APPLICATION OF INFORMATION TECHNOLOGY IN THE BUILDING REGULATORY ENVIRONMENT

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INTRODUCTION

The Building Code and its associated regulations, standards, interpretations, rulings and explanatory support documents form a body of material which, like any law and its regulations, are complex and, at times, esoteric. It is comprised of a series of concepts and their relationships, rules, exceptions to rules and examples. It essentially defines prescriptive states, conditions and actions for the builder/designer or identifies performance requirements for materials or systems. There is seldom rationale for the rules that could easily be understood and thus few answers to the question, "Why?". This makes building regulations difficult to develop, to use and to enforce. In this paper some applications of computers used in the Code Development process, as a user tool and as an instructional tool will be discussed.

CODE DEVELOPMENT PROCESS

Building Codes in Canada are developed through a consensus building process. Proposals are recommended by Code development staff, Code users, manufacturers, etc. These proposals go through a technical review before distribution for public comment. Results of the public consultation process are reviewed by technical committees which make final recommendations on the proposed Code revisions. The Canadian Commission on Building and Fire Codes has the ultimate responsibility for developing the National Building and Fire Codes; similarly, the provinces have the responsibility for developing the provincial Codes. (see Figure 1)

Building Codes are becoming more cumbersome and complex. The number of competing building technologies has increased several fold and at the same time there are fiscal restraints on Code development authorities. This problem has been compounded with the involvement of a new generation of Code developers.

In 1986, the Ontario Buildings Branch initiated a joint project with the National Research Council of Canada to develop a framework for assessing the impact of Code requirements and proposed revisions.

Building Code Assessment Framework (BCAF)

The BCAF is essentially a computerized decision support system that assists Code developers in determining the appropriateness of including a requirement in the Code including its socio/economic impact. The key ingredients in developing the BCAF were the participation of Code specialists and the review of similar efforts in the U.S., Europe, Australia and New Zealand.

The BCAF has three main components: the Code Analysis Component (CAC); the Impact Analysis Component (IAC) and the Risk Analysis Component (RAC). The BCAF is supported by several databases.

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Code Analysis Component (CAC)

The CAC is a relational database that includes text and tables contained in the Building Code and links the requirements of the Code to their intended objectives and to building components (spaces) to which they apply.

The primary objectives of the OBC are consolidated into five categories which include fire protection, structural sufficiency, health, welfare and social concerns. These objectives are further refined to better relate to requirements of the Code (see Table 1).

The "ASKSAM" software package is utilized in creating this CAC relational database. In future, the CAC could be extended to include special notes on the intent of the Code requirement.

Impact Analysis Component (IAC)

In the past, Building Codes in Canada have not been subjected to a systematic analysis to determine the full spectrum of their impact on society. The Impact Analysis Component (IAC) is an analysis tool that enables Code developers to assess economic and safety implications of Code requirements.

In addition to a set of computational procedures, the IAC contains several databases. These databases are critical to the uniform application of the system. The databases include information about cost, annual volume of construction and design and construction details for 18 reference buildings. For each building type, expert opinions are documented for risk analysis purposes.

The IAC measures the incremental impact of Code revisions. The information is expressed in terms of capital cost; operation and maintenance costs; lost revenue and property damage; and injury and death. Life cycle cost analysis is used in determining the net economic impact.

Risk Analysis Component (RAC)

The RAC is designed to provide a systematic analysis of exposure to risk for an existing Code requirement or a proposed change to the Code. The CAF addresses four types of hazards:

- Fire and smoke
- Structural failure and collapse
- Indoor air pollution
- Personal accidents

Regardless of which hazard is being considered, the approach consists of the following factors:

- An overall societal viewpoint is taken
- All causes of risks are considered (as-built and in use causes)
- Data and expert judgement have been used to develop the exposure levels
- Consequences are expressed as death, injury and property damage

The Delphi approach is used in the development of expert opinion databases. This iterative approach utilizes the "Lotus 1-2-3" software package.

System Design

The conceptual design of the system consists of a model of the interaction between processes, data flows and data stores. Figure 1 illustrates how data will flow through the system and will be processed and stored. The six processes that are being considered in the design of the system are shown in the rounded boxes. These include:

- Code Analysis Component
- Statistical Analysis of the Expert Surveys
- Risk Analysis
- Maintenance of the Current Reference Building Data
- Maintenance of the Impact Analysis Parameters
- Impact Analysis Component

The information required for the operation of the system comes from the user. Data flows from the user to the processes and from the processes to data stores are represented by connecting lines. Based on the data flow model, a series of data structures were developed for the impact analysis system. There are about 31 data structures.

