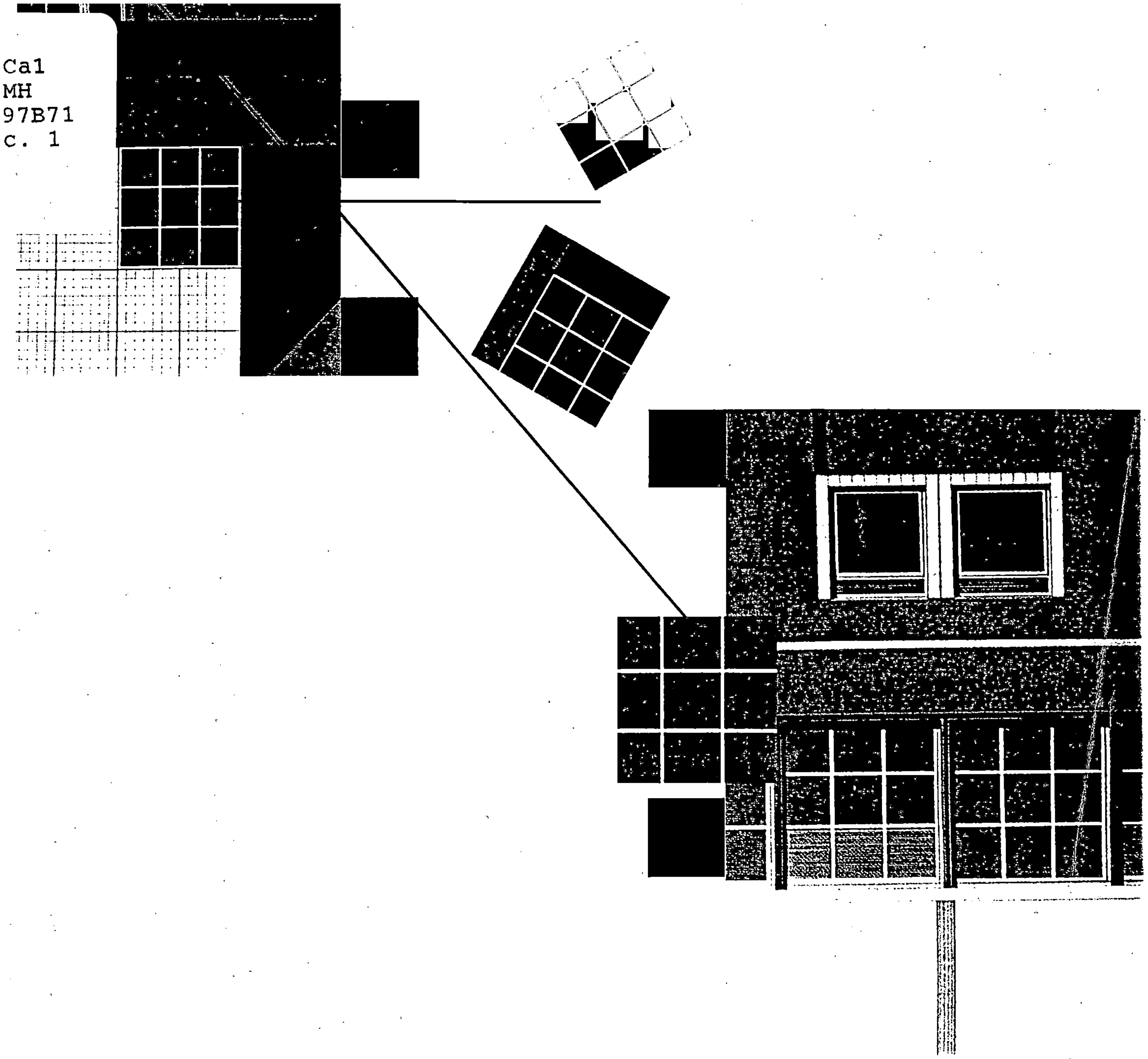
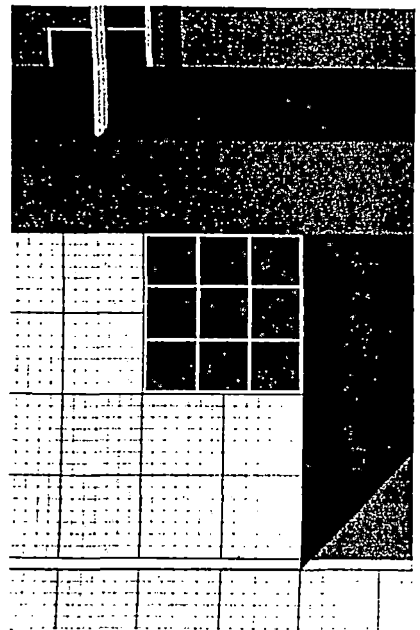


BUILDING ADAPTABILITY: A SURVEY OF SYSTEMS AND COMPONENTS

Canada Mortgage and Housing Corporation
CANMET, Natural Resources Canada

May 1997



BUILDING ADAPTABILITY: A SURVEY OF SYSTEMS AND COMPONENTS

Canada Mortgage and Housing Corporation
CANMET, Natural Resources Canada

Prepared by
Young + Wright Architects Inc.

In Association with
Engineering Interface Limited
and
Yolles Building Science Services Limited

PART IX REPORT
RAPPORT PARTIE IX

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ACKNOWLEGEMENTS

No research project unfolds as expected, and this study was no exception. The subject of adaptability pulled the study team in many directions throughout the entire process. However, when the work was completed, the team emerged having successfully made comprehensive, a varied and relatively uncharted area of investigation.

The following people are to be acknowledged in the making of this study.

Peter Gamble, principal researcher and writer, who brought a design interest and appreciation to the task of reviewing information, and who insisted that the writing remain clear and accessible to all.

George Shilletto, who contributed significant energy in the thoughtful formulation of conceptualization and the ordering of findings into systematic approaches to understanding adaptability.

Peter DiLullo and Robert Bach who were key participants in the study, bringing their significant engineering experience to bear on the topic of adaptability. Their approach to both respective descriptions of structural and mechanical/electrical engineering contributed immeasurably to the execution of this project.

Jutta Szep, tireless in her research of the published media and acknowledged authorities on the subject to provide the study group with the best current information.

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Messrs. Fanis Grammenos and Nils Larsson, acting as study liaison (research), are to be thanked for their consistent support and encouragement during all stages of our work. Their enthusiasm and unflagging interest were always present and their insightful comments kept the study on a steady course.

Neil Munro
May 1997

SUMMARY

BUILDING ADAPTABILITY: A SURVEY OF SYSTEMS AND COMPONENTS

The study aimed at investigating the question of what attributes render a building adaptable. If for buildings to be more sustainable they must be also adaptable, then it is imperative to define the attributes of adaptability.

To determine the attributes of an adaptable building, the study examined current thinking and practices in the fields of design, building systems and components. It also looked at real cases of building conversions where issues of adapting buildings to new uses were faced.

The study reviewed historical, social and design perspectives on why and how buildings change and identified the two fundamental and complementary approaches to adaptability: one based on design and another based on technology. These approaches were then tested through the examples of ten building conversions. This process yielded nine principles that could be followed during the design process of a building. In implementing these principles, a number of options in systems and components become possible and these are explained in a set of guidelines that relate specifically to elements of the building envelope, structure and environmental systems.

The study asserts that awareness of the potential for adaptability could in itself be a significant factor in designing adaptable buildings; when enhanced with the knowledge of principles and practical guidelines it could be a decisive factor in increasing a building's future potential and its environmental benigness.

SOMMAIRE

ADAPTABILITÉ DES BÂTIMENTS : UNE ENQUÊTE SUR LES SYSTÈMES ET SUR LES COMPOSANTES

Il s'agissait dans le cadre de l'étude de déterminer quels attributs rendent un bâtiment adaptable. S'il est vrai que pour qu'un bâtiment soit plus durable il doit également être adaptable, il est essentiel de définir les attributs de l'adaptabilité.

Pour ce faire, nous avons passé en revue les lignes de pensée et les pratiques actuelles en ce qui a trait à la conception, aux systèmes d'immeubles et aux composantes. Nous avons également examiné des cas concrets de transformation de bâtiments pour les adapter à de nouvelles utilisations.

