AutoCAD window. The extraction module identifies the objects from the layers used and the properties of objects, such as the area of a closed polyline object; measurements of DimAligned objects are found using VBA programming. The query UpdateQuery populates the instances related to drawing information that are kept blank in the process of storing lot data. The mouse click on the Check Drawing button, calls the IP module, which is

used for checking the site plan drawing and which highlights and changes the color of non-compliant objects in the drawing. The process of checking and labeling the site plan, as well as the drawn site plan is submitted as a part of building permits application.

4.6.4.2 City office environment

The approving authorities at the city office access the information about the project (submitted for building permit approval) from the central database and use the IP module to check the site plan's compliance to the city bylaws. The decision regarding issuing of building permit is made instantly. The approving authorities enter the ProjectID in three text boxes as shown in Figure 5-12. The building permit approval process is carried out in two steps: 1) Checking the compliance of the site plans drawing with city bylaws and 2) Generation of the building permit. Clicking on the Checking of Drawing button calls the IP module to check the site plan. The IP module highlights and changes the color of non-compliant components of the site plan drawing.

4.6.4.3 Sales offices environment

The Sales Office Environment tab, as shown in Figure 4-13 provides sales representatives with a valuable assistance in checking the compliance of site plan with the city bylaws. At the sales office, the sales representative accesses the instances of the approved design model stored in the building information database. The ProjectID combo box lists all ProjectIDs stored in the central database. The user selects the ProjectID in the combo box and clicks on the open button to open the site plan drawing in the AutoCAD environment. As per requirements, the changes in CAD drawing are completed and updated in the building information database. The updating of changes is completed in two steps: 1) Extraction of data and 2) updating the data in the database. The click event on Update Existing Project activates the code behind the button, which performs extraction of the drawing data process. The extracted data is passed to the data flow module, which updates instances of the

existing project stored in the building information database. The Verifying Changes button, checks the compliance of the changed drawing with city bylaws. IP module is used for verifying the changes made in the drawing. The changing and highlighting of non-compliant parts provides an instant answer for its compliance with city bylaws. Table 4-7 lists the name function and corresponding uses developed for the prototype.

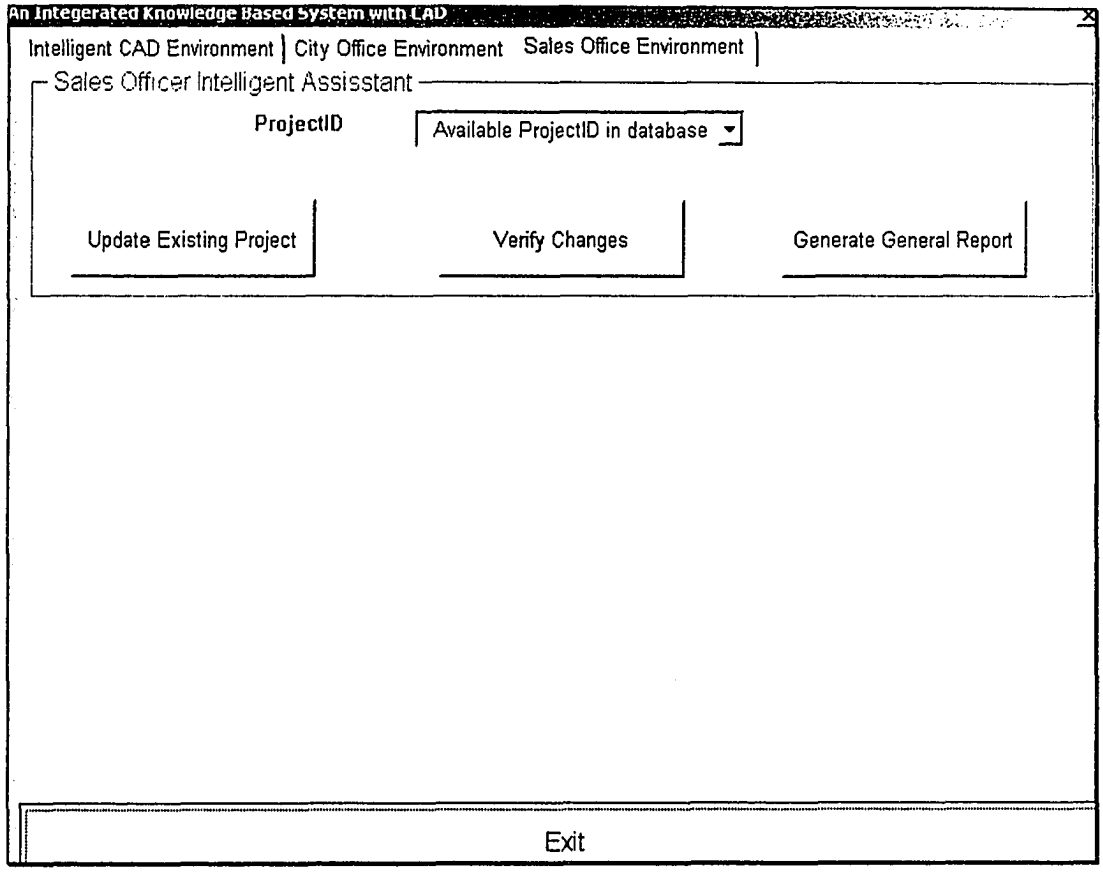


Figure 4-13: Sales office Environment Interface

Table 4-7: List of Function Used in the Prototype

No.	Function Name	Comments
1	CityOfficerExtractionofData	Collects project information from Building Information Database for City Officer
2	SalesOfficerExtractionofData	Collects project information from Building Information Database for Sales Officer
3	DatabaseRF1	Collects instances from City bylaws
4	Calldatabase	Opens the database using DAO objects
5	Transaction	Runs two function I.e. Extraction and StoreProjectData
6	DataStore	Stores project conditions (entered by user) to building information database
7	ProductIDQuery	Collects the existing projects in a database and shows all projects in combo box
8	AddNewProject	Populates lot dimensions of the shape, while other instances are kept empty. The other instances are populated after the design
9	StoredProjectData	Stores the drawing data in the database
10	ConvertDataFourSidesShape	Converts input data for lot dimension into metric system and this data is stored in a database
11	ConvertDataPlotShapeI	Converts input data for a lot dimensions into metric system and this data is stored in a database
12	UpdateQuery	Updates data in building information database
13	OpenProjectI	Collects the address (path) of stored projects and open it in the CAD environment for the City Officer
14	OpenProject	Collects the address (path) of stored projects and open it in the CAD environment for the Sales Officer

4.6.5 System advantages and limitation

The proposed system aims to provide a common platform for the participants of housing industry and also to provide the assistance for checking the compliance of drawings with respect to the city bylaws. The advantages and limitation of the ISCAD are listed below:

Advantages:

1) *Open system layout*: The conceptual model is developed to be application independent and may be implemented anywhere in the AutoCAD environment. It is developed using the Visual Basic for Applications, which is added to AutoCAD at no extra cost.
2) *DAO provides a dynamic processing environment*: DAO (Data Access Objects), a Microsoft object-oriented interface with databases, provides a dynamic processing environment by encapsulating Access's Jet functions; this enables AutoCAD to access and manipulate the records in the central database without opening the DBMS. Furthermore, any entries, changes and data processing are dynamically updated in the database. This is an advantage particularly to the approving authorities as well as to the sales representative.
3) *Building code assistance*: Building codes assistance contains residential construction-code information illustrated in the CAD drawings gathered from the National Housing Code of Canada 1998 and Illustrated Guide. This provides a better drafting environment and facilitates the search for building code provisions.
4) *Central database storing information of all housing projects*: The central database stores information (metadata) and electronic files related to project information, and drawing data; this allows the project participants to access information. The ease with which stored data can be accessed is one of the key tangible advantages of the proposed model. Enabling project

participants to access the stored data in a central format ensures consistency, integrity and accuracy for the various uses of the data.

5) *Automation*: The drafting of the building pocket and the labeling of the site plan automatically saves time for the preparation of each building permit application. Checking of the site plan compliance with city bylaws improves the productivity and efficiency of the existing development permit approval process.

Limitations:

1) *Considers limited shapes*: The proposed methodology is based upon the classification of shapes and storage of lot data in the central database. As explained in the methodology section, there is variety of shapes from simples one to complex ones. The developed system consists of automation of two shapes, which covers 60-65% of lot shapes in the subdivision plan.

2) *Provides limited building codes assistance*: Although, the prototype interface have sixteen menus corresponding to the sixteen divisions of the National Housing Code (NHC) of Canada 1998 and Illustrated Guide; but it provides assistance only on the "Room and Space Dimension" provisions listed in the NHC.

5 CASE STUDIES

This chapter makes use of up-to-date "real world" case studies to validate and verify the developed system. Case studies are presented in this chapter demonstrating the effectiveness of the developed prototype.

The objective of this chapter is to demonstrate the validation and verification of the proposed methodology, which is used to develop the ISCAD system. The validation of the developed system started from inception and proceeded to completion, testing the system's individual components against their intended use. Illustrative case examples are used to manifest the function of the prototype, which also verifies its functions. The following functions have been validated in the prototype:

1. Storage of lot data process.
2. Automatic drafting of lot shape and building pocket in AutoCAD.
3. Extraction of drawing data.
4. Checking the compliance of the site plan drawing with the city bylaws.
5. Updating the drawing data in a building information database
6. Data flow from AutoCAD to databases and vice versa
7. Database queries
8. Overall system integration

5.1 Case Examples for Storing Lot Data Process

The case examples have been chosen to illustrate the essential features and operations used in the storage data process developed in the ISCAD system. This example has been extracted from the subdivision plan having plan number 022 6762; it covers a 2.81 hectare area and was registered on November1, 2002. The plan shows a survey of subdivisions of part of N.E. ¼ SEC. 30, TWP. 52, RGE. 25, W.4 Mer and N.W. ¼ SEC. 30, TWP. 52, RGE. 25, W4 Mer, all within N. ½ SEC. 30, TWP.52, RGE.25, W.4 Mer., Edmonton, Alberta. Lewis Estate Communities is the registered owner of the subdivision plan; all distances are expressed in meters and decimals thereof and

distances along curved boundaries are arch distances. The following section describes a case example of the storage of lot data in the building information database.

5.1.1 Search for existing project

Proceeding with the integrated ISCAD system, the search in the building information database is made to verify the presence of a new project to be entered in the central database. The user entered the ProjectID in the Search Project ID frame and a mouse click on the Search Existing Project button performed a search in the building information database and a message was displayed on the screen. The message appeared on screen verified that the central database does not store the ProjectID to be entered. When the Add A New Project button is clicked, the Store Lot Data frame appears on the same interface is shown in Figure 4-6.

5.1.2 Verification of lot shape

Verification of lot shape is the checking of the lot shape in the subdivision plan against the available shapes in the prototype. The Available Lot Shapes form provides the list of shapes available in the prototype, and also illustrates the methodology developed for tagging shape name as shown in Figure 4-7. The mouse click on the Spin System button in the Store Lot Data frame provided an access to the Alberta Land Titles website. By performing the search on the web site, a subdivision plan showing the lot dimensions was downloaded. Figure 5-1 shows a view of the subdivision plan showing the details for a house lot having plan number 022 6762, block number 22, and lot number 29. The figure shows the details of the lot number 29 having block number 22.

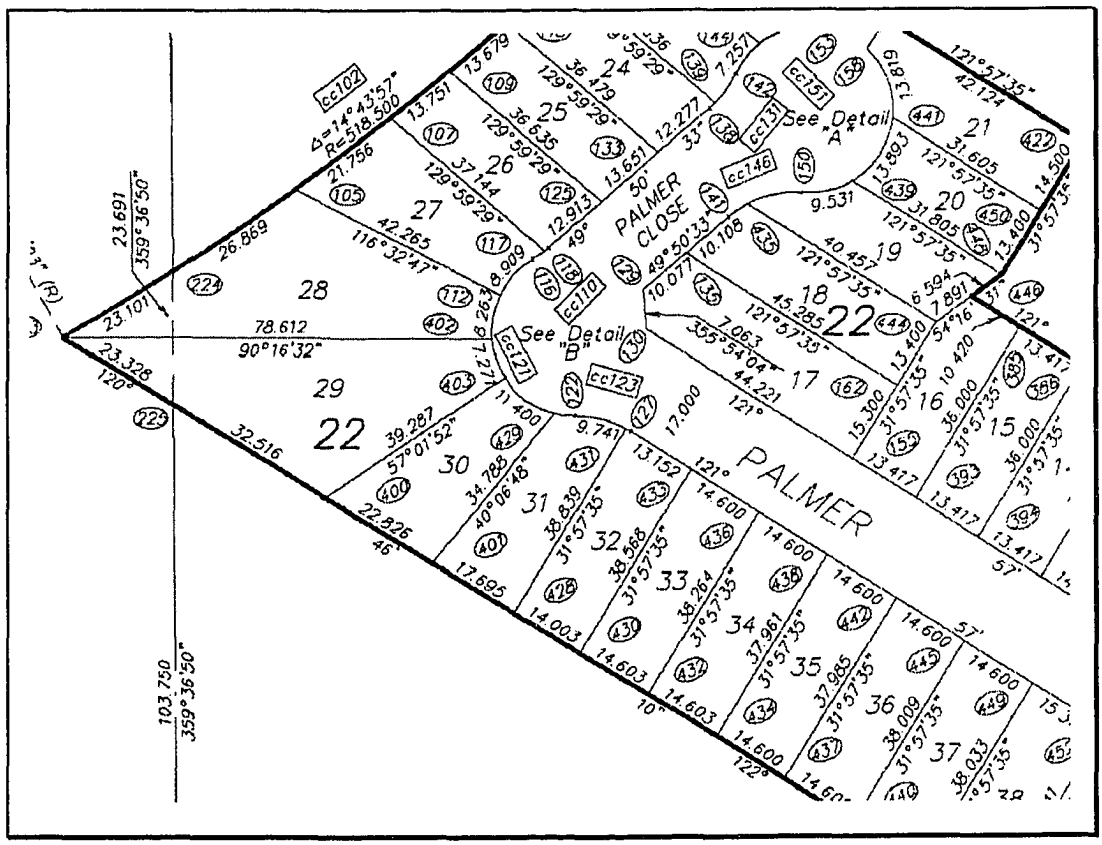


Figure 5-1: Subdivision Plan of the Case Study

A careful look at the lot shows that it consists of three sides and an arc at the front. The methodology used for the classification of lot shape in the prototype classifies it as 1110. Then raw data was prepared for the lot. Table 5-1 lists the parameters of lot shape 1110.

Table 5-1: List of Lot's Parameters Used in the Case Study

Title Name	Side Name	Graphic Element	Length (Meters)	Angle	Radius	Arc Length
AB	Right Side	Line	78.612	180d16'32"	N.A.	N.A.
BC	Rear Side	Line	55.944	120d46'10"	N.A.	N.A.
CD	Left Side	Line	39.287	57d01'52"	N.A.	N.A.
DA	Front Side	Arc	N.A.	N.A.	15.00m	7.271 m

5.1.3 Input data and its storage in the database

The lot shape details were collected from the subdivision plan and the lot shape was selected from the Select Lot Shape combo box. The mouse click on the Data Input form button displayed input form for PlotShapeI lot shape. The lot details were filled into the Input Data Form for PlotShapeI input form. Figure 5-2 shows the captured screen of the input form having lot details calculated above.