The system produces two types of standard reports. The first includes various listings of the data files. The resulting IAC and RAC analysis make up the second type of reports.

CODE USERS TOOL

Introduction

Designers, contractors, building officials and others active in the building industry are confronted with a myriad of building regulations to which they must conform. In Ontario, the Ontario Building Code and its related documents govern the construction of all new buildings. These ever-changing documents can become a source of frustration for its users who must constantly keep abreast of current Code requirements. This paper examines how a computerized Code saves time and money while contributing to enhanced accuracy and thoroughness by allowing quick search and retrieval of Code requirements and related information.

Purpose of Project

The purpose of this project was to develop an effective text and image retrieval system for the Ontario Building Code and other related documents. For Code users, a computerized Code would save time and money while contributing to enhanced accuracy and thoroughness by allowing quick search and retrieval of Code requirements and related information (both text and diagrams).

A computerized Code would reduce the chance of errors and overlooking critical information; furthermore, it would contribute to more informed and consistent interpretation of Code material. Those benefitting from computerization of the Building Code include Code development and enforcement agencies, and Building Code users (architects, engineers, consultants, builders, government agencies, etc.).

Feasibility Study

In 1986, the Ontario Ministry of Housing undertook a feasibility study of the project. The study concluded that there was overwhelming support for a computer-based Building Code. The initial requirement was to develop a computer-based text and image retrieval system that could later be evolved into an expert system.

System Alternatives

Because of the large and diverse database which included over 3000 pages of text and over 400 illustrations, a system had to be selected that could effectively and efficiently handle this volume of information. The three hardware options considered by the Ministry included a mainframe system and two stand-alone systems consisting of either an IBM 386 personal computer or a Compact Disk - Read Only Memory (CD-ROM) system.

Other criteria which were considered included:

Flexibility - To permit hardware to run other software programs and to allow for upgrading of existing systems.

Delivery - To distribute the product over a large geographic area. (In Ontario there are 850 municipalities and 30,000 Ontario Building Code holders).

Security - To prevent the information from being damaged or altered.

Cost - To develop an affordable product for end users.

Mainframe System

The prototype of an on-line mainframe system was developed in cooperation with an external firm. Mainfrane as a single information source was offering its users the most recent and relevant information - in theory, the Code on a mainframe system could be updated on a daily basis. Although this appears to be a desirable feature, it would be impractical and unfeasible for the Ministry to subsequently provide hardcopy updates to some 30,000 Code holders on a frequent basis.

Information Technology Services of the Ministry carried out a feasibility study in the summer of 1987 regarding a comparative analysis of the technology options and related costs. The conclusion reached was that the mainframe approach was not appropriate or cost effective for the following reasons:

- Difficulty in retrieving illustrations.
- Long-distance telephone fees outside the Metropolitan Toronto area would discourage users.
- High annual subscription fee plus hourly rates.
- Interference in telephone transmission lines could affect accuracy of search.
- Long waiting periods for users to gain access to mainframe.

It was concluded that a mainframe system would discourage its use rather than encourage it.

Stand Alone System - IBM 386 PC

The use of an IBM 386 compatible personal computer was also examined as a stand-alone system. High initial cost, difficulties associated with distribution of information to users and lack of security were the main reasons this system was rejected.

Stand Alone System - CD-ROM

CD-ROM is a stand-alone system that has been used as an information management tool in other applications - Sweets Construction Catalogue, Centre for Occupational Health and Safety, Northern Telecom maintenance manuals and other applications. The compact disk has an enormous storage capacity of over 600 megabytes which can be expanded. The information on the compact disk cannot be altered by the user, thus assuring security of information for the Ministry.

A prototype of a CD-ROM based system was developed and presented to Code Advisors, municipal officials, private consultants and at a meeting of deputy ministers where it was strongly supported.

In 1987, after thorough examination of this technology, the Ministry proceeded with the full-scale development of this system.

CD-Code Hardware Requirements

- CD-ROM drive in conjunction with IBM compatible personal computer (286 or 386), (XT or AT), including PS/2. A Macintosh version of the program is also available.
- 640 K Random Access Memory (1 Mb expanded memory board recommended).
- Minimum 2 Mb hard disk space for software and operation.
- Xerox 4045 or Hewlett Packard Laserjet printer for text and images.

CD-Code Software

CD-CODE is a Compact Disc Read Only Memory (CD-ROM) product utilizing the following sophisticated text and image management software:

Fultext Text Retrieval (Fulcrum Technologies Inc.)