L'étude cherchait à déterminer d'un point de vue historique, social et conceptuel pourquoi et comment les bâtiments changent et elle a permis d'établir les deux façons fondamentales et complémentaires d'aborder l'adaptabilité : l'une basée sur la conception et l'autre, sur la technologie. Ces approches ont ensuite été mises à l'essai au moyen de dix exemples de transformation de bâtiments. De ce processus se sont dégagés neuf principes que l'on peut suivre au cours de la conception d'un bâtiment. À l'application de ces principes, plusieurs options se dégagent en matière de systèmes et de technologie; elles sont expliquées dans une série de lignes directrices se rapportant particulièrement aux éléments de l'enveloppe, de la structure et des systèmes environnementaux du bâtiment.

L'étude révèle que la seule connaissance du potentiel d'adaptabilité est un facteur important de la conception des bâtiments adaptables; si l'on y ajoute la connaissance des principes et des lignes directrices pratiques, ce pourrait être un facteur décisif pour augmenter le potentiel éventuel du bâtiment et en réduire l'incidence sur l'environnement.

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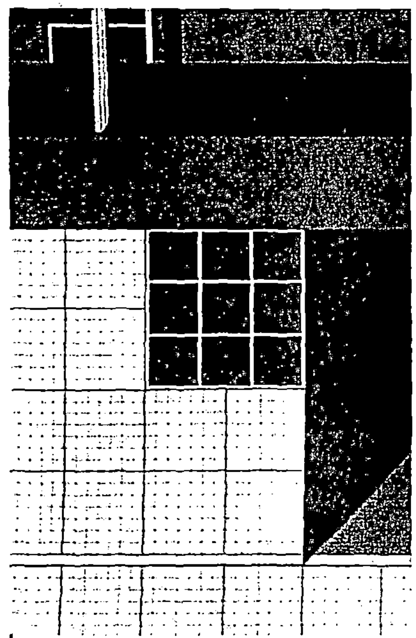


Introduction

1. INTRODUCTION

At the heart of this study is the nature of adaptability. How do we recognize it? How do we design for it? The report looks at current theory and technology from exhaustive international sources addressing the adaptability of buildings. In light of this, actual Canadian case studies are considered and some guidelines are formulated for designers facing the opportunities and problems associated with adaptability. The outcome of the research is seen as an information tool for designers and builders. The work is primarily concerned with medium-rise to high-rise construction, and the scope of research is focused on but not restricted to residential programmes.

The adaptability of any given building is influenced by a large number of factors. Many of these are necessarily beyond the scope of this study: context on the street, changes in the neighbourhood and city fabric, changes in use and zoning, market forces, economic cycles, etc. Our work focuses on the physical "on site" characteristics of the built form. We are interested in the actual systems and components as they relate to building adaptability and the planning/design issues that make a building adaptable.

1.1 Understanding Adaptability

flexibility < adaptability > conversion

Adaptability can be said to be the capacity a building has for absorbing substantial change. On the one side of adaptability is flexibility: easy change or minor shifts in the space plan and furnishings in a building. This is a lighter kind of transition than adaptability. On the other side of adaptability is the notion of conversion. This refers to the forceful change from A to B and involves a shift in the fundamental nature of the building. During a conversion there is spatial, service, and structural change and often some component of demolition.

A conversion project becomes adaptable when the new use is not seen as the final use. There are a number of different system approaches to adaptability each addressing a different aspect of the issue; from analysis to implementation and evaluation.

DUFFY APPROACH

One way to describe a building is in terms of several discrete functional layers. The following comes from Frances Duffy of the London design firm DEGW and is discussed further in section 3.1 - Adaptability and the Open Building System:

A building's shell means its structure and skin. Ideally, these will last the life a building. Heating and cooling, ventilation, light, water, electricity, etc. constitute the service aspect of a building. Services may be altered a few times during a building's life. The scenery includes fixed interior items like partitions, ceiling and floor finishes, fixtures, and so on. The setting refers to moveable items that can be changed on a day to day basis such as furniture. Problems can arise when scenery becomes service or when service becomes shell.

BRAND APPROACH

Stewart Brand, creator of the Whole Earth Catalog and author of "How Buildings Learn:

What happens after they're built", interprets Duffy's four S's which are geared toward commercial building re-use, and creates a more general purpose set.

1. SITE : The eternal geographic setting.

2. STRUCTURE : The foundation and loadbearing elements. This lasts the life of the building (30-300 years).

3. SKIN : The exterior surface that gets changed every 20 years or so to keep up with fashion or technology.

4. SERVICES : The working guts of the building - wiring, plumbing, HVAC, elevators, etc.

Brand adds the idea that these layers are dynamic entities that are in constant contact with one another creating what he calls "shearing layers of change". When these temporal layers are recognized and understood, designers and builders are better equipped to create adaptable buildings.

DESIGN AND TECHNOLOGY

For a systems approach to design and construction, any synthesis to accrue there must be a clear understanding of the divisions between the components (technology) and the selection/integration process which assembles and integrates them in a functioning whole. The components (technology) are produced to meet specific criteria determined during the design phase of a project. These criteria may include environmental issues, recycling issues, as well as technologies based on principles (O for D) which promote adaptability through increased process efficiency.

It is useful to differentiate between adaptability that is technology-based and that which is design-based. The former addresses physical devices and material systems that have been manufactured for building construction. These items have specific performance requirements and their tangible properties can profoundly affect the adaptability of a building. Design-based adaptability, on the other hand, has more to do with conceptual planning. Spatial decisions like floor to floor heights, location of circulation routes and cores, shape and size of floor plates, etc. all affect adaptability. Design-based decisions for a mechanical installation, for example, might include the formulation of a system's functional requirements independent of specific machinery or products. The differentiation between technology-based and design-based characteristics played an important role in the organization of the nine case studies of this report, their data, and the analysis of the information.

IMPLEMENTING ADAPTABILITY

The Open Building System, or OBS, is an approach to design and construction which makes a distinction between two conceptual layers of a building: the base/support and fit-out/infill. The former refers to the rudimentary shell which is constructed in a generic way to meet, rather than anticipate, the needs of a wide range of infill possibilities. The OBS is a systems approach aimed at improving the clarity and efficiency of building construction. It is not unique in its field having been pre-dated by the SEF, another attempt to construct flexible building systems. Lastly, the "Revaluing Building" approach has been developed to create flexible interior work environments.

Design for Disassembly (DFD) is a design method emphasizing the ability to separate a product (or building) back into its constituent components after it has been assembled. It is, among other things, a strategy for sustainability in that it permits a much easier way of separating "used" materials after they have completed a service life. Some of the DFD strategies include: reversible connections, standardized parts of manageable size, and explicit labeling of components to positively identify the material and manufacturer.

Evaluating Adaptability

Flexis is a device for increasing the flexibility of systems, or installations, and the buildings they occupy. The Flexis method uses a numerical rating system to assist the project team in formulating the demand and assessing the supply of flexibility.

Conclusion

All of the above illustrate approaches to either the analysis or implementation of adaptability and represent steps towards increased adaptability rather than one single approach. Duffy and Brand expand our understanding of building with respect to component system, roles and cyclic life spans. This understanding can then be developed in design and technology-strategies implemented through a structured building system such as OBS. Evaluation of system performance (such as Flexis) allows for the opportunity to test specific solutions, improve performance by adjustment, etc., and therefore can also be used as a design tool.

1. INTRODUCTION

La présente étude s'articule autour de la nature de l'adaptabilité. À quoi la reconnaissons-nous? Comment faisons-nous la conception dans cette optique? Le rapport fait l'inventaire de la théorie et de la technologie d'aujourd'hui concernant l'adaptabilité des bâtiments à partir de nombreuses sources internationales. Ensuite, on y examine des études de cas au Canada et on y formule des lignes directrices à l'intention des concepteurs pour lesquels des occasions et des problèmes reliés à l'adaptabilité se présentent. Le résultat de la recherche est perçu comme un outil d'information pour les concepteurs et les constructeurs. Le document porte principalement sur les constructions de hauteur moyenne à élevée et la portée de la recherche est axée principalement, sans s'y restreindre, sur les programmes résidentiels.

Un grand nombre de facteurs influent sur l'adaptabilité de tout immeuble, dont bon nombre dépassent nécessairement la portée de l'étude : le contexte dans la rue, les modifications apportées au tissu du quartier et de la ville, les changements d'utilisation et de zonage, les forces du marché, les cycles économiques, et ainsi de suite. Nous nous concentrons principalement dans cet ouvrage sur les caractéristiques matérielles « sur place » du profil d'aménagement. Nous nous intéressons aux systèmes et aux composantes mêmes et à la mesure dans laquelle ils rendent le bâtiment adaptable, ainsi qu'aux questions de planification et de conception qui font que le bâtiment est adaptable.