The Input Data form for the PlotShapeI form disappeared when the OK button was clicked on. The lot details are saved in the central database; Figure 5-3 shows the captured screen of the Project Table, showing that a new ProjectID has been created. The instances of the new added project are kept blank; these are populated as the project design progresses.

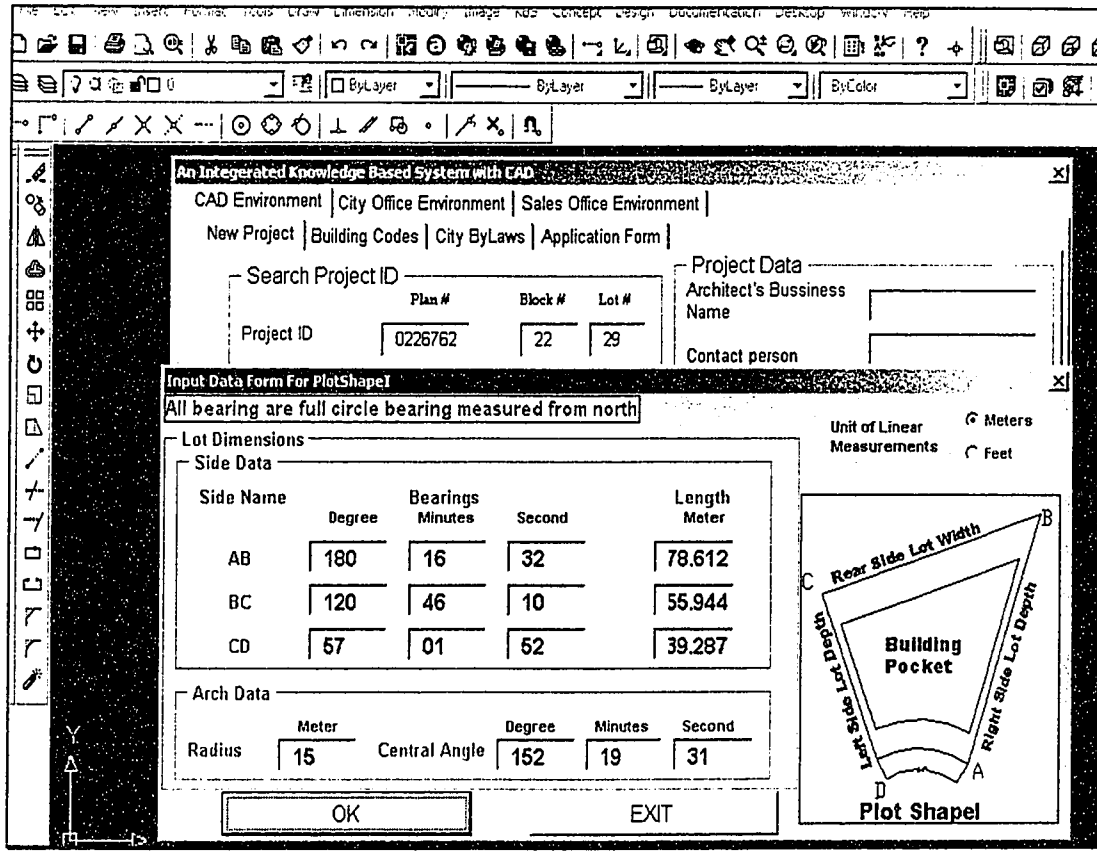


Figure 5-2: Input data form for Storage of Lot Data

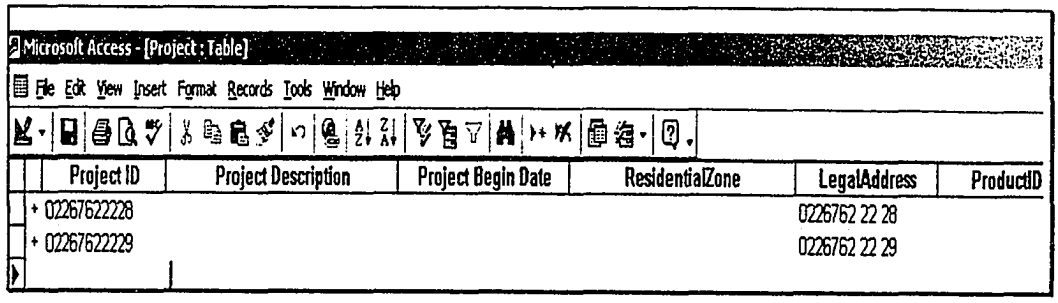


Figure 5-3: Project Table Showing a Newly Added ProjectID

5.2 Case example for the Development Permit

The following project has been chosen to both illustrate and describe the essential features of the developed prototype; the case study also verifies and validates the functions of the prototype. This case demonstrates how the system is used for preparing and checking the drawing of the site plan for lot shape that are available in the prototype. The case has been extracted from the actual project developed by Ahassan Sukkareih, a builder in Edmonton, and has Lot #144, Block #8, and Plan #022 5750 in the Haddow Stage-14B, Edmonton, Alberta. It is a two-story house developed in the single detached residential zone (RF1). Appendix C contains the site plan submitted to the City of Edmonton respectively.

The conceptual design of ISCAD was developed after thorough interviews with architects and engineers. The interviews consisted of reviewing city bylaw requirements and the drafting procedures adopted for the design of a site plan for a new house. The need for an integrated system for a better drafting environment, and automation of the building permit approval process was confirmed.

The architect/engineer (A/E) at Pals Surveys & Associates drafted the site plan for the proposed house. Drafting the site plan involved drawing the lot shape in CAD environment. The lot data for the plan was extracted from the subdivision plan. Taking into consideration the residential zone, and conditions such as the building on the corner, the height of the building governed the side yard calculations and building pocket for the proposed house was drawn. Performing side yard calculations and

drafting the building pocket manually is a time-consuming process. The plan for the buildings proposed on the site was drafted; the offsets for the proposed building were provided from the existing building. Then drafting of the construction plan was carried out, and drawn according to the minimum requirements of the building codes. The non-availability of building code assistance in CAD environment compels the A/E to look to other resources in order to check the minimum requirements. As is required, the building permit application form, including the application form, the site plan, and the construction plans, was submitted to the City of Edmonton office for approval. The submitted application was added to the City of Edmonton database for records. The approving authority (Development officer) verified the compliance of the site plan with the city bylaws. The verification of the site plan involved the determining the minimum requirements applicable to the project, a task that was also performed by the A/E during drafting of the site plan. The development officer approved the site plan as it complied with city bylaws.

5.2.1.1 Preparation of the development permit with the ISCAD system

Search Existing Project: The case example utilized in this section takes into consideration the preparation of development permit for a new house to be constructed on the site. To proceed with the integrated system ISCAD the existence of lot data in the database was checked. Figure 5-4 is a captured screen of the message generated after performing the search for the ProjectID in the building information database.

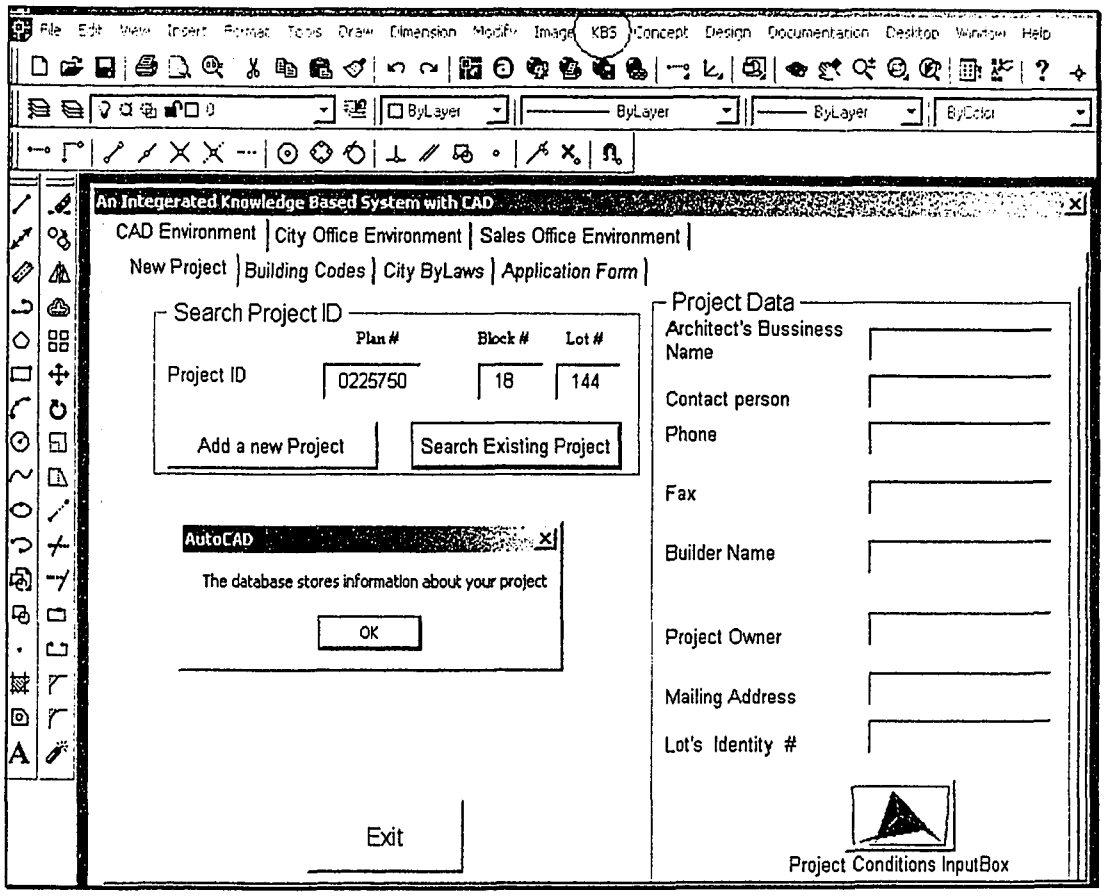


Figure 5-4: The Results of the Search for the ProjectID

The building information database stores the dimensions of the lot data under the ProjectID, a combination of plan number, block number, and lot number. As discussed in the previous section, the lot data not stored in the database needs to be entered using the storing lot data process described in section 5.1.

Entering of Project Data: The project related information is filled in the text boxes and are stored in the central database for future use. Figure 5-5 is a captured screen of the interface with project data for the case study.

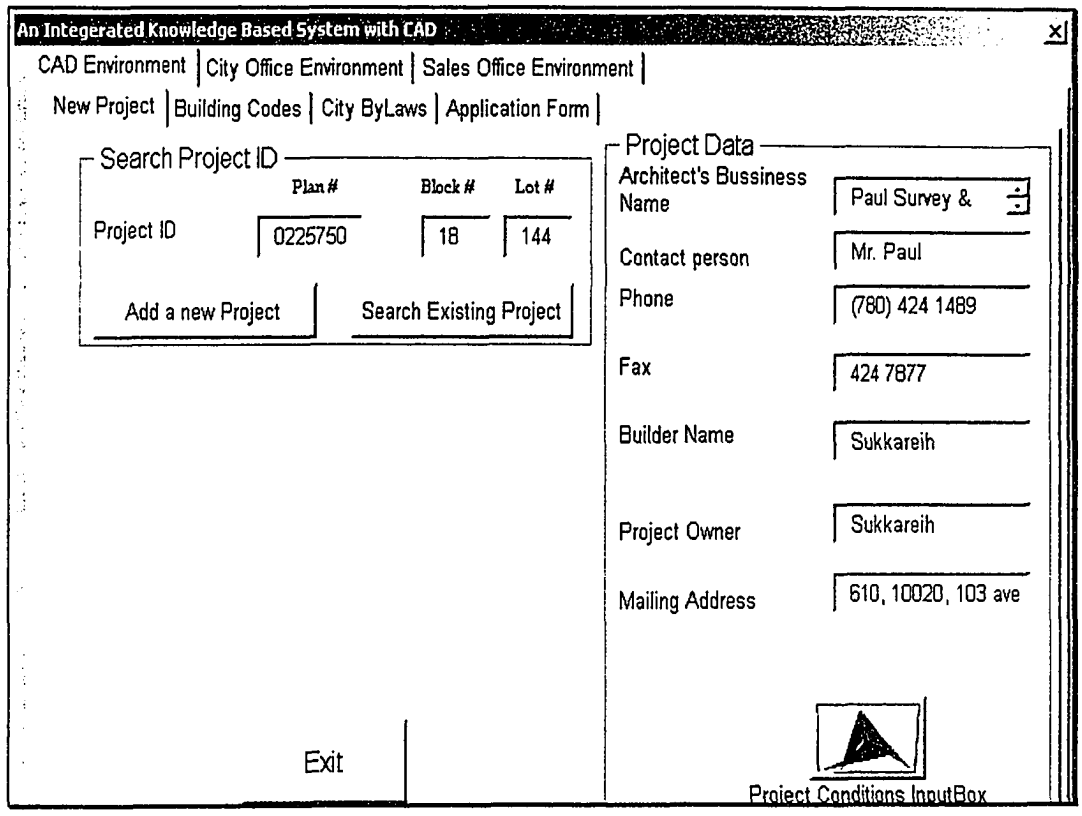


Figure 5-5: Project Information Data Entering Screen

Entering the Site and Building Characteristics: The mouse click on the Project Conditions InputBox Button displayed the Input Data for Project and Site Conditions form as shown in Figure 4-9. The case example is a two-storey house with an attached garage to be constructed on the site, which is a middle lot with lane abutting the site.

Drawing of Lot Size and Building Pocket: After entering the project and site condition into the Input Data for Project and Site Conditions form, a mouse click event on the Draw PlotSize opened "AEC Arch (Metric-Int)" template in AutoCAD environment and the lot size and building pocket were drawn automatically. Figure 5-6 shows a message giving minimum requirements of yards displayed on the AutoCAD screen. The minimum requirements are side yard calculation performed by the IP module.