Image Fultext Management Software (Reference Technologies Inc.)

Fultext Dictionary (Reference Technologies Inc.)

Customization (Megalith Technologies Inc.)

CD-Code 1991 Databases

1. 1990 Ontario Building Code
2. Guide to the OBC
3. Code and Construction Guide for Housing
4. Building Materials Evaluation Commission Authorizations
5. Ontario Buildings Branch Opinions
6. OBC Plans Examination/Inspection Checklists

Capabilities of CD-Code

- Quick search and retrieval of text and diagrams using
  - one or more keywords and/or Code reference numbers
  - word selection from "Wordwheel" (list of suggested words)
  - outline of all databases in "Table of Contents"
- Menu-driven with built-in help features to ensure "user friendliness".
- Image display capabilities - panning around an image as well as shrinking or expanding the image.

- Browsing feature which allows the user to scan text adjacent to (preceding or following) the text retrieved by the key words/phrase/strip. This will help the user to ascertain the context of the requirement.
- Notepad feature that allows user to extract selected portions of text to save on a DOS file and supplement text with commentary notes.
- Dictionary feature that allows user to call up definitions of defined Code terms.
- Bookmark feature enables user to mark specific pages within documents being viewed for quick recall later during the current work session.
- Print capabilities of both text and graphics.
- Copy capabilities of text.

Future Direction

The Ministry committed itself to a five-year program (1987 to 1992) for the development and updating of CD-CODE. The first version of CD-Code was released in 1989 and updated in 1991. New issues of CD-Code are released to accommodate significant changes made to the Ontario Building Code and related documents. Some of the planned and envisioned future changes to CD-CODE include:

- Enhancement of application software to further extend its powerful use.
- The inclusion of other pertinent Codes such as the Fire Code, Electrical Code, Plumbing Code, etc.
- Development of an expert system to act as a consultant, by accepting information on building type, size, etc., and providing a summary of construction requirements to achieve Code compliance.

CODE TRAINING

Performance Requirement

The technical learning requirement includes knowing specifically the parts of the building process and the portions of the building which the code addresses, where to find building process or materials requirements in the code and identifying deviance from code in plans or structures. It is not clear that the building inspector's use of the Building Code is identical to that of the builder or building professional. The inspector or plan examiner is checking existing buildings or proposed plans against code requirements where the designer accommodates the requirements for use and structural sufficiency of the building design to the Building Code as one of several verifications in a larger process. In other words, building officials use Building Code provisions as a reference standard whereas designers use the Code provisions as constraints. For building officials, the follow-on skills of being able to provide alternate solutions to building problems which conform to the code are not specifically required and in some cases are discouraged due to concerns about liability and professional jurisdiction.

Nature of the Learner

The usual learner is male and has technical training or experience in some aspect of building science, is practical and results oriented, learns best through visual experience and physical activity, wants to learn from real examples, wants to know why the material is useful for him to learn and generally is a deductive, linear thinker.

Current Instructional Method

It was determined that one of the better means of helping the adult learner deal with this material was to provide him with a learning environment which allowed him to deal with practical problems in code interpretation, discuss his solutions with other learners and require him to defend his solutions with support from the Building Code. This is done through a learning process wherein the instructional information is provided in learning manuals which must be read individually and the individual must then respond to the accompanying questions by locating the answer in the Building Code. Then he must confer with members of his small group to confirm the answer, make corrections as necessary and agree to a group consensus which is then presented to the whole class and defended. Instructional materials include drawings where available and visual support through some videotaped examples. The class facilitator keeps the process flowing and solves problems as they arise. The learners are discouraged from memorizing the building code due to the continuous and extensive code amendments. Instead they are encouraged to learn how the code is organized and to use the code continuously, confirming applicability of the code in each specific instance.

Requirement:

<u>Why Learning the Building Code is Difficult</u> -

* The code is not a seamless whole but is a somewhat discontinuous set of rules which occasionally overlap in some areas and are silent in others.

* It was created by non-professional writers attempting to write a legal document and has been amended several times with the new material being simply added to older material.

* There are awkward sentence constructions for rule exceptions which are used to avoid having to repeat the rule, e.g. "Except as provided in ....".

* Often the basis for a rule is not stated in the code but only implied, e.g. it does not say in the code that the larger the area of unprotected openings there are in a wall, the more likely will it allow fire to penetrate, but the code may lead you to assume it.

* There are topics in the code which are identified in rules in more than one section of the code without cross referencing. This makes it difficult for the novice to find complete answers to questions. It is also difficult for experienced users to find information in a part of the code with which they are unfamiliar.