1.1 Comprendre l'adaptabilité

flexibilité < adaptabilité > transformation

On peut définir l'adaptabilité comme la capacité d'un bâtiment d'absorber des modifications importantes. D'un côté de l'adaptabilité se situe la flexibilité : un changement facile ou des modifications mineures du plan spatial ou du mobilier du bâtiment. Il s'agit d'un type de transition plus léger que l'adaptabilité. De l'autre côté de l'adaptabilité se situe le concept de la transformation. C'est le cas d'un changement radical d'un état A à un état B qui modifie la nature fondamentale du bâtiment. Une transformation donne lieu à un changement de l'espace, des services et de la structure et comprend un certain élément de démolition.

Un travail de transformation devient adaptable lorsque la nouvelle utilisation n'est pas perçue comme l'utilisation finale. Il existe plusieurs approches systémiques à l'adaptabilité dont chacune porte sur un aspect distinct de la question, allant de l'analyse, à la mise en oeuvre et à l'évaluation.

APPROCHE DUFFY

On pourrait décrire un bâtiment comme un ensemble de couches fonctionnelles distinctes. La description suivante est avancée par Frances Duffy de la firme de conception londonienne DEGW; il en sera davantage question à la section 3.1 - Adaptabilité et système de construction ouvert :

La carcasse du bâtiment, c'est sa structure et son enveloppe. Idéalement, ces éléments dureront toute la vie du bâtiment. Le chauffage et la climatisation, la ventilation, l'éclairage, la plomberie, l'électricité, etc. constituent les services d'un bâtiment. Les services peuvent être modifiés à quelques reprises au cours de la vie du bâtiment. Le décor englobe les articles fixes de l'intérieur, comme les cloisons, les produits de finition du plafond et du sol, les luminaires, et ainsi de suite. La disposition désigne les articles mobiles qui peuvent être modifiés quotidiennement, comme le mobilier. Des problèmes peuvent se présenter lorsque le décor devient le service ou lorsque le service devient la carcasse.

APPROCHE BRAND

Stewart Brand, créateur du Whole Earth Catalog et auteur de « How Buildings learn : What happens after they're built » interprète les quatre éléments de Duffy qui visent la réutilisation des bâtiments commerciaux et crée un ensemble plus polyvalent.

1. EMPLACEMENT : L'éternel milieu géographique.

2. STRUCTURE : Les fondations et les éléments porteurs. Ils durent toute la vie du bâtiment (de 30 à 300 ans).

3. ENVELOPPE : La surface externe qui change environ tous les 20 ans au gré de la mode ou de la technologie.

4. SERVICES : Les entrailles laborieuses du bâtiment - le câblage, la plomberie, le CVC, les ascenseurs, etc.

Brand ajoute que ces couches sont des entités dynamiques en relation constante entre elles pour créer ce qu'il appelle les « couches de cisaillement du changement ». Lorsqu'ils reconnaissent et comprennent ces couches temporelles, les concepteurs et les constructeurs sont mieux placés pour créer des bâtiments adaptables.

CONCEPTION ET TECHNOLOGIE

Pour qu'une approche systémique de la conception et de la construction, ou pour que toute synthèse donne des résultats cumulatifs, il faut bien distinguer les diverses composantes (technologie) et comprendre le processus de sélection et d'intégration qui permet de les assembler et de les intégrer dans un tout fonctionnel. Les composantes (technologie) sont produites pour répondre à des critères précis établis au cours de la phase de conception d'un projet. Ces critères doivent tenir compte des questions relatives à l'environnement et au recyclage, ainsi que des technologies reposant sur les principes qui favorisent l'adaptabilité en augmentant l'efficacité du processus.

Il est utile d'établir la différence entre l'adaptabilité qui repose sur la technologie et celle qui repose sur la conception. La première s'applique aux appareils et aux systèmes matériels qui ont été fabriqués pour la construction de bâtiments. À ces éléments sont rattachés des exigences de rendement précises et leurs propriétés tangibles peuvent avoir des effets importants sur l'adaptabilité d'un bâtiment. Par contre, l'adaptabilité qui repose sur la conception se rapproche davantage des décisions prises en matière de planification conceptuelle et spatiale, comme l'espace entre deux planchers, l'emplacement des itinéraires et les centres de déplacement, la forme et la taille des plaques de plancher, etc. qui ont toutes des incidences sur l'adaptabilité. Par exemple, les décisions reposant sur la conception pour une installation mécanique peuvent comprendre la formulation des exigences fonctionnelles d'un système autres que celles qui ont trait à des machines ou des produits particuliers. La distinction entre les caractéristiques technologiques et les caractéristiques conceptuelles a joué un rôle important pour l'organisation des neuf études de cas qui font l'objet du présent rapport, les données qui y sont rattachées et l'analyse de l'information.

MISE EN OEUVRE DE L'ADAPTABILITÉ

Le Open Building System (OBS, système de construction ouvert) est une méthode de conception et de construction qui établit une distinction entre les deux couches conceptuelles d'un bâtiment : la base ou le soutien et l'intérieur ou le remplissage. La base désigne la carcasse rudimentaire construite de façon générique pour répondre aux besoins d'une vaste gamme de possibilités de remplissage plutôt que de les prévoir. L'OBS est une approche systémique qui vise à améliorer la clarté et l'efficacité de la construction d'un bâtiment. Il n'est pas unique dans sa catégorie puisqu'il a été précédé par le System for Education Facilities, une autre façon de tenter de construire des systèmes de bâtiment flexibles. Enfin, l'approche de « construction de réévaluation du bâtiment » a été mise au point pour créer des milieux de travail d'intérieur flexibles.

La conception en fonction du désassemblage est une méthode de conception qui met l'accent sur la possibilité de démanteler un produit (ou un bâtiment) en ses diverses composantes après qu'il a été assemblé. Il s'agit notamment d'une stratégie de durabilité, c'est-à-dire qu'elle permet d'enlever beaucoup plus facilement les matériaux «usagés» lorsque leur durée de vie utile est terminée. Parmi les stratégies de conception en fonction du désassemblage, on compte : les raccords réversibles, les pièces normalisées de dimension pratique et les étiquettes explicites sur les composantes, qui permettent d'identifier positivement le matériau et le fabricant.

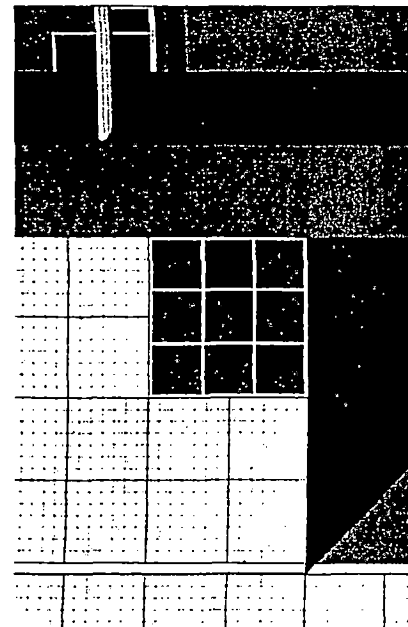
ÉVALUATION DE L'ADAPTABILITÉ

Flexis est un instrument qui permet d'augmenter la flexibilité des systèmes ou des installations et celle des bâtiments où ils se trouvent. La méthode Flexis emploie un système de cotation numérique qui aide l'équipe d'un projet à formuler les exigences et à évaluer l'apport de flexibilité.

CONCLUSION

Ce qui précède illustre les approches à l'analyse ou à la mise en oeuvre de l'adaptabilité et représente les mesures visant à augmenter l'adaptabilité par étapes plutôt que par une approche unique. Duffy et Brand nous font mieux comprendre le bâtiment en ce qui a trait au système de composantes, aux rôles et aux cycles de la durée de vie. On peut par la suite appliquer cette compréhension au moyen de stratégies conceptuelles et technologiques mises en oeuvre par le truchement d'un système de construction structuré comme l'OBS. L'évaluation du rendement d'un système (comme l'approche Flexis) permet de mettre à l'essai des solutions précises, d'améliorer le rendement en apportant des ajustements, etc. et, par conséquent, elle peut également servir d'outil de conception.