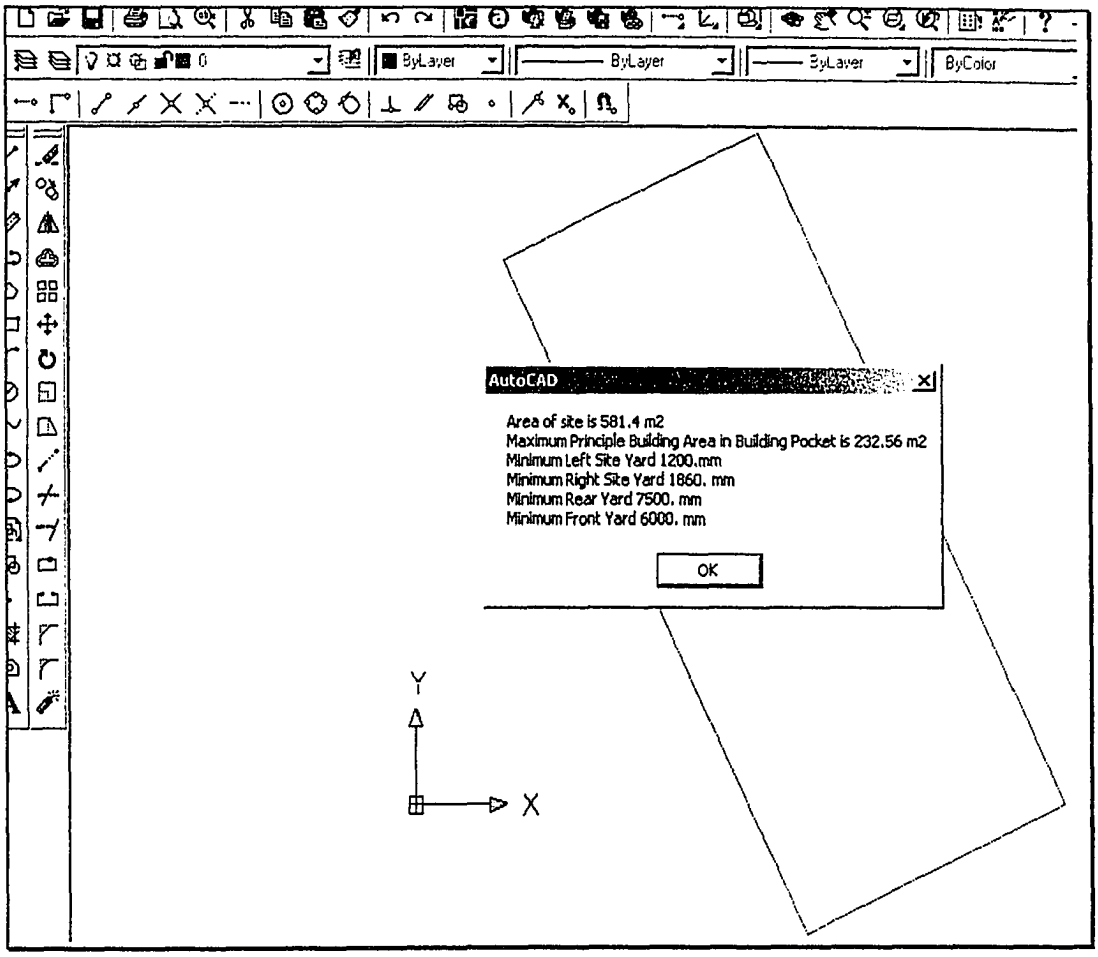


Figure 5-6: Yards Minimum Requirement Calculations

As explained in the methodology, the calculated side yard requirements are sent to the automation module, which automatically draws the building pocket inside the lot. Figure 5-7 is a captured screen of the automatically drawn lot size and building pocket.

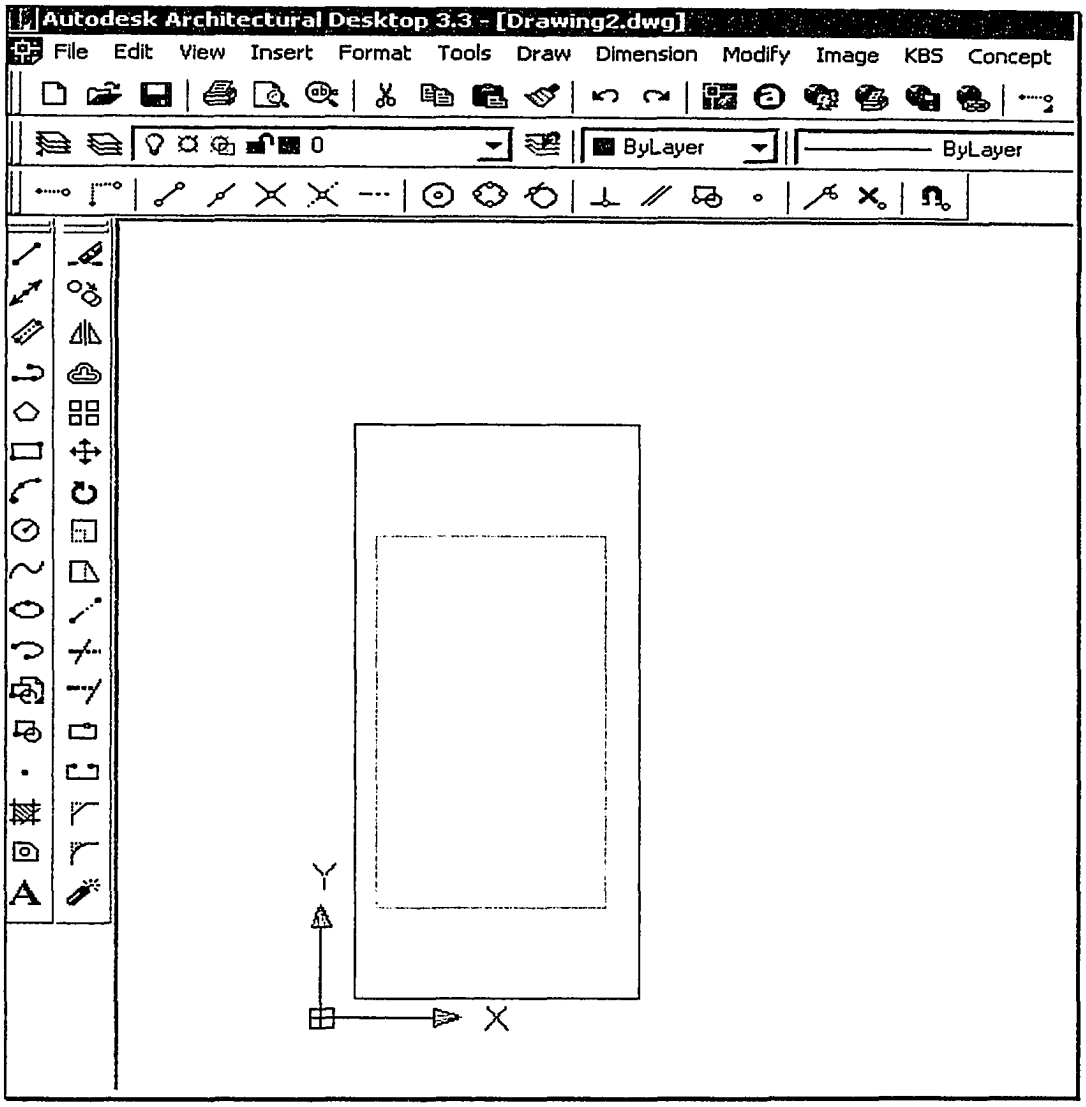


Figure 5-7: Automatically Drawn Lot Size and Building Pocket

Completing the Site Plan: The site plan that shows the dimensions of the proposed project site, the location of the proposed building, and the existing facilities on the site (power line, gas line, sewer line) was completed in specific CAD objects using specific layers. The principle building to be constructed on the site plan was represented by polyline object in the Principal building layer. Distances such as rear yard distance, and front yard distance were represented in specific layers created by the automation module. Figure 5-8 is the captured screen shot of the developed site plan showing the principle building area for case study.

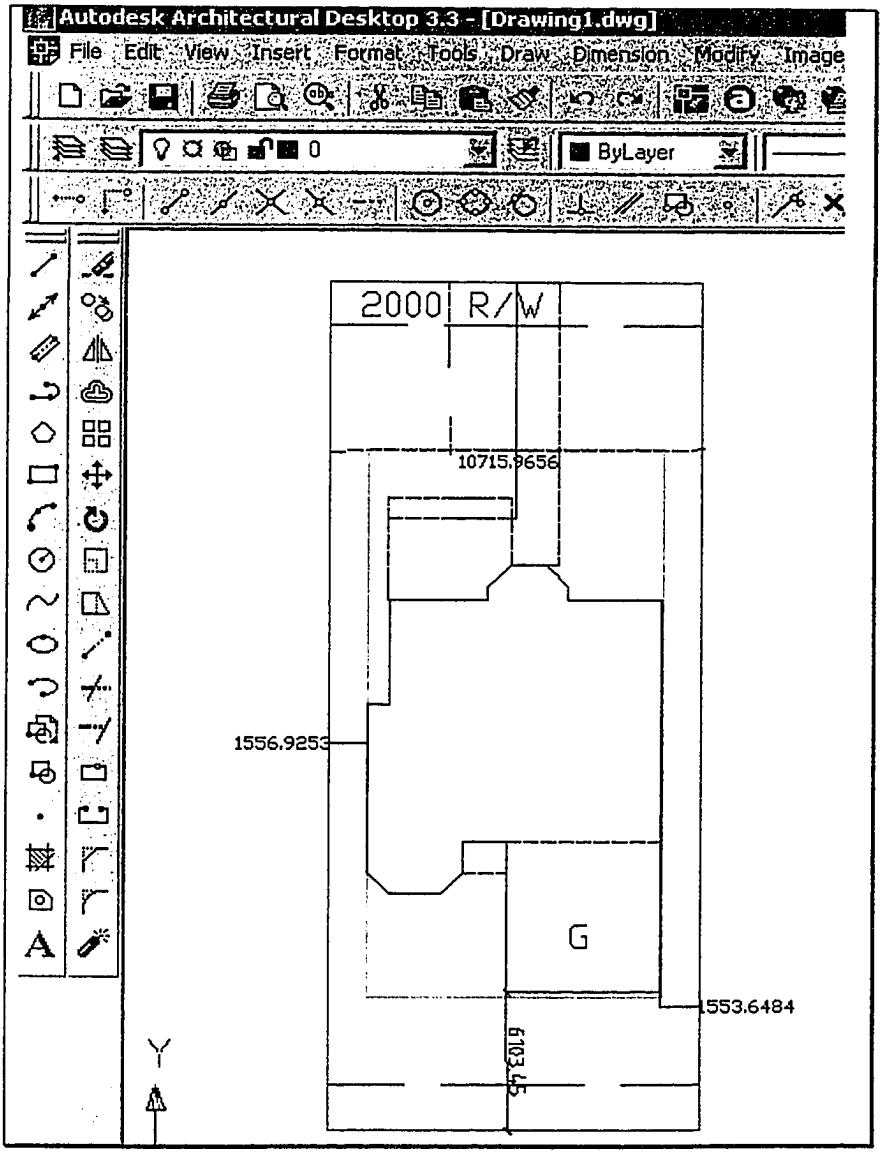


Figure 5-8: Site Plan showing Principle and Accessory Buildings

Saving the Drawing Data: As explained in the previous section, this is the process of saving the drawing data in the Building Information database. The ProjectID combo box the lists the ProjectID stored in the database. Figure 5-9 is a captured screen showing the list of available projects in the database. A mouse click on the Store Data button stored the lot data in the Building Information database; this involves the extraction of data from the CAD Drawing and its storage in the Building Information database.

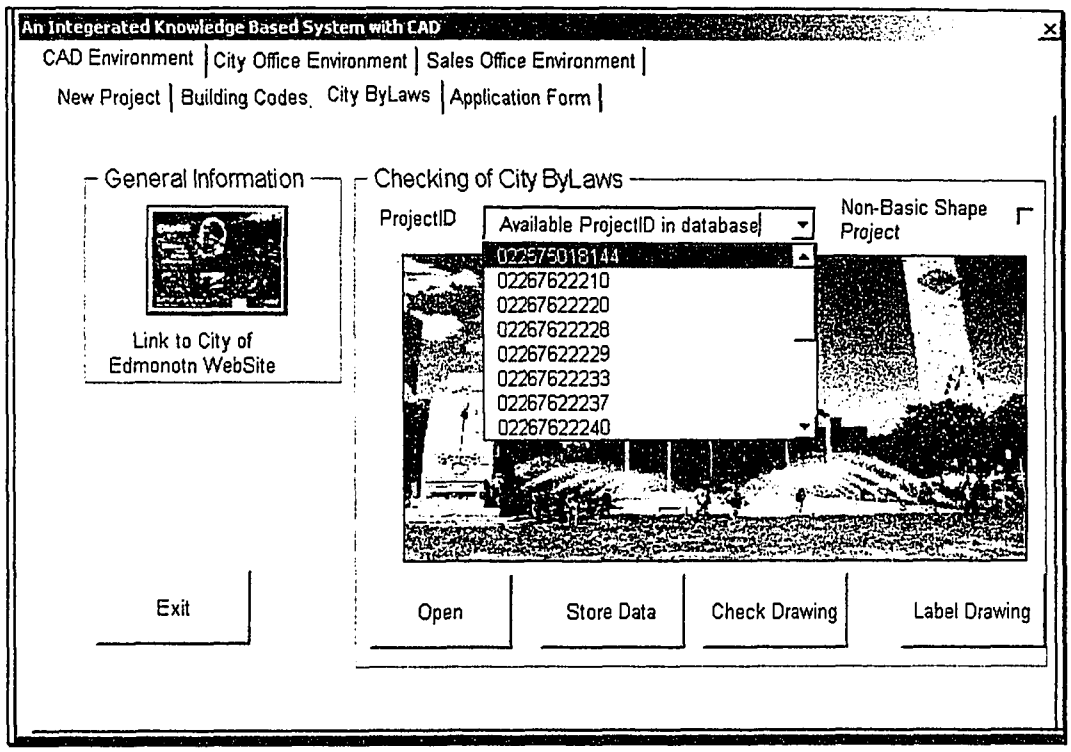


Figure 5-9: List of Available Projects in the Database

Checking of Drawing: Checking the site plan drawing with city bylaws before its submission as a part of a building permit application assures that the building permit will not be rejected. The mouse click on the Check Drawing button checked the site plan drawing with respect to city bylaw provisions and a message appeared to notify the user the state of the project with respect to its compliance with city bylaws.

Label Drawing: This option aims to accelerate the labeling drawings and setting drafting standards for housing industry. Labeling process is divided into two parts: 1) the basic data which needs to be provided for each project and 2) the information to be provided regarding the individual case. The mouse click on the Label Drawing button labeled the drawing for the basic information; input data for labeling is extracted from the building information database. Figure 5-10, and Figure 5-11 show the site plan with basic information and a site plan ready for submittal to city office respectively; the actual plans submitted for the case are shown in Appendix C.