* The code must be read with attention to detail and requires a high level of reading skill and comprehension to interpret it properly. It is abstract and requires an ability to visualize written descriptions of physical states. Relationships among knowledge primitives in the knowledge model of the code are complex and recursive with multiple referents for each element. This gives the effect of trying to model an n-dimensional construct in an n-1 or n-x dimensional space.

* The basic literacy skills of builders and building officials are not well developed.

Supplementary Instructional Method Requirement

We wished to use a method of instruction which improved the understanding of the more demanding areas of the Code but which could be delivered on an individual basis and use CD-Code as reference.

These areas, such as fire stopping and spatial separation are more than usually complex and difficult to understand and can profit from a high degree of visual augmentation and also need close support and guidance from learning materials which are sensitive to learning problems.

Knowledge organization and learning processes are closely specified in instructional systems where individual problems in learning must be anticipated and where there is difficulty providing impromptu corrective action. We wished also to have the learner change the relationships between concepts in accordance with rules which reflected the normal range of variation in the relationship and be able to see the impact of those changes. This would allow the learner a visual simulation of a variable relationship. Based on these requirements, we chose to explore the use of computer based learning including hypermedia and DVI to provide a training solution.

Learning Medium Selection

We wanted to determine the feasibility of creating a mixed media learning system which would interface with the CD-ROM Building Code as a reference. We also wished to determine what impact computer-based learning with a CD-ROM visual database, sound capability and interactive graphics displays would have on learning complex, rule-based procedures.

System Specification

We used Quest 3.50 instructional software with a Sound Blaster audio board to deliver the learning with a minimum requirement for a 286 system with 640k RAM and a hard drive with EGA board and monitor as a platform. The 'C' programming language was used to program the more difficult areas of graphic presentation and manipulation.

Development Procedures

The area of interest for this test of system functionality was Spatial Separation of buildings. A flow chart was developed which included the major concepts and their relationships as well as a method of determining spatial separation as expressed in the Building Code. A concept map was also developed which led to the determination that concept relationships could be classified into **area, boundary, quality** and **relationship** categories. It was found that rules, as expressed in the Building Code were of three sorts; first, **implied rules** which were not explicitly stated (The larger the surface area of the wall, the more likely will it catch fire), second, **general rules** derived directly from the Building Code and having general application (Any opening 130 cm^2 or less is not considered an unprotected opening.) and third, **special rules** derived from the exceptions cited in the code (If the building is sprinklered, the maximum area of unprotected openings may be doubled [for a given limiting distance]). We developed the overall design of the instruction including objectives, assessments, linking knowledge/skills required to best instructional method, etc. We then did a media/methods application analysis to determine which media best supported the instructional methods decided on. Specific frames were written and visuals identified for each frame.