Flexibility < Adaptability > Conversion



Methodology

2. METHODOLOGY

2.1 Literature Research

Sources

The following on-line sources were searched:

1. Library Catalogues:
   University of Toronto
   Metro Toronto Reference Library
   Library of Congress, Washington

2. Indexes:
   United States - Master File (newspapers and magazines)
   Canada - KIOSK (Canadian Business and Current Affairs)

3. Architectural Indexes:
   Avery - United States of America
   Architectural Database (RIBA-London) United Kingdom

4. Other Sources:
   In-house library of periodicals, books and reference material

Please refer to Bibliography of Materials relevant to the study area.

TOPICS

The following are general topic headings that were investigated:

- The Open Building System (OBS)
- Building conversions
- Environmental issues as they relate to building adaptability
- Technology issues as they relate to building adaptability
- Design for Disassembly
- Structural and mechanical issues relating to adaptability

2.2 Conversion Study

METHOD

The case studies (Section 4 and Appendix) are buildings undergoing conversion, complete or in progress, representing a wide variety of project types. The goal was to identify and report on building conversions that varied substantially in: size and scope of alteration, use category (change within a single use and from one use to another), construction technology, form of ownership, etc. By looking at these real cases of adaptive reuse, the actual practice of adapting buildings can be considered in the light of the current theoretical efforts identified in the literature research.

Nine conversion projects were selected from three Canadian cities. The case studies range from midrise to highrise construction and all of the projects involve some amount of use category change, as follows:

1. An industrial warehouse to mixed use (office, retail and residential).
2. A retail warehouse to residential (loft condominiums).
3. A factory to offices to residential (loft condominiums).
4. A retail store to offices with residential new construction.
5. A bank and office tower to residential condominiums with retail.
6. An office tower to residential condominiums and offices.
7. An office tower with retail to residential condominiums with retail.
8. A pair of office towers with retail to residential condominiums with retail.
9. A residential building to a hotel.

Data Collection

Information for each of the case studies was collected from project developers and architects, various project consultants, municipal building and planning records, direct observations in the form of site visits and photographs, sales brochures and building tours, and various forms of published information (newspapers, magazines, professional articles, etc.).

Data from the above sources was used to complete the case study data tables which appear at the end of this report in Appendix A & B. Basic information, quantitative and qualitative, was collected and organized into two categories:

1. Architectural/Planning Design Information
2. Technological Design Information

The former is information dealing with standard architectural and planning issues such as use and occupancy, gross floor area, site ratio and coverage. This data also includes basic design information like the number of storeys, the configuration of the floor plate, bay sizes, core information, circulation routes, parking requirements, etc.
The latter group of data includes information to do with technology issues: the kind of material and systems for the substructure and structure, envelope specifics such as type of cladding, windows and insulation, description of the various service systems, partitioning information, sound control measures, etc.

Literature Research

3. LITERATURE RESEARCH: CONCEPTS AND TRENDS

3.1 Adaptability and The Open Building System

During the early course of our research it became apparent that published material on Building Adaptability as a specific design feature was in short supply, especially in North America. The European experience was based largely in The Netherlands, initiated by the ideas and work of N. John Habraken in his Open Building System which, although promoting the idea of flexible housing, was primarily intended to facilitate change within the residential use category and not conversion to other uses. In fact, **most other flexible system buildings reviewed (eg. schools, office space) were intended to promote evolutionary changes within a single use.** Although the Open Building System is primarily discussed in terms of low and mid-rise residential projects, the underlying principles could theoretically be applied to any building use and they speak directly to issues of building adaptability.

The origins of Habraken's Open Building System (OBS) are rooted in a democratic attitude toward mass housing for people. If a design priority is placed on user input then a multi-unit residential project, for example, can be built to meet specific individual needs in terms of spatial arrangement within a unit, service requirements, finishes, etc. rather than anticipate these specific needs. This is achieved with the OBS by making a distinction between the rudimentary base building which is constructed first, and the fitting-out of the individual units just prior to inhabitation.

Dr. Stephen Kendall (a student of Habraken and a strong proponent of Open Building in North America) has been writing about and promoting the ideas of OBS for new and adaptive re-use residential construction. Kendall describes The Open Building System as an attitude toward building that recognizes the complexities of service systems and the need for keeping these separate from the building itself. With the Open Building System, each subsystem is given optimal freedom for design layout and installation. The basic goal is to find ways of ordering and combining systems so that the interference between systems is minimized. This approach is intended to make the building process more efficient and it makes possible the repair, replacement or redesign of a subsystem much easier. The ordering principles make clear from the outset a discrete relationship between the building itself and its systems and creates clear interfaces between the subsystems. The overall form of the building remains intact throughout all changes to the subsystems.

Many residential projects have been built with the OBS approach over the past twenty years, particularly in Europe and in eastern Asia, and may now be gaining momentum in the North American housing industry. Early Open Building housing projects from the Netherlands in the 1970's and 1980's embodied the concept of separating base building from infill systems and did so using existing technology. Presently there are a handful of proprietorial fit-out systems available since there has been enough growth in the market demand to warrant the attention of research and development.

One system features a raised floor system similar to those found in some contemporary office buildings. The raised floor has been tailored for residential applications by creating a 75 mm plenum above the slab or subfloor through which domestic service conduits are run. The tiles themselves are made of particle board supported on plastic legs with adjustable steel threads.

Another system uses only conventional materials that are already available from typical building supply sources, but provides an on-site installation crew to perform the fit-out. This system includes a 50 mm loose fill layer through which a number of conduits for hydronic heating, water supply, etc. are run. On top of this, a Fermacell (a gypsum and recycled paper product) subfloor is laid and this in turn receives a finished floor that can be any number of materials.

A third system involves a number of companies that have come together to develop new techniques and arrangements for providing flexible domestic services. This group has been researching and developing a new interior partitioning system, a raised floor for bathrooms and a "plug-ready" kitchen.

The fourth system features two newly developed elements: the Matrix Tile and the Baseboard Profile. The tile is made of expanded polystyrene foam and has grooves on the top and bottom surfaces for conduits to be run through. The baseboard profile is a composite of wood and plastic that attaches to the horizontal tile and to the vertical wall system. The baseboard has a cross-sectional shape that accommodates the wiring for electricity and electronics. This system is supported by a special software application that will coordinate the process of designing and supplying the system. An important feature of this system is the designation of a lower system and an upper system. The lower system includes the matrix tile and the baseboard profile along with all of the things that go with them. The upper system includes walls, doors and their frames, cabinets and plumbing fixtures. All of the elements in the upper system are familiar items already available in the marketplace while the two baseboard and tile elements have been created specifically for the system. The ordering concept into two distinct zones prevents systems from crossing over and interfering with each other.

The central idea with Open Building System is the distinction, both conceptual and physical, made between the **base building** which provides *structure, space and shelter*, and the **infill** which is just about *everything else*. The OBS is in part a formal recognition of the fact that buildings have become increasingly more and more complex since the first central heating, plumbing and electrical systems were introduced a century ago. The number and complexity of service systems continues to grow in contemporary buildings and new construction projects are often required to accommodate systems for computer networking, communications, security, etc. As the whole of the building becomes more sophisticated and potentially more convoluted, an open builder would point out that some services are likely to obsolesce before other services and certainly long before the base building does. The need, therefore, is for a way of building that recognizes these eventualities and facilitates easy change.

THE DUFFY APPROACH

According to Francis Duffy, co-founder of a British firm that specializes in leading-edge office design, "A building properly conceived is several layers of longevity of built components". Duffy argues that there really isn't such a thing as a building, or at least the physical building itself becomes insignificant from a cost point of view when consideration is given to the whole lifespan. He goes on to explain that it is useful to distinguish four layers in a building: Shell, Services, Scenery and Set. The Shell refers to the structure of the building and in some cases it is also the skin as with, say, a loadbearing masonry building. The shell lasts the entire lifetime of a building, typically over fifty years. Services are all of those pipes and ducts and cables and the machinery associated with them. Services also includes elevators and escalators and most scenery has a lifespan of around fifteen years. Scenery is made up of fixed interior elements like partitioning, ceilings, finishes, etc. Duffy considers a five to seven year lifespan to be appropriate for these items. Finally, there is the Set which describes the daily or monthly rearrangement of office furnishings and furniture (mobilia in Italian). With this in mind it can be seen that over a single fifty year lifespan of an ordinary office Shell, there may be three generations of Services and ten generations of Scenery. **When cost is applied to the equation, the initial investment of capital into the building shell is overwhelmed by the money needed to maintain the other three layers.**

The separation of an office building into four distinct layers based on functional longevity is an idea that seems to fit well with the open building system. In fact, OBS designers and builders are quick to point out that the fundamental differentiation between base building and infill (or tenant fit up) is a standard convention of office and retail projects. It is typical for base building construction to occur well in advance of and without specific knowledge of the end users' individual needs. Office towers and retail malls, for instance, are built to completion with only a minimal amount of spatial resolution. Tenants will be found to buy, rent or lease the space and then the final fit-out takes place with the occupants providing themselves with a space plan, fixtures and furnishings. Similarly, as an office or retail building undergoes the churn of outgoing and incoming tenants, arriving occupants will bring with them an entirely new Set and possibly Scenery to be integrated within the existing framework of Shell and Service.