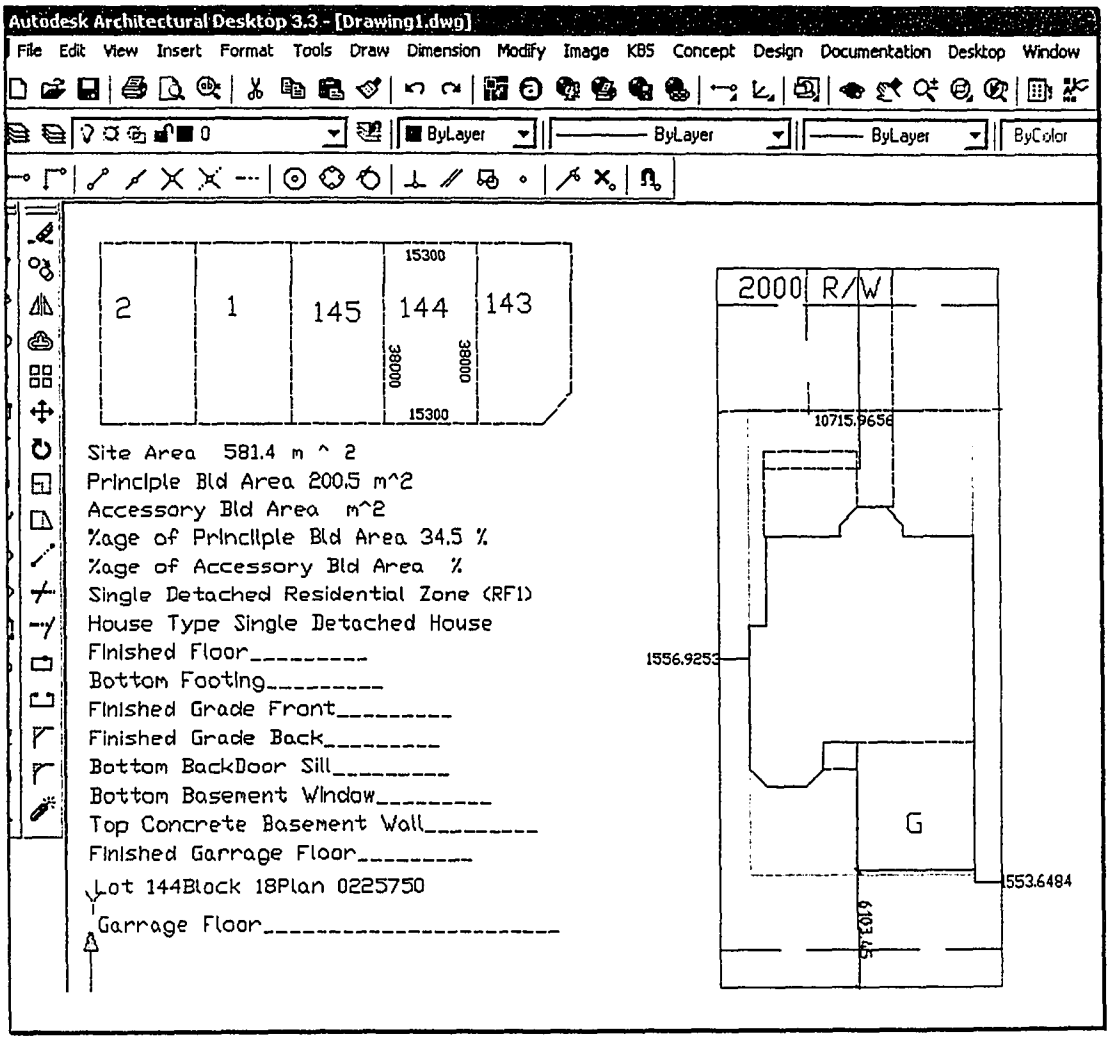


Figure 5-10: Site Plan with Basic Information

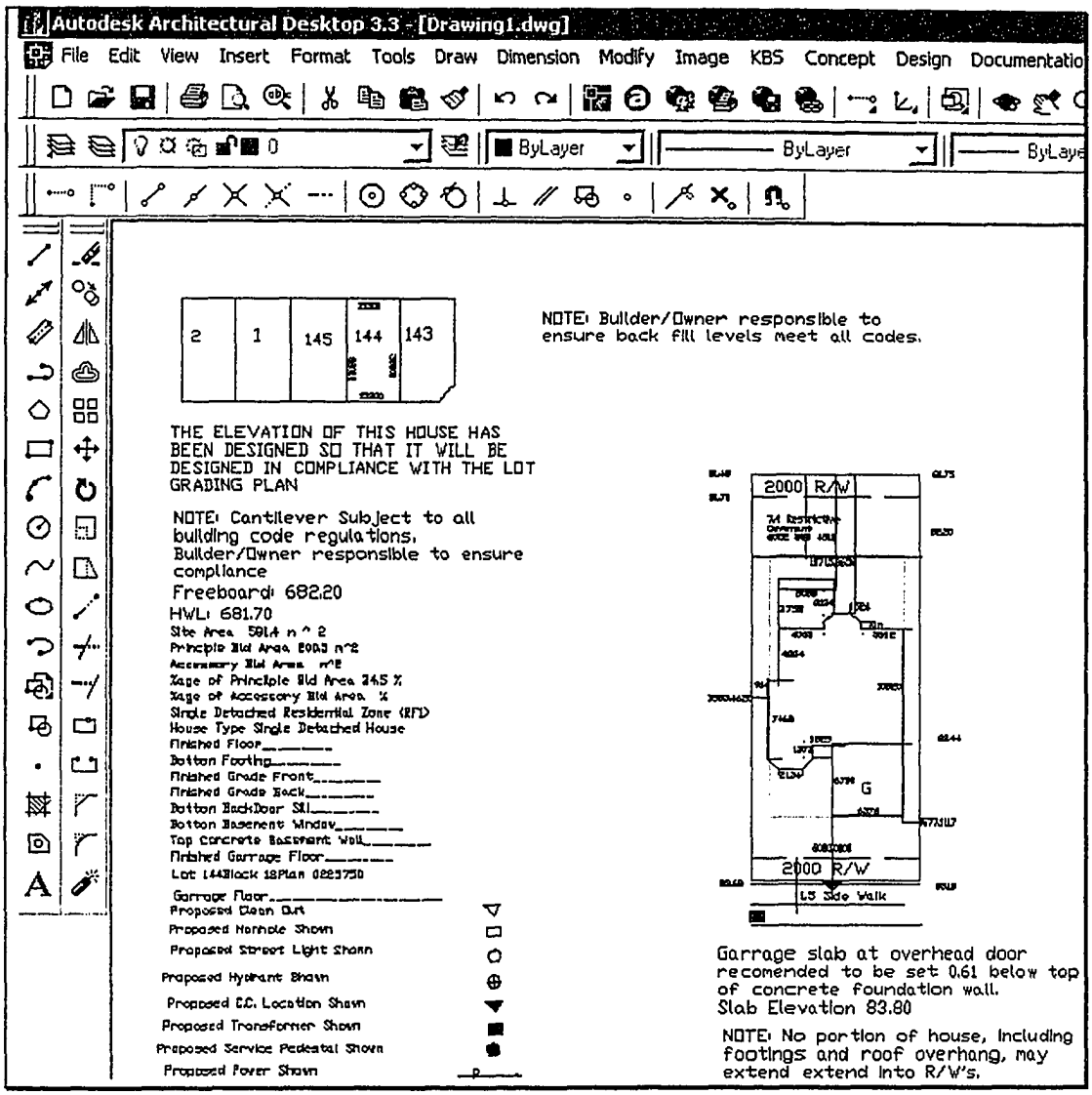


Figure 5-11: Site Plan Ready for Submission

5.2.1.2 Approval of the development permit with the ISCAD system

This process is carried out in the city office environment where the approving authorities are informed that a new permit application has been submitted for approval. The ProjectID was entered in the text boxes as shown in Figure 5-12. The approval of the development is carried out in two steps 1) checking of the drawing and 2) generation of the development permit. Checking the site for compliance with city bylaws, a process, which uses the developed IP module, is completed. The mouse

click on the Generate Development Permit button generates the development permit, which is shown in Appendix D.

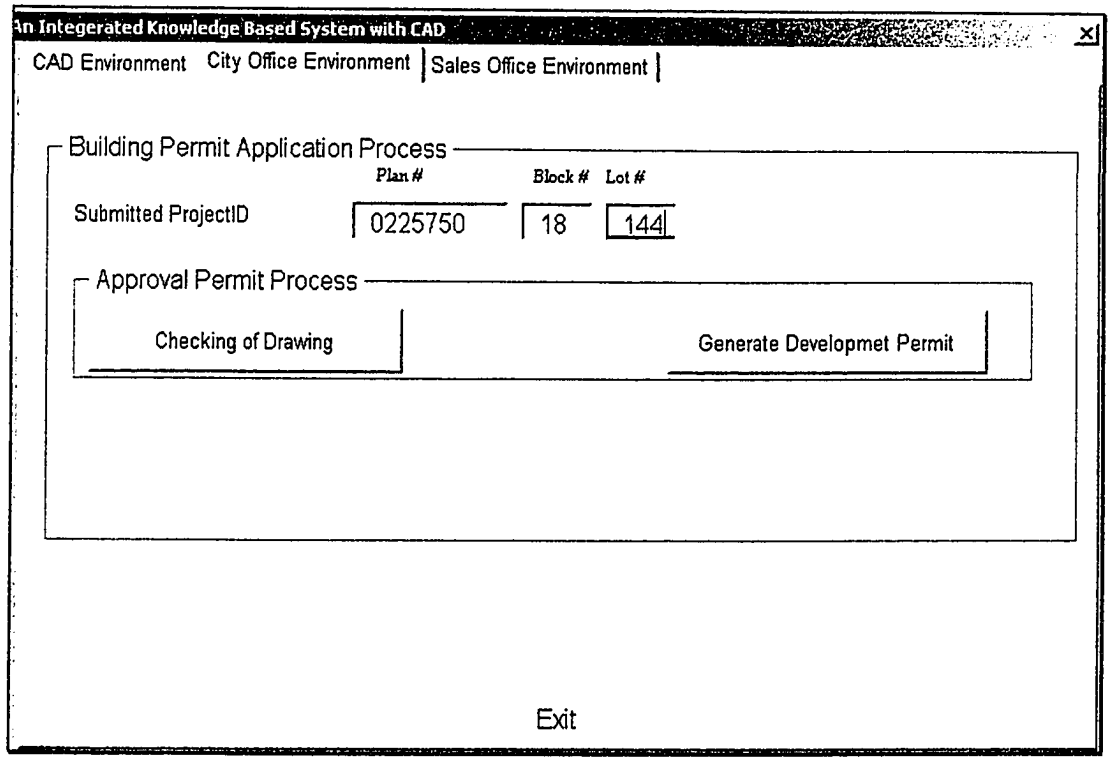


Figure 5-12: Permit Approval Process

5.2.1.3 Verification of changes with the ISCAD system

As explained in section 4.6.4.3 (Sales Office Environment), ISCAD provides instant feedback as to the feasibility of changes in the site plan. Figure 4-13 refers to the interfaces developed for the sales office environment; these allow for the changes in the site plan and for checking the site plan against city bylaws. The user (the approving authorities) selects the ProjectID 022575018144 and a mouse click on the open button opened the specific project in the AutoCAD environment. The front wall of garage was moved one foot ahead as per the client's request. A mouse click on the Update Existing Project button updates the drawing information in the Building Information database. Updating the drawing involves two steps: 1) extraction of the drawing data and 2) updating the information in the database. Verification of changes involves checking the modified drawing; the verification uses the IP module to check compliance with city bylaws. The mouse click on the verification module verifies the

changes made in the drawing. Figure 5-13 shows the highlighted non-compliant object displayed by the IP module after checking the drawing's compliance with city bylaws. In this case, the answer that suggests non-compliant changes is immediately provided. Thus the suggested change cannot be accepted.

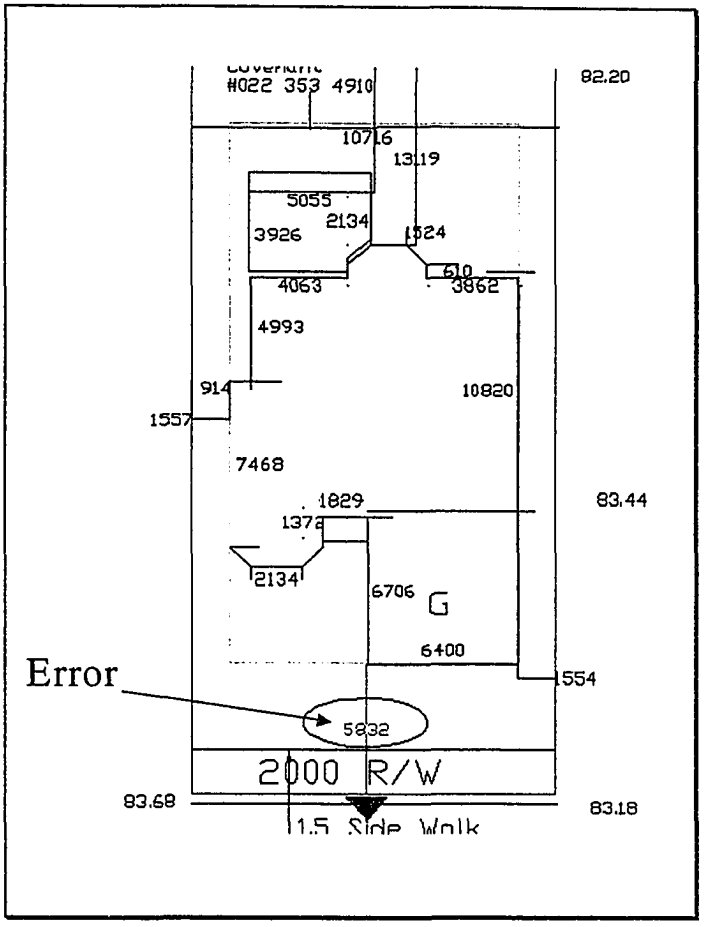


Figure 5-13: City Bylaws Violation: Non-compliant Object is Highlighted

5.3 Summary and Comments

The validation of ISCAD was performed with the case example. The aforementioned case study verifies the effectiveness of the various components for their intended uses and demonstrates the functions of the developed prototype. The proposed process emphasizes the use of electronic documentation, automatic checking of drawings, and automation by customization of CAD. The storage of drawing data in the central database makes it readily available to participants in the housing industry. The most

significant advantage of ISCAD is its capacity to integrate the processes carried out for drafting the development permit, its approval process, and checking the feasibility of changes with respect to city bylaws. Error and omissions are avoided by eliminating redundancies and automating the processes involved in the preparation, submission, and approval of the development permit.

6 SUMMARY AND CONCLUDING REMARKS

6.1 Conclusion

The housing construction industry is slow to undertake research and development of advanced computer technology needed to maintain the improvement of production performance in the modern world. Demands for changes within the industry come from both technological advancements as wells as different groups in the society. Ever-changing environments coupled with increasing demand from society for houses, necessitate a drive towards integration. Greater optimization of processes should be achieved to bridge the growing gap between social needs and the residential industry's supply. A computer integrated system for the preparation and approval of development permits for housing has been developed and presented in this thesis. The system consists of an automation module, two central databases, the IP module, and integrated building code assistance module. A user-friendly interface is developed to integrate the processes carried by the participants in the residential industry. The automation module allows the architect to accelerate the preliminary drafting process; it automatically draws the preliminary lot boundary and a building pocket compliant with city bylaws in the CAD environment. The city bylaws database stores the instances of the minimum requirements in the residential zones. The building information database stores the instances of the site plan. The developed databases are relational database designed using Entity Relationship (ER) diagram and are implanted using MS-ACCESS DBMS. Data access objects (DAO) are used to convey the information from the databases to the CAD environment and vice versa. The information-processing module (IP) is a set of city bylaws provisions written using IF-THEN statements in Visual Basic. The extraction module uses the Visual Basic Application (VBA) to extract the data from the CAD drawing, and the IP module compare the parameters of the existing drawing with the minimum requirements of the city bylaws stored in the city bylaws database. In addition, IP is accessible to all the participants of the project and is used to check the compliance of suggested changes in the site plan.

6.2 Research Contributions

The contributions of this research can be summarized as follow:

- The proposed methodology minimizes the redundancy involved in the development permit approval process.
- The research provides an intelligent CAD environment during the drafting of the site plan for the development /building permits applications.
- The research paves the way for the setting of drafting standards for residential industry.
- The research provides a tool incorporating IP with a CAD model to automate the city bylaws compliance drafting process.