Results

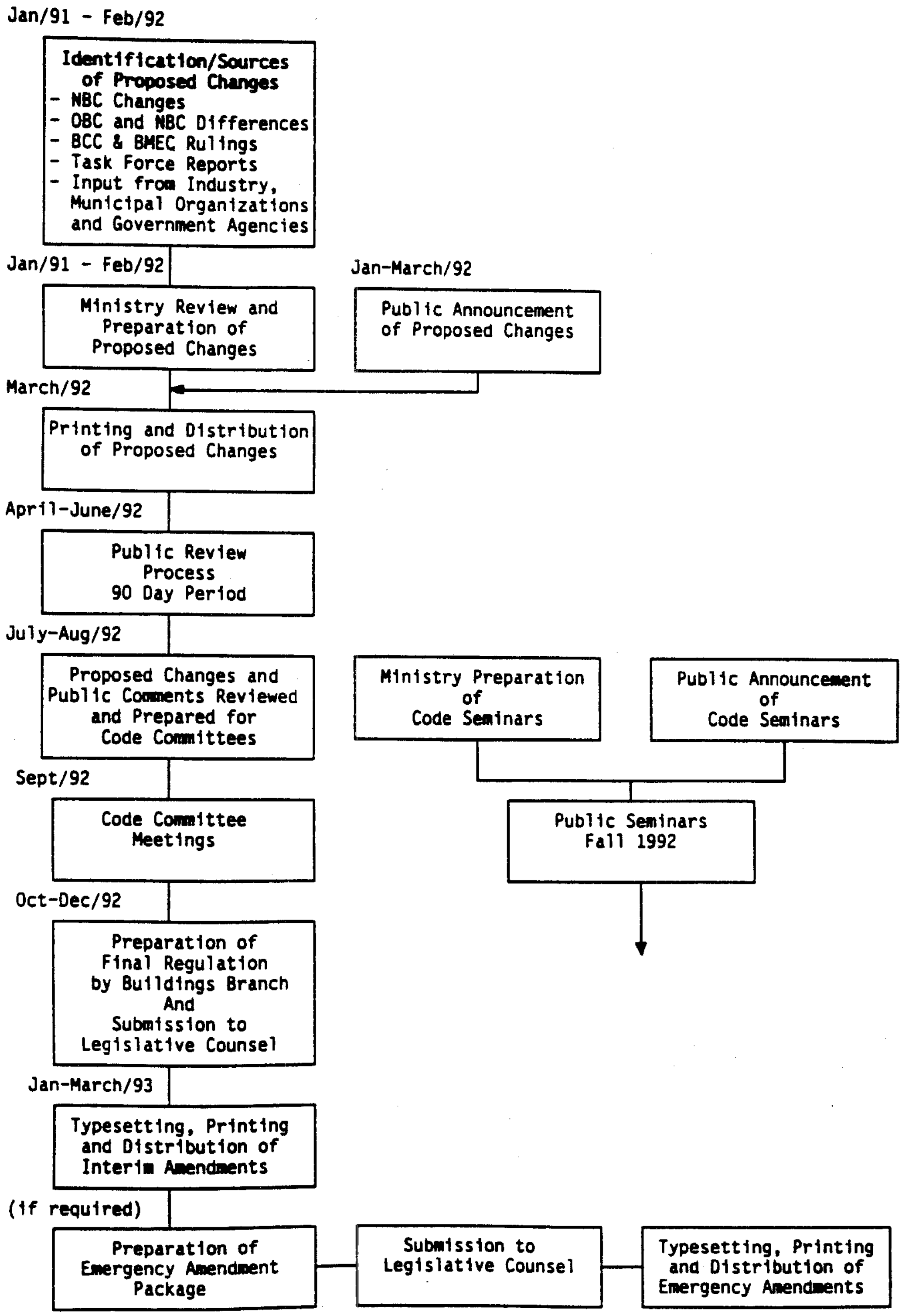
We succeeded in demonstrating that it was feasible to interconnect the various hardware systems and manage them through a computer based training system. Technically, the most difficult part was to provide the user with a graphic interface which was sophisticated enough to allow the user to move the "building" graphic and have the system translate the position of key points on the building into displayed numerical data about orientation of the building, distance from the lot line, changing areas of unprotected openings in the building and required limiting distance.

For the objective related to the product as an instructional vehicle, there was mixed reaction to the program. We did not have a version of the program available to test with novices until recently and the focus on the technical objective left the program somewhat disjointed. A version was tested with knowledgable building inspectors and although formal evaluations were not done, the results were positive. They especially appreciated the graphic interface which allowed them to move the building and see the effect on requirements for spatial separation. Many asked for a job aid or expert system which displayed a graphic of a building of their design and into which they could insert specific data and move the building to an optimum place allowing greatest percentage of unprotected openings for the distance from the lot line.

TABLE 1

PRINCIPAL CODE OBJECTIVES				
FIRE PROTECTION	STRUCTURAL SUFFICIENCY	HEALTH	WELFARE	SOCIAL CONCERNS
FIRE PREVENTION	STRUCTURAL INTEGRITY	WATER SUPPLY		ACCESSIBILITY (BARRIER-FREE DESIGN)
		AVAILABILITY	CONVENIENCE	
FIRE DETECTION	SERVICEABILITY	WASTE DISPOSAL		SECURITY FROM ENTRY
		SEPARATION	CONVENIENCE	
FIRE SUPPRESSION		INDOOR AIR QUALITY		PRIVACY
		TOXICITY	ACCEPTIBILITY	
FIRE ENDURANCE		THERMAL ENVIRONMENT		ENERGY CONSERVATION
		TOLERABILITY	ACCEPTABILITY	
FIRE SEPARATION		VISUAL ENVIRONMENT		
		VISIBILITY	SUITABILITY	
SMOKE CONTROL		NOISE & VIBRATION		
		TOLERABILITY	ACCEPTABILITY	
MEANS OF EGRESS		PHYSICAL HAZARDS INJURY		
AREAS OF REFUGE				

ONTARIO BUILDING CODE AMENDMENT PROCESS - INTERIM AMENDMENTS 1992/93



* The Code Development process includes regular meetings with senior management and the Minister.

April 1992

FIGURE 1

FIGURE 2

BUILDING CODE ASSESSMENT FRAMEWORK
IMPACT ANALYSIS COMPONENT

DATA MODEL