Design professionals experienced in commercial design understand the "industry" standards for base building design that allow for a contemporary standard of tenant improvements. Buildings that are off the norm (or challenge these standards) can end up being hard to market and lease up. Some typical examples for retail space, a typical depth of 19.81 metres with a width or storefront face of 6.10 metres (module); typical retail floor to floor ±4.57metres; commercial office typical dimensions involve window wall to core in the 13.72-16.76 metre range and a 9.14 x 9.14 metre structural column bay and 1.53 metre module for mullion spacing. The point here is that, within these particular use categories, there are a very specific set of "standards" or conventions that allow a large range of internal fit-out solutions or adaptable configurations. The OBS really promotes the application of this approach to residential uses. **There does not appear to be any literature that compares the various use "standards" in an attempt to find commonality or "modules" that support a higher level of building adaptability between one use category and another.**

William McDonough has proposed that building designs be based upon such a module that is flexible in accommodating residential and office uses. The Hannover Principles are a set of maxims that encourage the design professions to take sustainability into consideration. It states "Buildings should be designed to be flexible enough to accommodate many human purposes, including living, working, or craft, thereby allowing the materials to remain in place while serving different needs. Provision should be made for the disassembly and re-use of all products by the manufacturer if necessary. The recyclability of entire structures must be considered in the event that building fails to be adaptable to future human needs." In theory, it is relatively simple to marry a 6.10 metres residential module within a 9.14 metre bay system (2 x 9.14 = 3 x 6.18); and another variation of 1.53 -1.22 metres planning module is possible. Traditionally, residential modules were based upon .61 and 1.22 metres module for components, and .91, 1.22, 3.66 modules for room sizing. These do not lend themselves readily to a 1.53 metres base.

3.2 Structural Issues for Adaptability

The guidelines for adaptability of building structures presented in this paper are intended to assist design professionals, urban planners, academic researchers and students in formulating basic design parameters for buildings for real development projects and as the basis for further research and study to improve the socio-economic utility of our built environment.

In the real world, the capital cost of construction is almost always close to the top, if not at the top, of the developer's list of priorities in building projects. Short term economics, especially in the private office/commercial/residential development industry, has led to admirably efficient structural designs. These structures suit the intended building programme extremely well for the reasonable 30 to 40 year economic life span of the project. Beyond this time frame, conversion of buildings, most notably mid-rise to high-rise office buildings converted to residential apartments, can be done with minimum modification to the structure. This is generally true when the gravity loads due occupancy for the original building programme are more severe than for the new programme, as is the case for office buildings converted to residential use. If there is no vertical expansion involved in the conversion, then the lateral load resisting system of the building will also most likely be structurally adequate.

It could be argued, therefore, that efficient structural systems for office buildings are inherently adaptable for conversion to residential use. This, however, would be a very narrow definition of the concept of adaptability of structure. Most office building structures are adaptable to residential use by reasons of circumstance rather than by design. Further, if the concept of adaptability is broadened to include notions of structural flexibility, in the sense of the degree of difficulty to effect major structural modifications, durability, workmanship of original construction and quality control, then the fact that some office buildings can be easily converted to other functions, in particular residential use, can be considered due to blind luck.

It is clear that truly adaptable structures must be designed assuming that multiple programmes will occupy the building at various stages throughout its physical life span which is different than its economic life span. These programmes will naturally have different gravity load design requirements. The chronological order in which these programmes will occupy the building must not be assumed. For example, it should not be assumed that residential use of a building will always follow the office occupancy, or that commercial retail use will follow warehouse occupancy. This would obviously lead to one way adaptable structures, i.e., structures that can be readily re-used for only less severe occupancy load functions. This in fact is not structural adaptability at all.

The physical life span of a structure built in accordance with modern building codes, and which is enclosed by a building envelope that protects the structure from the weather, can safely be assumed to be well in excess of 100 years. Over this time period it is conceivable, due to an increasing population and due to limited land being available for development in large urban centres, that vertical expansion of buildings may be an increasingly viable option to provide affordable housing and commercial space close to urban centres with good transportation and services infrastructure. **The vertical expansion of structure is practically impossible, or at least prohibitively expensive, unless allowed for in the original design or if the building use changes to an occupancy that has a much less severe gravity load requirement**, e.g., a multi-level warehouse building converted to residential loft apartments. Relying on a favourable order of occupancy with respect to vertical expansion again leads to one-way structural adaptability.

Providing for vertical expansion for all buildings or semi-urban centres puts a financial burden on the initial developer, who will likely never realize the economic benefits attributable to this built-in structural adaptability. The financial burden will vary depending on site specific conditions, but can be easily quantified. The economic benefit, however, is much more difficult to measure. The adaptable structure clearly has socio-economic benefits for the community in which it is built and for the global environment in terms of the efficient use of the earth's resources. The political challenge is to determine ways in which truly adaptable structures can be built in a capitalist society. This challenge is far greater than developing technical guidelines for adaptable structures.

Materials and Systems

The primary structural materials for midrise construction are concrete, steel and masonry.

The commonly employed concrete systems are described as follows:

1. Reinforced concrete shearwall and solid one-way slab.
2. Reinforced concrete frame with beams and columns and solid one- or two-way slabs.
3. Reinforced concrete frame with columns supporting two-way flat slabs.
4. Post-tensioned concrete frames with columns and solid two-way slab.
5. Prestressed precast concrete frame and prestressed hollow core floor slab units.

There are three common systems for steel:

1. Steel frame with columns, beams and purlins and composite concrete on metal desk.
2. Steel frame with columns and composite beams, purlins and concrete on metal deck.
3. Steel frame with columns, beams, open-webbed steel joists and composite concrete on a metal deck.

Mixed systems include:

1. Masonry shearwall and one-way solid reinforced concrete slab
2. Masonry shearwall and prestressed hollow core floor slab units.
3. Steel frame and prestressed hollow core floor slab units.
4. Lift slab construction - concrete floor and steel columns.

There are five common lateral load resisting systems:

1. Reinforced concrete core.
2. Reinforced concrete shearwalls.
3. Braced structural steel core.
4. Braced structural steel frame.
5. Reinforced masonry shearwalls.

The most adaptable structures utilize two-way floor construction, simple gravity load framing with a column grid, and localized lateral load resisting elements. Structural materials which act non-compositely are more adaptable to modification than composite materials or prestressed concrete. A reinforced concrete frame with columns supporting solid two-way flat slabs and a reinforced concrete core has the potential to be the most adaptable structure for a building. Generally, local modifications can be made without significantly affecting the overall structure.

Loads

For interior spaces a live load allowance of 4.8 kPa is generally sufficient for all occupancies except for stack rooms in libraries, factories, and some warehouse facilities. For floors above the ground floor a live load allowance of 2.4 kPa is sufficient for all occupancies except for those listed above and some assembly, retail, mechanical rooms, hospital operating rooms, laboratories and recreational rooms.

With respect to adaptability, buildings with the lower floor designed for 4.8 kPa live load and the upper floors designed for a 2.4 kPa live load will generally be able to accommodate most mixed-use occupancies.

Earthquake loads may be an important consideration for adaptability is some regions.

The design for lateral seismic force is related to the building occupancy which is expressed in engineering formulae as a Seismic Importance Factor and is equal to a range from 1.5 for designated post-disaster buildings (hospitals, fire stations, etc.), to 1.3 for schools, and to 1.0 for all other buildings. Based on this formula, and all other things being equal, post-disaster buildings and schools must be 50% and 30% more lateral seismic force respectively than other buildings.