In addition, the newly developed and implemented methodology is designed to assist the A/E, the city officer, and the sales officer through the different stages of the residential building project and it assists the A/E in preparing the development permit applications. The developed IP is used for checking the site plan drawing's compliance with city bylaws. The storage of project information in a central database allows the project participants to access information: enabling project participants to access the stored data in a central format ensures consistency, integrity and accuracy in the various uses of the data.

6.3 Recommendation for Future Research

This research presents a system that automates the development permit approval process for the residential industry. The future expansion of the proposed model includes the enhancement of the proposed methodology for the building permit approval process. The following is a list of recommendations for future endeavors:

1. Develop a methodology to automate the construction plan drawing based on parametric analysis. A simple menu based interface will allow the CAD operators to search for CAD entities based on any combination of properties. AutoCAD entities for example such as doors, and windows are the drawing primitives grouped into objects with architectural design information

associated with them. The properties of the objects will be governed by the stated properties of the corresponding objects in the building codes.

2. Develop model class abstraction for each kind of architectural design element, to be drawn and rendered in the CAD Environment. Also plan to use Virtual Reality Modeling Language (VRML) and share the information stored in the integrated database
3. Enhancement of the building information database: The development of an IFC-compliant object oriented product model will provide a class for physical as well as non physical objects encountered in the residential building project. An object will also encapsulate procedures that can be used to describe behavior of these objects. This could be used to store a richer kind of data and knowledge product, including design, manufacturing and operational parameters. The data stored in the building information database could be used to develop project management functions including cost estimation, and scheduling and to study the effect of possible changes on the estimating and the scheduling.
4. Enhancement of the City Bylaws database: The enhancement includes the development of an IFC compliance database that will store the instances of the minimum requirements for the objects used for the development of drawings.
5. Enhancement of IP module: The enhancements in the IP module will include the development of more functions that will check the constructions plan drawing's compliance with the building codes provisions.
6. Enhancement of Building Codes Help: The developed prototype provides help only on the "Room and Space Dimension" provisions listed in the NHC. More drawings illustrating the building code provisions could be added to assist the draftsman in designing the plan and elevation drawings of the proposed model. (See 4.6.5. System advantages and limitations)

Inclusion of more shapes: The prototype presented in this thesis consists of limited number of shapes and inclusion of more shapes will increase the scope of the developed prototype. (See 4.6.5. System advantages and limitations)

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APPENDIX A:

Sub-division Plans

(See Subdivision Plans, Page No. 104,105, in Pocket)

772 2037

REGIONAL OR MUNICIPAL PLANNING

THE CITY OF EDMONTON
MUNICIPAL PLANNING COMMISSION
FINAL SUBDIVISION APPROVED
FILE No. 76-L-174 LESSARD
DATE 1 Sept 1977 SUB. No. 147-5

PROVINCIAL PLANNING DIRECTOR

SUBDIVISION AND DEVELOPMENT REGULATIONS
APPROVED
75-L-174 1 Sept 1977
File No. Date

Parcel(s) 37-4 shown thereon to be the remainder as defined in the Planning Act in respect of this plan.

Under the provisions of Section 22 of The Planning Act 1963, the above endorsement is effective for a period of twelve months from the date of the above approval.

DIRECTOR OF SURVEYS

SURVEY APPROVED
DIRECTOR OF SURVEYS
DATE APPROVED 1977 Sept 8
EXD. A.G.S. FILE: 14023 334/28386
APPROVAL VALID FOR TWELVE MONTHS.

LAND TITLES

PLAN NUMBER 772-2037
HEREBY CERTIFIED AS DULY SIGNED AND REGISTERED IN THE LAND TITLES OFFICE FOR THE NORTH ALBERTA LAND REGISTRATION DISTRICT.
12 SEPT 77
REGISTRAR
7721738(1)

NOTE:
1. STATUTORY IRON SURVEY POSTS FOUND SHOWN THUS ... ●
2. STATUTORY IRON SURVEY POSTS PLANTED SHOWN THUS ... ○
3. ALBERTA SURVEY CONTROL MONUMENTS FOUND SHOWN THUS ... ●
4. BEARINGS ARE GRID REFERRED TO THE MERIDIAN THROUGH 114° WEST LONGITUDE 3° TRANSVERSE MERCATOR PROJECTION AND DERIVED FROM PLAN 782-0870 USING A.S.C.M. 928 & 28.32 AND 926.264 33
5. DISTANCES SHOWN ARE IN FEET AND DECIMALS THEREOF.
6. DISTANCES ON CURVED BOUNDARIES ARE ARC DISTANCES.
7. LOT NUMBERS SUFFIXED "U, G & W" ARE PUBLIC UTILITY PARCELS.
8. 1/2" SQUARE x 16" LONG IRON BARS PLANTED AT ALL LOT CORNERS UNLESS SHOWN OTHERWISE.
9. BEARINGS ON RADIAL LINES SHOWN THUS (89° 59' 60").
10. AREA REGISTERED UNDER THIS PLAN SHOWN OUTLINED THUS ... CONTAINING 88.74 ACRES.

I, GRANT CROSS OF THE TOWN OF FORT SASKATCHEWAN, ALBERTA, ALBERTA LAND SURVEYOR, MAKE OATH AND SAY:
THAT THE SURVEY REPRESENTED BY THIS PLAN WAS MADE UNDER MY PERSONAL SUPERVISION,
THAT THE SURVEY WAS MADE IN ACCORDANCE WITH GOOD SURVEYING PRACTICES AND IN ACCORDANCE WITH THE PROVISIONS OF THE SURVEYS ACT, AND
THAT THE SURVEY WAS PERFORMED BETWEEN THE DATES OF JUNE 17th AND NOVEMBER 28th, 1976, AND THAT THIS PLAN IS TRUE AND CORRECT, AND IS PREPARED IN ACCORDANCE WITH THE PROVISIONS OF THE LAND TITLES ACT.

SWORN BEFORE ME AT THE CITY OF EDMONTON IN THE PROVINCE OF ALBERTA, THIS 2nd DAY OF DECEMBER 1976.
A COMMISSIONER FOR OATHS IN AND FOR THE PROVINCE OF ALBERTA
ALBERTA LAND SURVEYOR

I, ALEX PRESTON OF THE CITY OF EDMONTON IN THE PROVINCE OF ALBERTA, MAKE OATH AND SAY:
I WAS PERSONALLY PRESENT AND DID SEE DARCY WILLIAM KURYCH, TILLIE KURYCH & ANGUS G. MACDONALD, NAMED IN THE WITHIN INSTRUMENT WHO ARE PERSONALLY KNOWN TO ME TO BE THE PERSON NAMED THEREIN, DULY SIGN AND EXECUTE THE SAME FOR THE PURPOSES NAMED THEREIN.
THAT THE SAME WAS EXECUTED AT THE CITY OF EDMONTON IN THE PROVINCE OF ALBERTA, AND THAT I AM THE SUBSCRIBING WITNESS THERETO.
THAT I, ALEX PRESTON KNOW THE SAID DARCY WILLIAM KURYCH TILLIE KURYCH & ANGUS G. MACDONALD AND WHO ARE IN MY BELIEF OF THE FULL AGE OF EIGHTEEN YEARS.

SWORN BEFORE ME AT THE CITY OF EDMONTON IN THE PROVINCE OF ALBERTA, THIS 29 DAY OF JUNE A.D. 1976.
A COMMISSIONER FOR OATHS IN AND FOR THE PROVINCE OF ALBERTA.
WITNESS TO OWNERS AND CAVEATOR(S) SIGNATURES

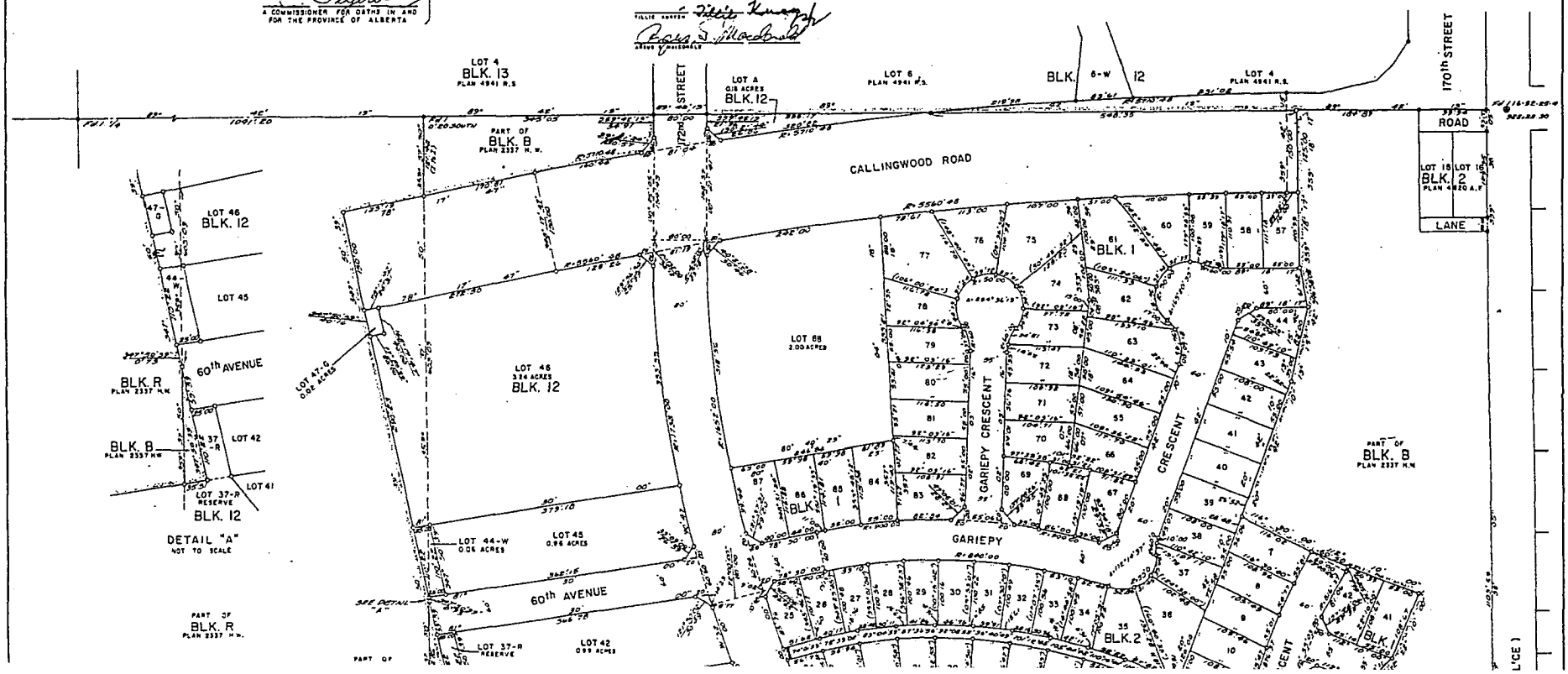
SIGNED BY THE REGISTERED OWNERS
DARCY WILLIAM KURYCH
TILLIE KURYCH
ANGUS G. MACDONALD
IN THE PRESENCE OF
WITNESS

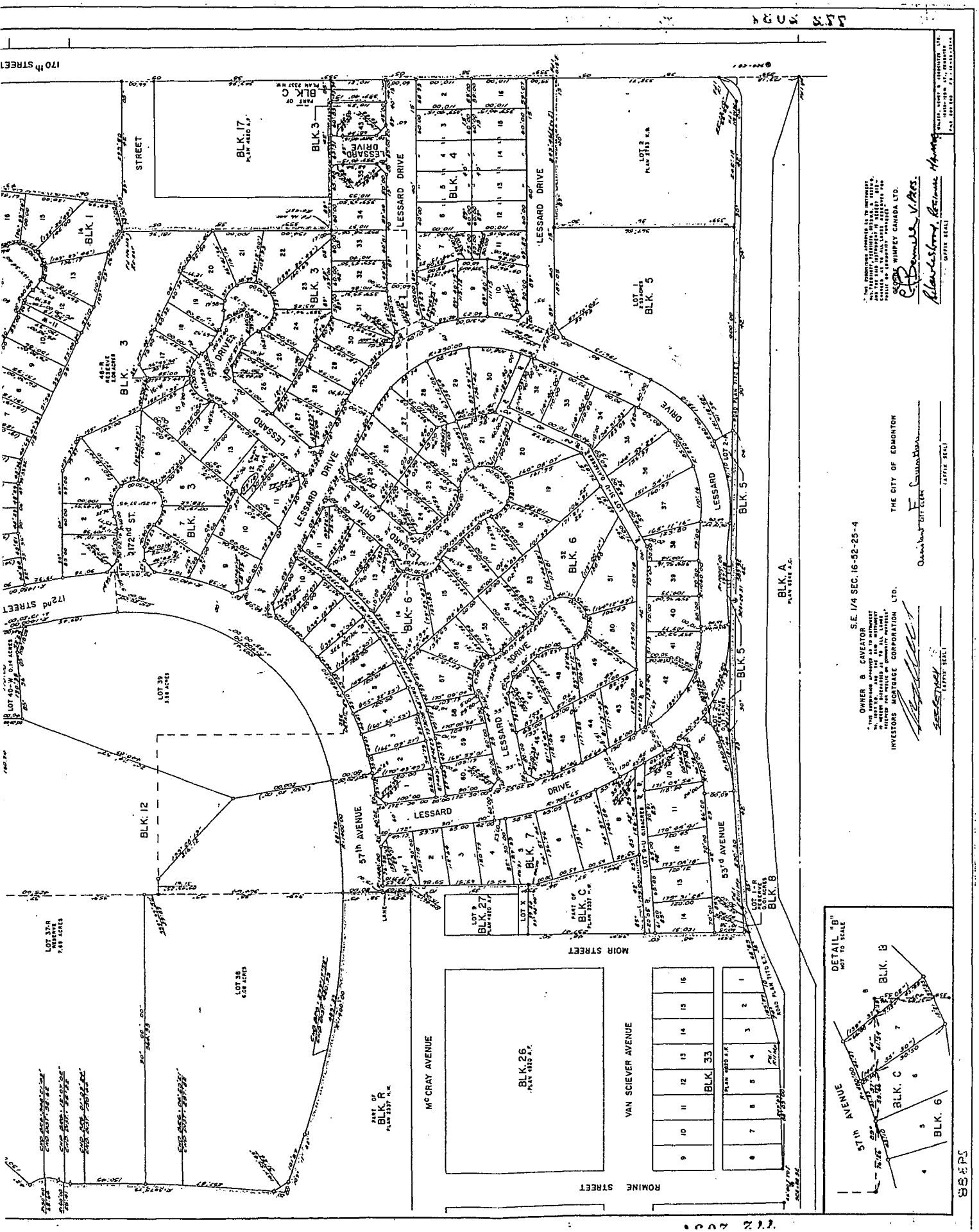
LESSARD
PLAN
SHOWING SUBDIVISION OF

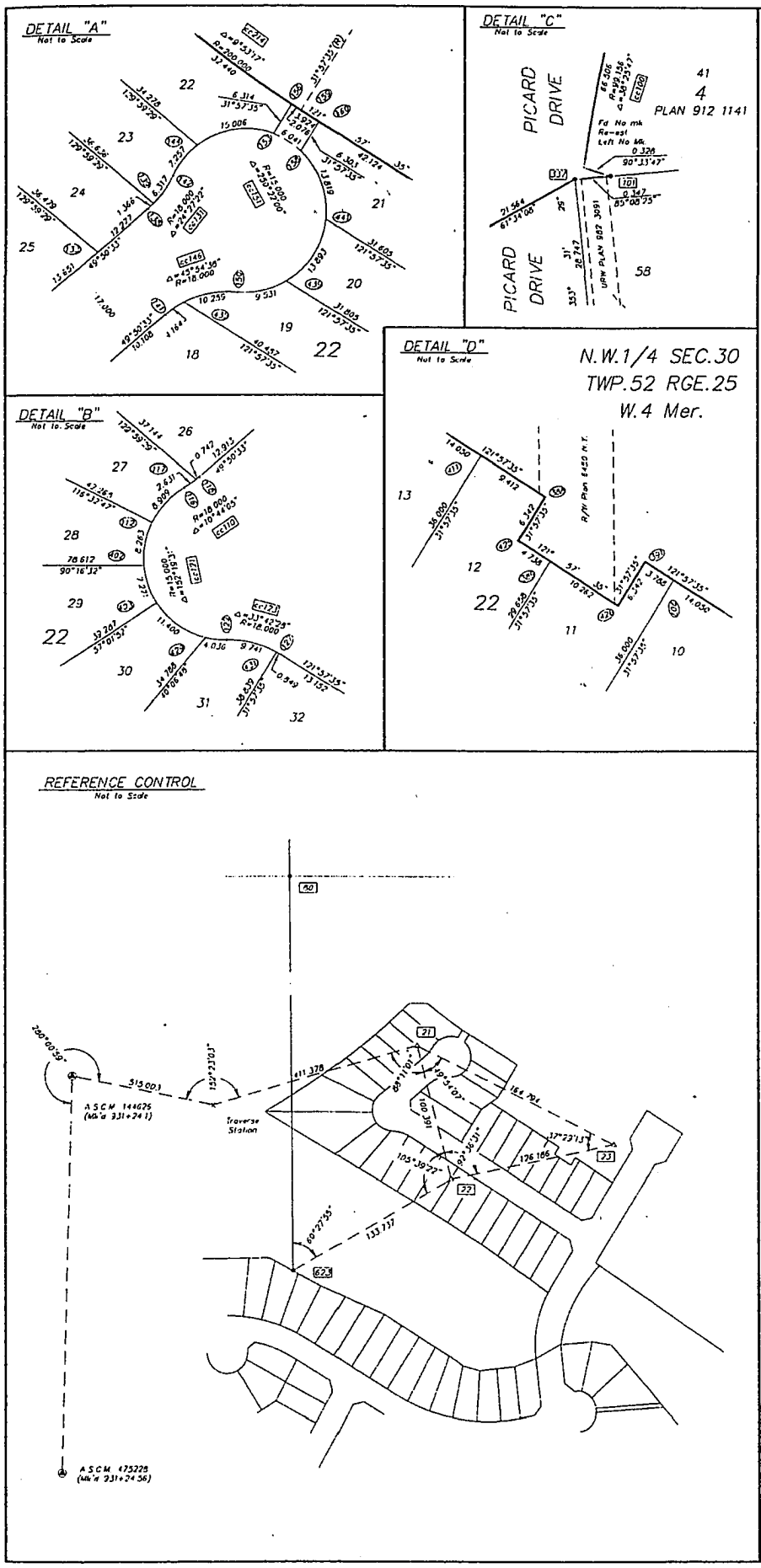
BLOCK	PLAN	AREA (Ac's)
PART OF B	2337 H.W.	81.73
PART OF C	2337 H.W.	28.79
PART OF R	2337 H.W.	10.22

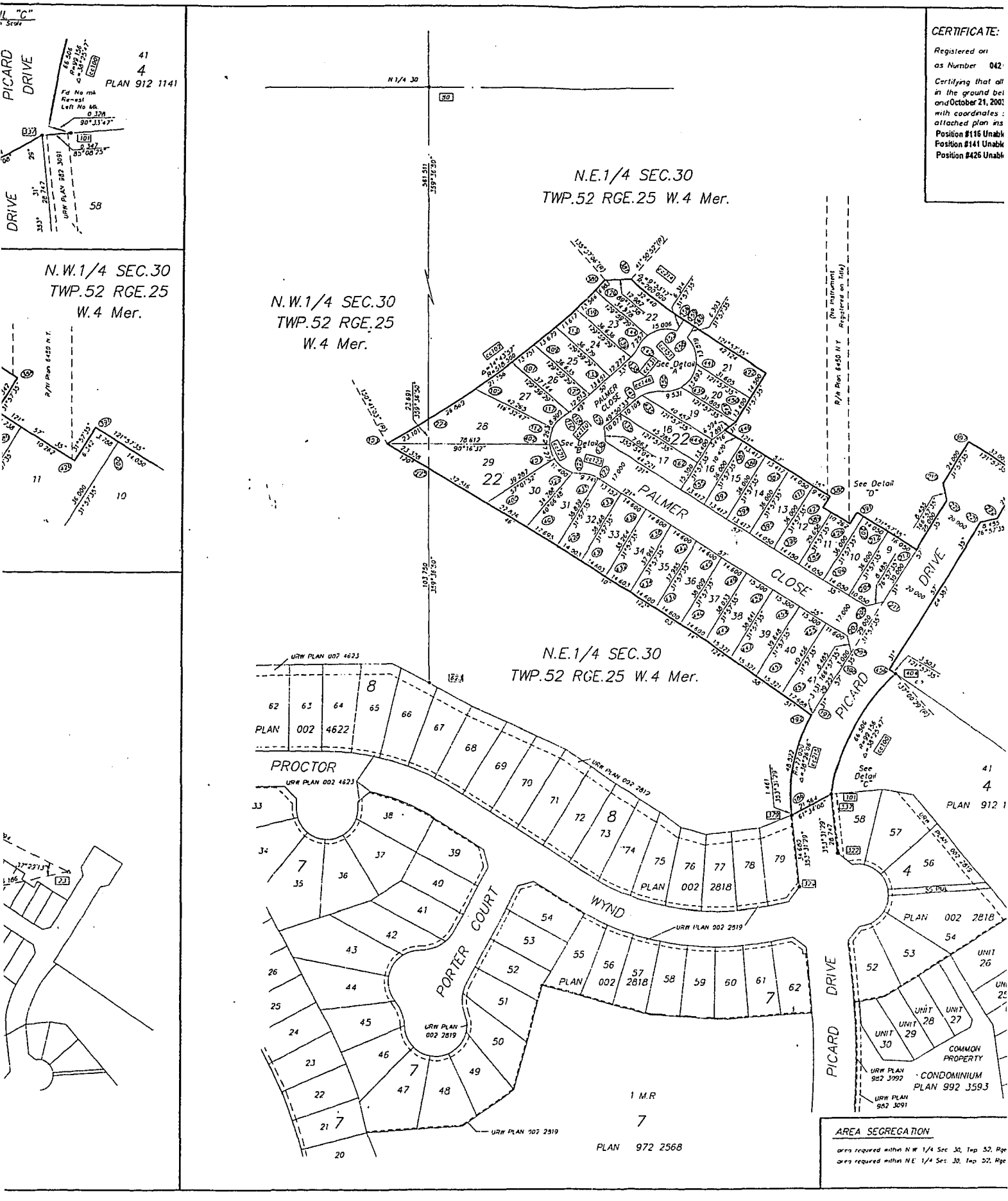
IN THE
N.E. 1/4 SEC. 16, TWP. 52, RGE. 25, W.4th M.
EDMONTON ALBERTA

SCALE: 1/1000 BY: GRANT CROSS A.L.S.
1976









Page No. 105

CERTIFICATE: SECTION 47, SURVEYS ACT

Registered on February 13, 2004

as Number 042 067 154

Certifying that all Statutory Monuments were placed in the ground between the dates of October 4, 2003 and October 21, 2003 and are positioned in accordance with coordinates shown on the plan or on the attached plan instrument except for the following.

Position #116 Unable to post due to driveway

Position #141 Unable to post due to dirt pile

Position #426 Unable to post due to fence post

C. Jones
REGISTRAR

LAND TITLES OFFICE

PLAN No. 022 6762

ENTERED AND REGISTERED

ON November 1, 2002

INSTRUMENT No. 022 417 271

Merlyn P. Cafindos
A.D. REGISTRAR
N.A.L.R.D.

LEWIS ESTATES
POTTER GREENS STAGE 6

PLAN SHOWING

SURVEY OF SUBDIVISION

OF PARTS OF

N.E.1/4 SEC. 30, TWP. 52, RGE. 25, W.4 Mer.

AND

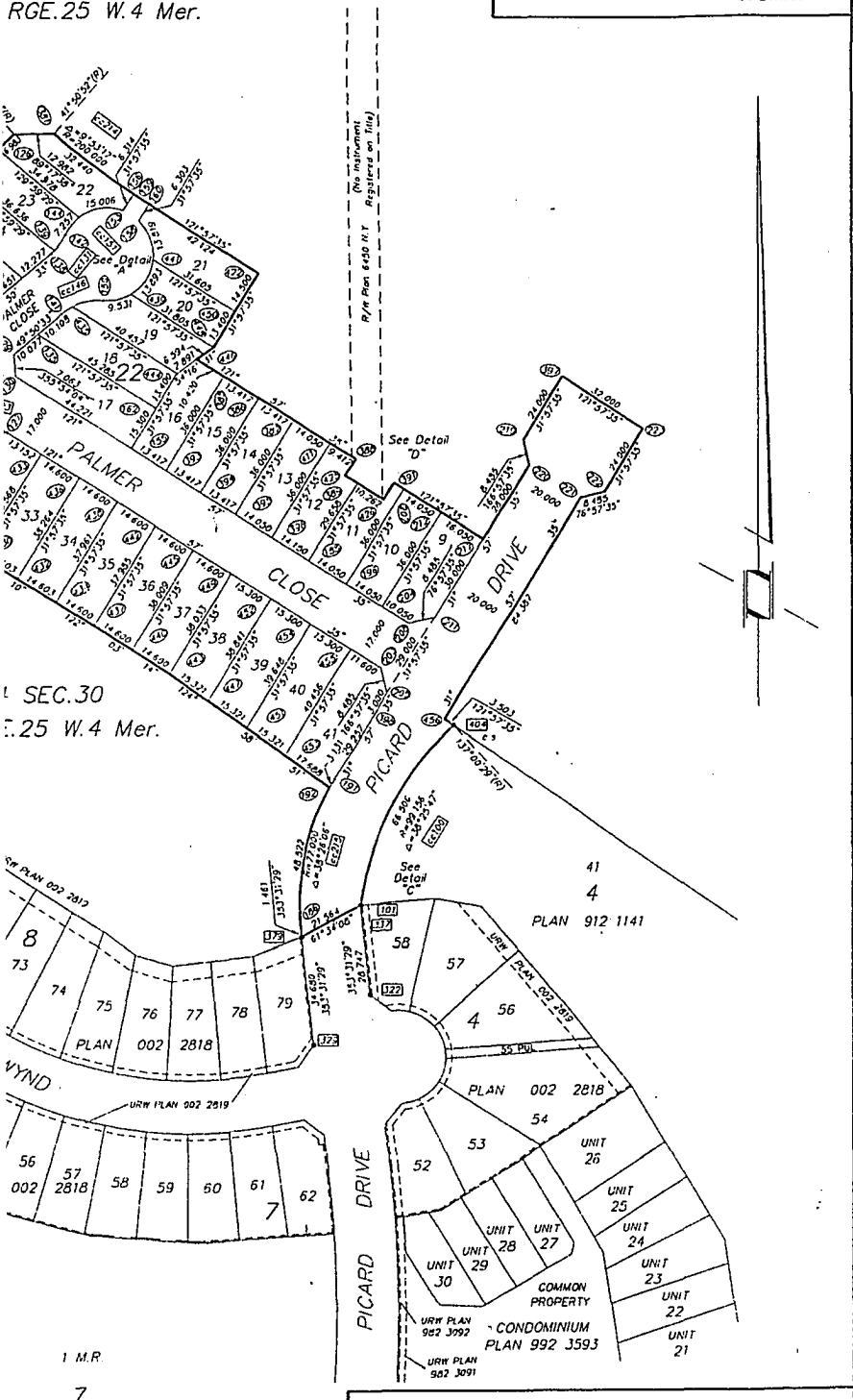
N.W.1/4 SEC. 30, TWP. 52, RGE. 25, W.4 Mer.

ALL WITHIN

N. 1/2 SEC. 30, TWP. 52, RGE. 25, W.4 Mer.

EDMONTON ALBERTA

Scale 1:1000 — 0 10 20 40 60 80 100 120 Metres



LEGEND

Area to be registered shown bounded thus ——— contains 2.81 ha.

Statutory Iron Survey Posts found shown thus ● 222

Alberta Survey Control Markers found shown thus ⊕ A.S.C.M.

Curve centre coordinates are shown thus (c222)

The position where Statutory Iron Survey posts are to be placed pursuant to Section 47 of the Surveys Act are shown thus ○ 227

Reference Monuments, 0.025 x 1.000 long iron bars, planted shown thus △ 113

NOTES

Coordinate positions for Survey Monuments found or placed by this survey, Survey Control Markers used, Reference Monuments installed, and for the location of all Survey Monuments to be placed in accordance with Section 47 of the Surveys Act are shown in a Table of Coordinates attached to the Plan Instrument

The Coordinate values are 3TM, the reference Meridian is 114° West Longitude and based on NAD 83 datum

The Combined factor used is 0.999799

All distances are expressed in metres and decimals thereof.

Distances along curved boundaries are arc distances

All cutoffs are 6.0 metres unless otherwise noted

Cutoff on Lot 22, Block 22 is 9.0 metres

A.S.C.M. denotes Alberta Survey Control Marker	P.U.L. denotes Public Utility Lot
c.s. denotes Countersunk	R denotes Radius
Δ denotes Central angle of curve	(R) denotes radial bearings
Fd denotes Found	Re-est denotes Re-established
ha denotes Hectare	R/W denotes Right of Way
Mer. denotes Meridian	Rge. denotes Range
Mk. denotes mark	Sec. denotes Section
Mk'd denotes marked	Twp. denotes Township
M.R. denotes Municipal Reserve	URW denotes Utility Right Of Way

Bearings are grid, referenced to the Meridian of 114° West Longitude, based on Nad 83 datum and derived from the A.S.C. Markers shown on this plan.

REGISTERED OWNER

LEWIS ESTATES COMMUNITIES INC.

SUBDIVISION AUTHORITY

CITY OF EDMONTON
FILE NO.: SUB/02-0032
DATE APPROVED: OCTOBER 28, 2002

SURVEYOR

N.R. MATTSON, A.L.S.