In terms of adaptability, the post-disaster level of earthquake loading should be checked at the design stage as this may be the controlling lateral load case over the entire extended life of the building.

Foundations

The least adaptable part of a building is the foundation. This is true regardless of the actual type of foundation selected for a building. The main reason for this is the restricted accessibility of the foundation in the completed building. Any kind of structural modification to the foundations will generally be very costly.

Footings, mats, piles or caissons are sized for a specific building on a specific site to spread the building load over the underlying stratum such that the safe allowable bearing pressure of the soil or rock is not exceeded and such that differential settlements between adjacent areas of the building are within acceptable limits. Foundations bearing on solid rock generally have reserve load bearing capacity due to the relatively high allowable bearing capacity of rock and since foundations on rock do not experience long term differential settlement problems. Foundations bearing on sand or clay generally do not have this reserve load bearing capacity. Long term differential settlement can be a concern for buildings found on clay since settlement of clay soil is dependent upon pressure level, moisture content of the clay and the time duration of loads.

3.3 Mechanical and Electrical Issues for Adaptability

The following section describes mechanical and electrical systems for midrise to highrise buildings in general terms and how they are designed using standard equipment and guidelines as recommended by The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE). It is a contemporary account of mechanical and electrical issues as they relate to adaptability.

The design of mechanical systems responds to the loads imposed by the building envelope design, internal lighting loads, internal equipment loads, and internal occupant loads. The amount of energy required for heating, cooling and ventilation is dictated by these loads. While the systems must be capable of meeting the maximum loads imposed, they must also be capable of modulating downward to a level required when these loads are well below the maximum.

Building designers are required to recognize specific mechanical/electrical load characteristics when designing a system for new construction or for a conversion project. Typical loads for various occupancy types are as follows:

Typical loads for Various Occupancies

occupancy type	heating kW/sf	cooling Btu/hr/sf	ventilation cfm/sf	lighting W/sf	receptacle W/sf	people sf/person
multiple unit residential	0.12	30	0.09	1.5	3.0	175
office	0.08	43	0.27	2.0	3.0	110
retail	0.06	40	0.25	3.0	3.0	50
hotel/motel	0.12	40	0.15	1.4	1.0	150

From the table above, it can be seen that multiple unit residential occupancies have the lowest cooling, occupant and ventilation loads and one of the lowest lighting loads. For this reason, the conversion of any of the other occupancy types to multiple residential can generally be accommodated by the capacity of the existing mechanical systems. Similarly, the electrical distribution system for lighting of any other occupancy type would probably meet the needs of multiple unit residential occupancy. The electrical system for an office could accommodate the receptacle load, but buildings designed for other occupancy types would have an inadequate distribution system. Rewiring the interior of a building to meet revised performance criteria can be one of the easiest and least expensive revisions to implement provided there is good accessibility throughout the distribution network. If a conversion project has been stripped of impeding internal elements and there is open access to the conduit routes, installation is greatly simplified. Where the main service has to be enlarged or relocated, larger expenditures may be required.

Whether the project at hand is a conversion or new construction, the selection of a specific mechanical system is determined only after a host of factors is carefully considered: available space, ability to match load variations, density of loads, building type, efficiency, and flexibility. When a building is being converted to a residential use, it must be recognized that **the standards of comfort expected in an MUR tend to be higher than other types.** Occupants expect to be able to sit quietly dressed in indoor clothing without feeling the radiation and convection effects of outdoor ambient conditions even when seated, and without feeling drafts for excessive air velocities or hearing noise from the machinery. These criteria are considerably more stringent than for any other occupancy, including office and hotel/motel. For this reason, conversion to a multiple unit residential occupancy may require new air handling and hot water heating systems designed to meet these needs. Where heating and cooling are by central hot water and central chilled water respectively, the central plant may be retained but the zone delivery systems will usually need to be revised.

Estimates of Service Life of various HVAC Systems Components

Component		median age (years)
Cooling units	window	10
	commercial air cooled	15
	commercial water cooled	15
	reciprocating chillers	20
	centrifugal chillers	23
	absorption chillers	23
Boilers	steel, water tube	24
	steel, fire tube	25
	cast iron	35
	electric	15
Furnaces	gas or oil fired	18
	unit heaters (gas or electric)	13
Fans	centrifugal	25
	axial	20
Pumps	base mounted	20
	pipe mounted	10
Cooling Towers	galvanized metal	20
	wood	20
	ceramic	20
Controls	pneumatic	20
	electric	16
	electronic	15

From ASHRAE Handbook 1995 HVAC Applications, Chapter 33

Occupancy Type and HVAC System

Occupancy Type	Typical System Description
Multiple Unit Residential:	
rental	2-pipe fan/coil with central plant
condominium	water loop heat pump
Office:	
< 1 858.07 sm	packaged rooftop single zone
1 858.07 to 6 967.76 sm	packaged rooftop VAV with perimeter reheat
> 6 967 76 sm	built-up central VAV with perimeter reheat
Retail:	
< 4 645.17 sm	packaged rooftop with single zone
> 4 645.17 sm	packaged rooftop VAV with perimeter reheat
Hotel/Motel:	
< 3 storeys	packaged terminal air conditioners
> 3 storeys	4-pipe fan/coil with central plant

From ASHRAE 90.1

Criteria for Adaptability of Buildings - HVAC and Electrical

Factor	Conversion Type		
	Office to Highrise MUR	Industrial to Midrise MUR	Highrise MUR to Office
HVAC Plant			
heating boiler	retain-capacity check	replace	retain
chiller	retain or replace	N/A	new
cooling tower	retain or replace	N/A	new
incremental A/C	N/A	new	N/A
HVAC Distribution System			
perimeter heating	retain	new	retain
central air distribution	replace	new	new
perimeter air distribution	replace	N/A	new
ventilation system	new	new	new
Service Water Heating			
heater/boiler/tank	*replace*	*replace*	*retain-downsize*
distribution system	replace	replace	retain-downsize
Electrical System			
elevators	retain	replace	upgrade
electrical distribution	replace	replace	upgrade
lighting	New (except garage and stairwells)	new	new

Mechanical and Electical Systems Design

Design concepts for adaptability of the mechanical and electrical systems of a building can take two approaches. The first of these is a Distributed Energy System (Type I) where energy sources are brought to the occupied space for conversion into heating, cooling, lighting or other uses. The other approach is a Central System (Type II) which brings preconditioned media to the occupied space from a central plant for space heating, service water heating, and space cooling.

Electricity is always distributed as a Type I system. Heating, ventilation, and air conditioning (HVAC) services can be either a Type I or a Type II system. Lighting is almost always a Type I system, but one example of an exception is a proposal for a central lighting source using a sulphur lamp with fibre optic distribution.

ASHRAE 90.1 suggests a hierarchy for energy transport systems based on their inherent energy efficiency. The Type I system is the most energy efficient, followed in order by Type II systems using a phase change (including steam or refrigerant), Type II systems using a single phase liquid fluid (typically water), and finally Type II systems using air which is the least efficient.

Type I - Distributed Energy System

A distributed energy system requires a designer to bring electricity and natural gas or some other kind of fossil fuel to the occupied space for powering HVAC equipment, lighting, office equipment, appliances, and machinery. While the Distributed Energy System design approach is quite standard for electricity as a power source, it is growing in popularity for natural gas in some market sectors. Examples are found in the multiple unit residential market, where natural gas is piped through the building, metered at the apartment demising wall, and supplied to one or more appliances used for space and service water heating. The same concept has been used in some motel buildings for the provision of space heating.

The Distributed Energy System offers the designer individual space temperature control, smaller overall building space allocation for piping, and the potential for individual tenant billing of utilities. The designer would be obligated to design the energy service distribution system to handle the maximum load that would be placed on the system by anticipated future uses of the space, resulting in oversizing of the energy distribution systems for all other uses. This is a relatively small price to pay for adaptability. Terminal units and air distribution systems would be selected for the current space use, to be replaced by larger or smaller units and systems as necessary to accommodate changes. This would parallel changes currently made to lighting systems for differing tenant needs.