DATES OF SURVEY

BETWEEN APRIL 18, 2000 and SEPTEMBER 10, 2002

ALBERTA LAND SURVEYORS' ASSOCIATION PERMIT NUMBER P046 The Focus Corporation Ltd

AREA SEGREGATION

area required within N.W. 1/4 Sec. 30, Twp. 52, Rge. 25, W4 Mer. ..... = 0.023 ha

area required within N.E. 1/4 Sec. 30, Twp. 52, Rge. 25, W4 Mer. ..... = 2.785 ha

Total = 2.808 ha

FOCUS INTEC
A DIVISION OF THE FOCUS CORPORATION LTD
Suite 1000
9925 - 109 Street Edmonton Phone 466 6555 Fax 421 1217

JOB No. 100480-00

DWG.NO 100480-00-LS-2

DP\LTR\CLK\NRM

APPENDIX B:

General Definitions

Abut or **abutting** means immediately contiguous to or physically touching, and when used with respect to a lot or Site, means that the lot or Site physically touches upon another lot, Site, or piece of land, and shares a property line or boundary line with it.

Accessory means, when used to describe a Use or building, a Use or building naturally or normally incidental, subordinate, and exclusively devoted to the principal Use or building, and located on the same lot or Site.

Approving Authorities Both development officer and building codes safety officer check the drawing compliance to city bylaws and building code provisions respectively. The approving authorities include both development officer and building codes safety officer.

Class A Permitted Development: This Class includes all developments for which applications are required and are for a Permitted Use or Accessory Building or activities and the Development Application complies in all respects to the regulations of this Bylaw. Applications for Signs, accessory functions and the occupancy of existing buildings on Sites regulated by a Direct Control provision and conforming to that provision shall also be considered a Class A Permitted Development.

Class B Discretionary Development: This Class includes all developments for which applications are required and are for a Discretionary Use or require a variance to any of the regulations of this Bylaw. This Class of Permit also includes all applications on Sites designated Direct Control not noted in Class A Permitted Development.

Corner Lot means:

1. driveways, aisles and parking lots unless they are part of a Parking Garage which extends 1.0 m or more above grade; or

Edmonton Zoning Bylaw means a land use bylaw, as that term is used in the Municipal Government Act.

Enclosed Front Porch means an entrance structure typically located at the front or side of a Dwelling at the ground floor entry level, consisting of a roof and floor, where the front and sides of the structure have been enclosed by solid walls or windows.

Floor Area means the total Floor Area of the building or structure, contained within the outside surface of the exterior and Basement walls, provided that in the case of a wall containing windows, the glazing line of windows may be used.

Floor Area Ratio means the numerical value of the Floor Area of the building or structure relative to the Site upon which it is located, excluding: (a) Basement areas used exclusively for storage or service to the building; (b) parking areas below grade; (c) walkways required by the Development Officer; and (d) Floor Areas devoted exclusively to mechanical or electrical equipment servicing the development, divided by the area of the Site.

Front Lot Line means the property line separating a lot from an abutting public roadway other than a Lane. In the case of a Corner Lot, the Front Line is the shorter of the property lines abutting a public roadway, other than a Lane. In the case of a Corner Lot formed by a curved corner, the Front Lot Line shall be the shorter of the two segments of the property line lying between the point determined to be the actual corner and the two points at the extremities of that property line.

Front Yard means the portion of a Site abutting the Front Lot Line extending across the full width of the Site, situated between the Front Lot Line and a line on the Site parallel to it, at a specified distance from it, and measured at a right angle to it along its full length.

Frontage means, where used with reference to residential development, the lineal distance measured along the Front Lot Line; and where used with reference to non-residential development, the length of the property line of any side of a separate development which is parallel to, and abuts, a public roadway, not including a Lane, which is directly accessible from the development. The Frontage of an individual premise in a multiple occupancy development shall be considered as the total width of the bays occupied by that premises which have exposure parallel to any Frontage of the multiple occupancy development.

Garage means an Accessory building, or part of a principal building designed and used primarily for the storage of motor vehicles and includes a carport.

Height means, when used with reference to a building or structure, the vertical distance between the horizontal plane through grade and a horizontal plane through:

Lane means an alley as defined in the Highway Traffic Act, 1980.

Living Room means any room in a Dwelling used for the common social activities of the occupants, and designed for general living, whether or not combined with specific activities such as dining, food preparation, or sleeping. Unless provided in such combination, a kitchen or dining room is not a Living Room.

1. lot located abutting a public roadway, other than a Lane, which changes direction at any point where it abuts the lot;
2. lot located at the intersection of two public roadways, other than Lanes; or

Mobile Home Lot means the space allotted for the installation of one Mobile Home in any Mobile Home Park or Mobile Home Subdivision.

Parcel A specified area of land.

Permitted Uses means those uses of land, buildings or structures for which Permits must be issued by the Development Officer, if the development meets all applicable regulations.

Provided that in both cases the lot shall not be considered a Corner Lot where the contained angle formed by the intersection or change of direction is an angle of more than 135 degrees. In the case of a curved corner, the angle shall be determined by the lines tangent to the property line abutting the public roadways, provided the roadway is not a Lane, at the point which is the extremity of that property line. In the case of a curved corner, the point which is the actual corner of the lot shall be that point on the property line abutting the public roadway, provided the roadway is not a Lane, which is nearest to the point of intersection of the tangent lines.

Rear Lot Line means either the property line of a lot which is furthest from and opposite the Front Lot Line, or, where there is no such property line, the point of intersection of any property lines other than a Front Lot Line which is furthest from and opposite the Front Lot Line.

Rear Yard means the portion of a Site abutting the Rear Lot Line extending across the full width of the Site, situated between the Rear Lot Line and a line on the Site

parallel to it, at a specified distance from it, measured at a right angle to it along its full length.

Side Yard means that portion of a Site abutting a Side Lot Line extending from the Front Yard to the Rear Yard. The Side Yard shall be situated between the Side Lot Line and a line on the Site parallel to it, at a specified distance from it, and measured at a right angle to it along its full length.

Site Coverage means the total horizontal area of all buildings or structures on a Site which are located at or higher than 1.0 m above grade, including Accessory Buildings or Structures, calculated by perpendicular projection onto a horizontal plane from one point located at an infinite distance above all buildings and structures on the Site. This definition shall not include:

Site means an area of land consisting of one or more abutting lots.

Site Plan shows where the buildings are located on the property.

Site Width means the horizontal distance between the side boundaries of the Site measured at a distance from the Front Lot Line equal to the minimum required Front Yard for the Zone;

2. steps, eaves, cornices, and similar projections;

Storey means that portion of a building, which is situated between the top of any floor and the top of the floor next above it. If there is no floor above, the Storey is the portion of the building, which is situated between the top of any floor and the ceiling above it. If the top of the floor directly above a Basement is more than 1.83 m above grade, such Basement shall be considered a Storey for the purpose of this Bylaw.

Subdivision Plan A plan dividing land into two or more parcels.

1. the average level between eaves and ridges in the case of a pitched, gambrel, mansard or hipped roof, or a roof having a slope of more than 20 degrees; provided that in such cases the ridge line of the roof shall not extend more than 1.5 m above the maximum permitted building Height of the Zone;
2. the highest point of the roof in the case of a building with a flat roof or a roof having a slope of less than 20 degrees; and

3. unenclosed inner and outer courts, terraces and patios where these are less than 1.0 m above grade.

Yard means required open space unoccupied by any portion of a building or structure 1.0 m or more above grade, unless otherwise permitted in this Bylaw. A Yard is not a Setback, Amenity Area or Separation Space; and

Zone means a specific group of listed Use Classes and Development Regulations, which regulate the use, and development of land within specific geographic areas of the City. The Use Classes and Development Regulations are contained in Parts II and IV of this Bylaw, and may be subject to the regulations contained in Part I of this Bylaw, while the geographic areas to which they apply are shown on the Zoning Map, comprising Part III of the Bylaw.

Zoning Bylaw Compliance Certificate ("Compliance Certificate") means a document which may be issued by a Development Officer, upon request and upon payment of the required fees, indicating that a building(s) located on a Site is (are) located in accordance with the Yard regulations of this Bylaw and the Yards specified in Development Permits which may have been issued for the Site. A Compliance Certificate shall not operate as a Development Permit nor shall it approve any variance to the Yard regulations of this Bylaw not previously approved;

Residential uses classes:

Apartment Housing means development consisting of one or more Dwellings contained within a building in which the Dwellings are arranged in any horizontal or vertical configuration, which does not conform to the definition of any other Residential Use Class.

Duplex Housing means development consisting of a building containing only two Dwellings, with one Dwelling placed over the other in whole or in part with individual and separate access to each Dwelling. This type of development shall be designed and constructed as two Dwellings at the time of initial construction of the building. This Use Class does not include Secondary Suites.

Garage Suite means development consisting of a self-contained Dwelling located above a rear detached Garage, which is Accessory to Single Detached Housing. A

Garage Suite has cooking, food preparation, sleeping and bathing facilities, which are separate from those of the principal Dwelling located on the lot. For the purpose of this clause, "cooking facilities" includes any stove, hotplate, oven, microwave oven, toaster oven or electric griddle, as well as any wiring or piping containing the energy or power source for such facilities. A Garage Suite has an entrance separate from the entrance to the rear detached Garage, either from a common indoor landing or directly from the exterior of the structure. This Use Class does not include Secondary Suites.

Mobile Home means development consisting of transportable Single Detached Housing which is suitable for permanent occupancy, designed to be transported on its own wheels, and which is, upon its arrival at the Site where it is to be located, ready for occupancy except for incidental building operations such as placement on foundation supports and connection to utilities.

Row Housing means development consisting of a building containing a row of two or more Dwellings joined in whole or in part at the side only with no Dwelling being placed over another in whole or in part. Each Dwelling shall be separated from the one adjoining, where they are adjoining, by a vertical Party Wall, which is insulated against sound transmission. Adjoining rooms may or may not be Habitable Rooms. Each Dwelling shall have separate, individual, and direct access to grade. This Use Class includes Semi-detached Housing.

Secondary Suite means development consisting of a self-contained Dwelling located in a structure in which the principal use is Single Detached Housing. A Secondary Suite has cooking, food preparation, sleeping and bathing facilities, which are separate from those of the principal Dwelling within the structure. For the purpose of this clause, "cooking facilities" includes any stove, hotplate, oven, microwave oven, toaster oven or electric griddle, as well as any wiring or piping containing the energy or power source for such facilities. A Secondary Suite also has an entrance separate from the entrance to the principal Dwelling, either from a common indoor landing or directly from the exterior of the structure. This Use Class includes Conversion of Basement space to a Dwelling, or the addition of new floor space for a Secondary Suite to an existing Single Detached Dwelling. This Use Class does not include

Duplex Housing, Semi-detached Housing, or Apartment Housing, where the structure was initially designed for two or more Dwellings, and does not include Boarding and Lodging Houses.

Semi-detached Housing means development consisting of a building containing Row Housing consisting of only two Dwellings. This Use Class includes two family Dwellings.

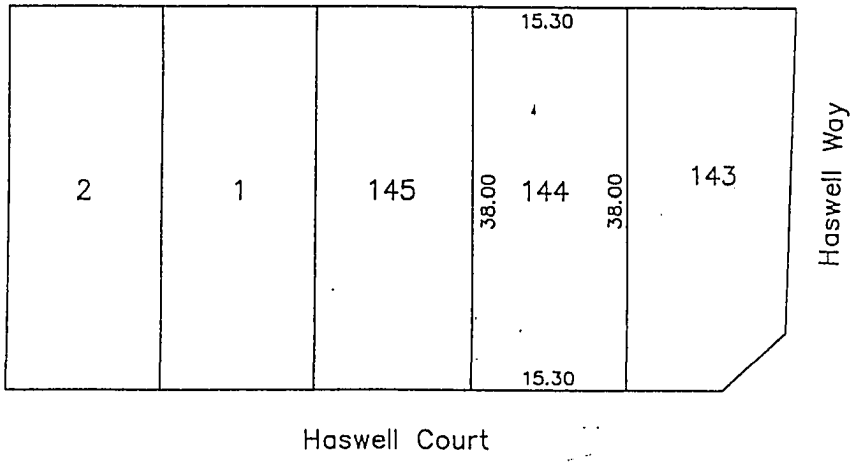
Single Detached Housing means development consisting of a building containing only one Dwelling, which is separate from any other Dwelling or building. Where a Secondary Suite is a Permitted or Discretionary Use Class in a Zone, a building which contains Single Detached Housing may also contain a Secondary Suite. This Use Class includes Mobile Homes, which conform to Section 78 of this Bylaw.

Stacked Row Housing means development consisting of Row Housing, except that Dwellings may be arranged two deep, either vertically so that Dwellings may be placed over others, or horizontally so that Dwellings may be attached at the rear as well as at the side. Each Dwelling shall have separate and individual access, not necessarily directly to grade, provided that no more than two Dwellings may share access to grade, and such access shall not be located more than 5.5 m above grade. This Use Class includes Duplex Housing and Row Housing.

APPENDIX C:

Development Permit and Site Plan for Case Study

(See Page No 115 in Pocket)



THE ELEVATION OF THIS HOUSE HAS BEEN DESIGNED SO THAT IT WILL BE IN CONFORMANCE WITH THE LOT GRADING PLAN.

NOTE:
Cantilever Subject To All Building Code Regulations Builder/Owner Responsible To Ensure Compliance.

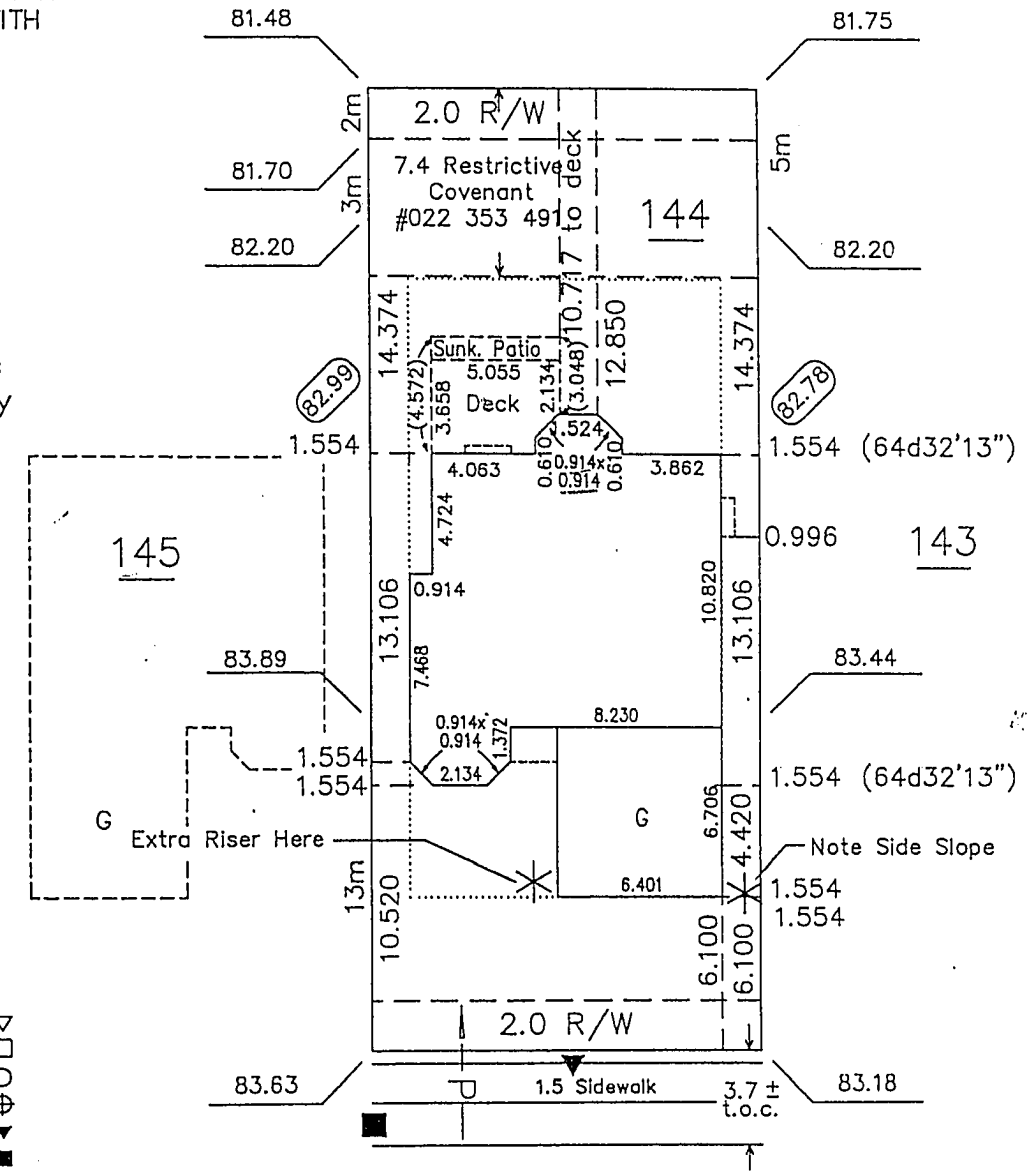
Note: No portion of the house, including footings and roof overhangs, may extend into R/W's

Lot Area:
581.4 Sq M
House Area:
202.9 Sq M
Site Coverage 34.9%
(Includes Deck)

Freeboard: 682.20
HWL: 681.70

RF1 zoning

Note:
Builder/Owner responsible to ensure back fill levels meet all codes.