Some examples of HVAC equipment suitable for Type I - Distributed Energy Systems include the following:

Packaged Terminal Air Conditioners (PTAC) are also refereed to as incremental units and these can incorporate direct expansion cooling and may also use electric resistance heating or have a gas furnace. They are usually selected to condition one room, but can be supplied with a duct kit to extend to a second or third room. They install in a sleeve through the wall to provide outside air access for condenser cooling, ventilation air, and combustion and venting of the gas furnace. PTAC's are also available as heat pumps and are available in capacities to 18 kW 10 kW. The current applications are predominately in MUR, hotel and motel, and small office occupancies.

Packaged In-Space Heating/Cooling Units are similar to PTAC's but are designed for use with an air distribution system. They are usually located in an enclosed room or closet in the conditioned space with an overhead duct system. Like PTAC's, they are also available as heat pumps and come with capacities to 18 kW, 10 kW. Current application for these units are multiple unit residential and small offices.

Packaged Rooftop Heating/Cooling Units are designed for use with ducted air distribution. They are generally located on the roof above the conditioned space, but may also be placed on grade beside the space. These units incorporate direct expansion cooling with electric resistance or gas heating. They are available as heat pumps and can be supplied for a single zone, multi-zone or variable air volume systems in capacities to 350 kW. The most common current applications are for offices, industrial, retail and food services uses.

Potable Water Space Heating is a system which uses a gas or propane fired domestic hot water tank located in the conditioned space, most often in a separate mechanical room. Hot water from the tank is used for space heating through a fan coil unit, baseboard radiation, or in-floor radiation. The fan coil option may also be combined with a direct expansion cooling unit. This system is currently only used in multiple unit residential applications.

Combination Hot Water/Service Hot Water Boiler refers to a system which uses a single gas or propane hot water boiler producing separate sources of hot water for space heating and service hot water. Units are often mounted on the wall in an area such as the kitchen. This system is more popular in European projects than it is in North America where it is limited to being one of many options for multiple unit residential applications.

Water Loop Heat Pump describes a self-contained unit which absorbs or rejects heat from a water loop maintained at temperatures between 16o C and 32o C by a boiler and cooling tower. This is a cross between a distributed energy system and a central plant system. The unit is designed for ducted air distribution and it is available in capacities to 5 tons. The current application is with office, MUR, retail, and mixed uses.

Type II -Central System

A Type II Central System conveys conditioned media produced from a central plant, including chilled and hot water or steam for space conditioning to the occupied zone, to be used either directly in radiation, or in units such as fan/coils for heating and cooling air. Service hot water is also piped from a central source. The central plant may be located within the building, or it may be situated as a district heating and/or cooling plant. While all air systems might also be considered in this category, such systems require large mechanical spaces, a careful matching of system design to conditioned space load, they are generally less adaptable and are consequently not included in this category.

The Central System requires the designer to size both the central plant and the energy transfer media distribution system to meet the maximum anticipated load. Control of the space conditions is achieved by a combination of central plant and space control. Central plant equipment is generally more reliable and durable than packaged equipment and it is often less expensive to maintain.

Some examples of equipment suitable for Central Systems includes the following:

Boilers in the central plant use hot water or steam and are available in a wide range of capacities. These units are powered using electricity, natural gas, or other fossil fuels. Hot Water boilers may also be used for service water heating. Boilers for district heating systems may have the added economic and environmental benefit of consuming biomass and waste as combustion fuel.

Chillers are also a part of the central plant and they are used to produce chilled water for cooling. They are available using electricity, natural gas or steam. Reciprocating electric chillers have a capacity that ranges from 18 kW to 530 kW. Centrifugal electric chillers have a capacity range from 700 kW to 21,000 kW. The absorption chillers use steam or natural gas and range from 175 kW to 5,300 kW tons capacity.

Terminal units in conditioned space include **fan/coil units** and **radiation units**. The fan/coil units transfer heat to/from the conditioned space from/to the heat transfer medium, which is usually water. The fan/coil units offer individual zone control provided the central system can provide sufficient hot or chilled water. Two-pipe systems must be set for heating only or cooling only, while the four-pipe system can do both simultaneously in separate zones. Radiation units transfer heat from the heat transfer medium to the conditioned space using natural convection and radiation. These units may be mounted on a wall or at the ceiling level and are sized to meet the heating load. It is worth noting that there has been some research and development done on ceiling radiant panels for cooling.

Conclusion

On balance, distributed energy systems are likely to be more flexible and adaptable to change in a building. Combined with finite useful lifespans of contemporary mechanical and electrical equipment, the adoption of a distributed approach allows for less costly investment in flexibility and future change.

3.4 Revaluing Buildings/Grids and Nodes

Finding ways to create flexibility and to provide an evolutionary edge to the workplace continues to be an area of intense research and experimentation. Institutions, corporations and other organizations who have a lot at stake in terms of productivity and efficiency have been drivers in the search for the ideal working space. Numerous studies have shown how an adaptive re-use of an existing building will cost as much as new construction, but the advantage of the reuse (revalue) approach is that “the money is being spent where it counts mostóon the inside in the form of infrastructure and furnishings. For the spatially, technically, and environmentally dynamic office, it is imperative that investments be made here rather than thinly spent on new shell and core and service and finish” and although discussion points to “the next generation of workplaces for high performance organizations”, the core idea that spatial flexibility can be achieved by technology applies directly to all forms of building adaptability.

So, how exactly does one use technology to create a flexible space? In the case of an office building, there is the recognition that workers, work stations, and teams of workers need a great deal of freedom to arrange themselves in any number of ways to complete certain work tasks. In order to achieve this freedom, there needs to be **an infrastructure of services in place that is infinitely mutable**, or at least as close to this as possible. The participants of the Steelcase seminar discuss the concept of grid and nodes: A description of infrastructural solutions that could be a significant response to these spatial/organizational dynamics begins with the concept of neighbourhoods or workgroups serviced by grids, and workstations serviced by nodes and controlled by users. In this infrastructural alternative, finer service grids would provide critical data, voice, power connectivity and thermal, visual and air quality conditions to each "lot" or neighbourhood (7 to 35 people) fed by multiple vertical cores and open horizontal plenums. An even finer layer of user modifiable nodes of service will be provided to each individual workstation, fed through flexible connections from the grid.

There are a range of existing and innovative building subsystem configurations that will support long term environmental, technical and physical quality for each individual workstation in the face of rapid change. The choices in zoning and individual control for the state-of-the-art workspace fall into the four categories of HVAC, lighting, data and enclosure:

1. Heating, Cooling and Ventilation Systems
    - Selection of a mechanical system type
    - Zone size, density and location of diffusers:
        - micro-zoning (one zone per workstation)
        - floor/furniture based air supply systems, or
        - flexible-grid flexible-density ceiling HVAC
        - increase supply and return air densities,
        - relocatable
    - Separating the ventilation from the thermal conditioning:
        - task-driven ventilation or constant-volume ventilation
        - water-based thermal conditioning and air-based ventilation
        - displacement ventilation
        - radiant heating and cooling
        - thermal load balancing
    - Controls:
        - air speed, volume, and temperature controls
        - density and location of diffuser control
        - outside air content and filtration controls, purge cycles

2. Lighting and Daylighting Systems
    - Fixture efficiency/efficacy
    - High level, ceiling-based, task-ambient lighting:
        - uniform and non-uniform task-ambient
        - density and location of task-ambient fixtures
        - direct and indirect lighting
        - lighting zones: density of on/off or dimming controllers
        - lighting zones: relocatable and individually controlled
    - Low level ambient lighting with controllable tasklights at the workstation:
        - design of ambient lighting and contrast glare
        - density and location of task lights, directional and occupancy controls
    - Effective daylight utilization:
        - light shelves, diffusers, reflectors and lenses
        - building surface/volume and orientation
        - room configuration
        - effective electric lighting interfaces and controls
        - controllable enclosure loads

3. Electrical and telecommunications systems

The merging of data, voice, video, and environmental sensors & controls into net work:

- network neighbourhoods and satellite closets
- homerun, star horizontal network configurations
- increased horizontal plenums: floor, ceiling, furniture, wireless
- power quantity, quality, reduced interference, reconfigurable outlet boxes
- changing workstation peripherals/desktop hardware
- shared equipment and social centres
- teaming/conferencing networks and spaces
- individual controls and energy management
- recyclability and resource management

4. Enclosure systems

Environmental contact for the individual:

- increased building periphery, windows and views
- access to open air landscaped areas for work and R&R

Sunlight and daylight - the layered facade:

- high visible transmission glass with light redirection devices
- sunshading: interior, exterior and integral devices
- lighting system interfaces and controls

Thermally balancing facades:

- reduced MRT differentials, infiltration and conductive losses
- high performance facades - high R, low SC
- air flow windows and water flow
- mullions
- photovoltaics and thermal storage facades
- double envelope facades

Natural ventilation and the open window

The above description of the four basic systems is geared toward zoning and control of the "dynamic and high productivity workplace". One specific and proprietorial approach to these issues is known as *Flexible Grid - Flexible Density - Flexible Closure Officing: The* Intelligent *Workplace*. This flexible grid, density, and closure system is a constellation of building subsystems that permit each individual (or workstation) to set the location and density of heating, ventilation, air conditioning, lighting, telecommunications, and furniture, including the level of workspace enclosure.