PROPOSED CLEAN OUT SHOWN ▽
PROPOSED MANHOLE SHOWN □
PROPOSED STREET LIGHT SHOWN ○
PROPOSED HYDRANT SHOWN ⊕
PROPOSED C.C. LOCATION SHOWN ▼
PROPOSED TRANSFORMER SHOWN ■
PROPOSED SERVICE PEDESTAL SHOWN ●
PROPOSED POWER SHOWN —P—

HOUSE TYPE	2 Storey
FINISHED FLOOR	84.71 9' Basement
BOTTOM OF FOOTING	81.46
FINISHED GRADE AT – FRONT OF HOUSE	84.10

WILL BE IN CONFORMANCE WITH THE LOT GRADING PLAN.

NOTE:
Cantilever Subject To All Building Code Regulations Builder/Owner Responsible To Ensure Compliance.

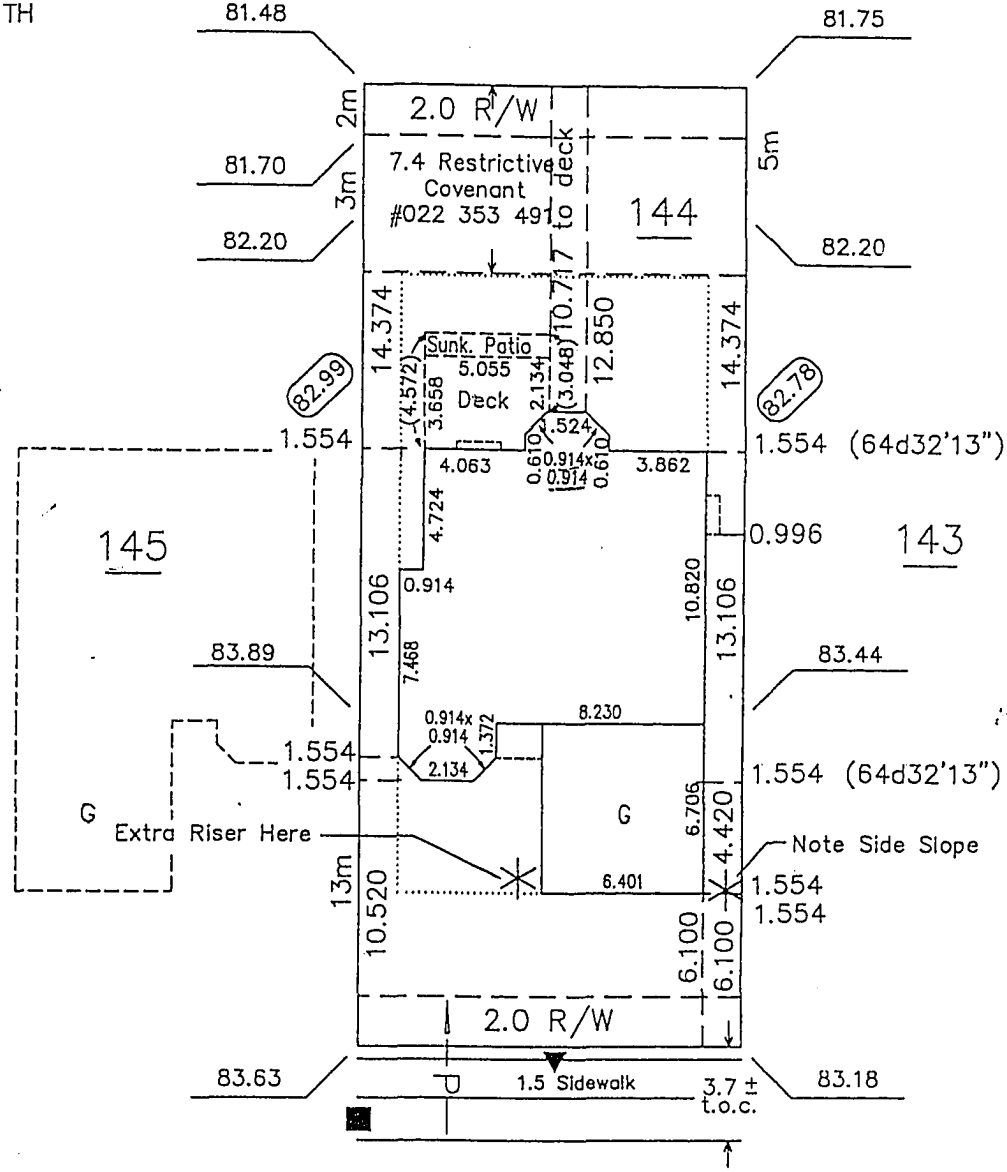
Note: No portion of the house, including footings and roof overhangs, may extend into R/W's

Lot Area:
581.4 Sq M
House Area:
202.9 Sq M
Site Coverage 34.9%
(Includes Deck)

Freeboard: 682.20
HWL: 681.70

RF1 zoning

Note:
Builder/Owner responsible to ensure back fill levels meet all codes.



PROPOSED CLEAN OUT SHOWN	▽
PROPOSED MANHOLE SHOWN	□
PROPOSED STREET LIGHT SHOWN	○
PROPOSED HYDRANT SHOWN	⊕
PROPOSED C.C. LOCATION SHOWN	▼
PROPOSED TRANSFORMER SHOWN	■
PROPOSED SERVICE PEDESTAL SHOWN	●
PROPOSED POWER SHOWN	–P–

HOUSE TYPE	2 Storey
FINISHED FLOOR	84.71 9' Basement
BOTTOM OF FOOTING	81.46
FINISHED GRADE AT – FRONT OF HOUSE	84.10
– BACK OF HOUSE	L–83.30, R–83.10
BOTTOM OF – BACK/SIDE DOOR SILL	
– BASEMENT WINDOWS	Well as required
TOP OF CONCRETE BASEMENT WALL	
GARAGE FLOOR	*SEE NOTE
SANITARY SEWER SERVICE INVERT	
FOOTING SIZE	0.20

GARAGE SLAB AT OVERHEAD DOOR RECOMMENDED TO BE SET 0.61 BELOW TOP OF CONCRETE FOUNDATION WALL.
SLAB ELEVATION 83.80

ALL DISTANCES SHOWN ARE IN METRES AND DECIMALS THEREOF.

BUILDER / OWNER IS LIABLE FOR ANY COSTS INCURRED DUE TO AN ERROR IN THE ABOVE PLAN IF CONSTRUCTION STARTS PRIOR TO THIS PLAN BEING APPROVED BY THE LOCAL APPROVING AUTHORITY

DATE OF REVISION
2 Oct. 20/03 C
1 Oct. 16/03 C
F.P.

BUILDER\OWNER

LOT 144 BLOCK 18 PLAN 022 5750
SUBDIVISION Haddow
IN Edmonton ALBERTA

SCALE: 1 : 300 DATE DRAWN: Oct. 3/03 C

Pals Surveys & Associates LTD.

THE CITY OF Edmonton

Project Number: 35546511-
Application Date: NOV 10,
Printed: December 8, 2003 at 1:0
Page: 1

House Development and Building Permit

This document is a Development Permit and Building Permit for the development described below, subject to the limitations and conditions of this permit, of the Edmonton Land Use Bylaw 5996 as amended, of the Edmonton Building Permit Bylaw 8664 as amended, and of the Alberta Building Code.

Applicant	Property Address(es) and Legal Description(s)

Scope of Permit

To construct a single detached house with attached garage, deck and fireplace.

Permit Details

Affected Floor Area (sq. ft.): 2865	Building Height (m): 6.85
Class of Permit: Class A	Front Yard (m): 6.1
Home Design Type: 2-storey	Rear Yard (m): 10.71
Side Yard, left (m): 1.55	Side Yard, right (m): 1.55
Site Area (sq. m.): 581.4	Site Depth (m): 38
Site Width (m): 15.3	Stat. Plan Overlay/Annex Area: (none)

I/We certify that the above noted details are correct.

Applicant signature:_____

Development Permit Decision

Approved

Subject to the Following Conditions

Any future deck development greater than 0.6m (2ft) in height will require development and building permit approvals.

The height of the principal building shall not exceed 10.0m nor 2 1/2 storeys as per the height definition of Section 6.1(33) of the Edmonton Zoning Bylaw 12800.

All yards, visible from a public roadway other than a lane, shall be seeded or sodded within eighteen (18) consecutive months of the issuance of an Occupancy Certificate for the development. Alternative forms of landscaping may be substituted for seeding o sodding as specified in Section 55.2(4)(b).

Notes:
Lot grades must match the Engineered approved lot grading plans for the area. Contact Drainage Services at 496-5500 for lot grading inspection inquiries.

The applicant is advised to research the Land Title for this property and to be aware of any restrictions in the Restrictive Covena # 022 353 491. This approval does not imply consent for any structure that does not meet the requirements of the Restrictive Covenant.

Due to the roll face curb construction at this property, there are no requirements for a separate curb crossing permit under Sectio 1210 and 1211 of Traffic Bylaw No. 5590. Approval is given for the access under this Development Permit.

Rights of Appeal

This approval is subject to the right of appeal as outlined in Chapter 24, Section 683 through 689 of the Municipal Government Amendment Act.

The permit holder is advised to read the reverse for important information concerning this decision.

THE CITY OF Edmonton

Project Number: 355465511-001
Application Date: NOV 10, 2003
Printed: December 8, 2003 at 1:06 PM
Page: 2 of 2

House Development and Building Permit

Issue Date: Nov 10, 2003 Development Officer: Signature:

Building Permit Decision

Issued

Conditions of Issuance

* Roof trusses supplied by Westek Truss Systems.
* Floor trusses, beams and columns supplied by Trail Building Supplies.
* Comply with all notations on stamped plans.
* Grade beam and pile system to comply with supplied Engineer's design including the use of 15 foot piles under the point loads.
* Door between the garage and dwelling to be weatherstripped and have a self closing device.
* Ceiling between garage and bedroom to have an effective gas barrier installed.
* The base of all footings to have a minimum of 4 feet of frost protection.
* All frame walls that project into the 4 feet side yard to have a minimum 45 minute fire resistance rating.
* An interconnected smoke detector required on each floor level including the basement.
* Door to future deck to be secured.
* All required deck guardrails to be minimum 36 in. in height (42 in. high if deck is more than 72 in. above grade) & all spaces between vertical members to be no more than 4 inches in width.
* Glass in guards shall be safety glass - laminated or tempered type conforming to CAN/CGSB-12.1-M "Tempered or Laminated Safety Glass".

Issue Date: Dec 08, 2003 Safety Codes Officer. Signature:

Fees	Fee Amount	Amount Paid	Receipt #	Date Paid
Water Usage Fee	$63.80	$63.80	056180	Nov 10, 2003
Building Permit Fee	$1,502.00	$1,502.00	056180	Nov 10, 2003
Electrical Fees (House)	$144.50	$144.50	056180	Nov 10, 2003
Electrical Fee (Service)	$40.00	$40.00	056180	Nov 10, 2003
Lot Grading Fee	$105.00	$105.00	056180	Nov 10, 2003
Safety Codes Fee	$19.00	$19.00	056180	Nov 10, 2003
Sanitary Sewer Trunk Fund	$780.00	$780.00	056180	Nov 10, 2003
Electrical Safety Codes Fee	$6.00	$6.00	056180	Nov 10, 2003
Total GST Amount:	$0.00			
Totals for Permit:	$2,660.30	$2,660.30		

The permit holder is advised to read the reverse for important information concerning this decision.

APPENDIX D:

Development Permit Developed by the Prototype

The City of Edmonton

ProjectID 022575018144

Friday, June 18, 2004

House Development and Building Permit

This document is a Development Permit and Building Permit for the development described below, subject to the limitation and conditions of this permit, of the Edmonton Land Use Bylaw 5996 as amennded, of the Edmonton Building Permit Bylaw 8664 as amended, and of the Alberta Building Code.

Applicant	Property Address(es) and Legal Description
Sukkarieh Ghassan 214, 4615-106 A Street NW	1606 - Haswell Co 0225750 18 144

Scope of Permit

To construct a Single Detached House with ☑ AttachedGarrage

Permit Details

Class of Permit	Class A	Affected Floor Area	Future work		
FrontYard (mm)	5,832	Site Width:	15,300	Height (mm)	7500
RearYard (mm)	10,716	LotDepth:	38,000	SideYard (mm)	2,167
SideYardL (mm)	1,557	Site.Area (m^2)	581.40	SideYardR (mm)	1,555

I/ We certify that the above noted details are correct.

Applicant Signature: _____

Development Permit Decision

Approved

Subject to the Following Condition

Any future deck development greater than 0.6 m (2 ft) in height will require development and building permit approvals

The height of the principle building shall not exceed 10.0 m or 2 1/2 storeys as per the height definition of section 6.1(33) of the Edmonton Zoning Bylaw 12800.

All yards, visible from the public roadway otherway than a lane, shall be seeded or sodded within eighteen (18) consecutive months of the issuance of an Occupancy Certificate for the development. Alternative forms of landscaping may be subsituted for seeding or sodding as specified in Section 55.2 (4)(b).

NOTE

Lot grades must match the Engineering approved lot grading plans for the area.

Rights of Appeal

This approval is subject to the right of appeal as outlined in Chapter 24, Section 683 through 689 of the Munciple Goverment Amendment Act.

Note: Building Permit is future work for this prototype.