Service Grid Types and Their Corresponding Nodes for an Adaptable Office

services needed at workgroup	services needed at workstation
HORIZONTAL	
GRIDS	**NODES**
data	data outlets
voice	voice outlets
video	video outlets
power	power outlets
.structural columns	structural beams
furniture	worksurface
ceiling grid	ceiling tile
ambient lighting	lighting fixtures
floor grid	floor tiles
thermal service	diffusers/radiators
ventilation	diffusers
plumbing	kitchenettes
security	doors
fire	sprinklers
environmental control/zones	sensors/controllers
acoustic/sound system	acoustic materials/speakers
windows	viewing cone
core to shell distance	wayfinding, access to vert. service
VERTICAL	
floor to floor heights	hor. plenum size & access
hor. plenum: ceiling, floor, furniture	size and access to service
floor to ceiling height	light & air distribution, service access
panel/wall height	light & air distribution, service access

While of interest to a discussion of adaptability, this approach to flexibility of workspace is of limited applicability to "residential" use since the degree and frequency of change required by residential use does not require the same intensity of service provided through a system of grids and nodes. Where office spaces may require change on a frequent basis, residential changes are linked to longer term family life cycles. An area of future research lies in the exploration/comparison of nodes and grids that could service change from one use category to another.

3.5 Flexis

Researchers in the Netherlands have made the observation that a large number of office buildings are becoming obsolete and unoccupied. Many older buildings on prime sites are losing their competitive edge in the marketplace because they are not sufficiently geared to the changing needs. Instead of adapting to the new requirements, many buildings are driven to demolition and new construction takes their place. This is a costly process, both financially and environmentally.

The Dutch Building Research Foundation (SBR) and the Dutch Institute for the Study and Stimulation of Research in the field of building installations (ISSO) jointly commissioned a study to investigate ways of curbing the obsolescence of these buildings. It was recognized that one of the key problems was the inability of building installations - specific product and material configurations, the components of which have been specified and which are the tangible form of a conceptualized system - to be sufficiently flexible. The increasing changes in user demands requires buildings and installations to be flexible enough to cope in new construction and adaptive re-use projects.

From the research comes a tool called **Flexis.** It is a method of communication which allows the project team to formulate the ***flexibility demand*** and to assess the ***flexibility supply.*** Flexis uses a kind of score card called an ***assessment form*** to judge the flexibility of an installation. Flexibility is broken down into four subcategories: ***partitionability, adaptability, extendibility and multifunctionality.*** Each of these has its own group of issues which are numerically rated, weighted, and totalled. The end result is a designation of the installation from *class 1: not flexible to class 5: highly flexible.*

Along the way to developing Flexis, the researchers needed to set up a consistent system for describing and determining the flexibility of buildings and their installations. They defined a four-tiered description of installations from the top down:

Functional Installation Concept is the formulation of the installation functions wanted in a building independent of specific product or project. It is a formulation of the demands to be met, and it is applied primarily during the programming phase of a building project.

Installation Systems are technical solutions fitting an installation concept independent of product or project. For each installation concept (= demand or performance requirement) various generic technical solutions or installation systems can be formulated and offered (= supply).

Installations are specific product or material configurations whose components have been specified and constitute the tangible form of the installation system previously formulated.

Installation Components exist at the greatest level of detail. They are the items or devices that are grouped by Flexis as follows: user-interface facilities, measurement and control facilities, distribution facilities, production units, supply and removal facilities, and constructional facilities.

The researchers have classified installations according to the function that they perform. There are two main groups:

1. Interior Environment Functions:
   - Temperature (heating and cooling)
   - Humidity (humidifying and dehumidifying)
   - Air (supply and return, cleaning)
   - Light (lighting and shading)
   - Noise (soundproofing and sound control)

2. Service Functions:
   - communication (internal, external, data, management)
   - gas
   - water
   - power
   - transport

The Flexis technique recognizes that installations operate within various spatial levels. Within the framework of Flexis, two major levels of modularity are distinguished: *local* and *central.* The central level is the set of all levels higher than local. In a building these could be a floor, a wing, and the entire building. Some examples of installation facilities existing at the central level are central supply units and distribution mains. The flexibility of any installation is greatly influenced by the spatial level at which it exists.

One of the fundamental ideas with Flexis is the definition of *flexibility* itself as it applies to buildings and building installations. A large number of flexibility characteristics were identified and have been grouped into four categories. Flexis calls these categories: Partitionable, Adaptable, Extendible, and Multifunctional.

Partitionability is the possibility of splitting up, rearranging or combining installation systems into different spatial units in a simple way. An important point in this connection is whether distribution, conversion, supply (transfer) and the measurement or control of installation functions takes place locally or centrally. Another important aspect is a possible distinction between the collective (support) and the individual (infill) mode of offering functions and the zoning of distribution facilities.

The **adaptability** of an installation is the possibility of altering installation systems in a simple way to meet changes in the user's demands (the installation function required) resulting, for example, from a structural or functional rearrangement of the building, from changes in use, the coming of other (groups of) users, or technological renewals and modernizations considered necessary.

Extendibility is the possibility of adapting installation systems in a simply way to additional user demands, for instance by the addition of more or new installation components called for by structural or functional extensions, both inside and outside the existing building.

Multifunctionality is the possibility of using or deploying installation systems or components for several functions. This allows of a more efficient use of space and permits clustering and concentration of installation components. This concept is sometimes called integration.

Installations can be compared by creating the *flexibility profile.* A diamond-shape graph is plotted with the four vertices representing the four sub-categories of flexibility. The overall flexibility of the installation is proportional to the area within the diamond. According to Flexis, a highly flexible installation can be described as follows:

Readily partitionable
-no distribution or removal network
-no conversion at central or supply level
-central and local transfer, measurement, and control

Readily adaptable
-good disconnectability (plug-in components)
-good accessibility (components at infill level)
-good adjustability

Readily extendible
-ample overcapacity (central and local supply facilities)
-liberally oversized
-good location

Highly Multifunctional
-highly integrated
-universal components

The researchers report that Flexis has been used by experts in the field and it has been the subject for discussion within the Open Building community. One future research goal is to continue the development of Flexis as a method of mapping and checking the supply and demand for flexibility not only for installations but for entire buildings in the design, construction and occupancy stages.

Flexis is an interesting analysis tool which would assist in assessing the degree of adaptability achieved by a specific design. It does, however, lead the designer to adopt a specific design philosophy which may be quite opposite to where he/she would proceed if other criteria, such as maintainability, energy efficiency, or reliability were to govern.

3.6 SEF: A Flexible School Design

During the 1970s, an ambitious program called the System for Educational Facilities, or SEF, was developed by the Toronto Board of Education. The objective of the program was to reduce capital costs and to increase programmatic flexibility to meet the needs of the growing number of baby boom children. To provide this flexibility the educational facilities would need to change and expand quickly in an economic way. More than twenty schools were built in the Toronto area according to the SEF agenda. The schools featured a uniform design approach to component systems, interior partitioning, ceiling systems, mechanical air distribution and lighting.

The SEF program challenged the conventional building industry in its systems approach and in its tendering and contracting methods. It is interesting to note that the ultimate success of the system lay in its ability to cope with rapid delivery of building facility through the clear articulation of a simplified building method and vocabulary. The SEF's ambition to be flexible and responsive to change through time was ultimately not achieved or, rather, not tested. Most of the schools that were built according to the program remain today with floorplates that have not been altered significantly.

3.7 Design for Disassembly

An emerging new direction in design, particularly in industrial design, places a priority on the ability to separate a product back into its constituent components after it has been assembled. This approach has been called **Design for Disassembly**, or **DFD**, and has evolved substantially since the late 1980's in the consumer goods markets and automotive manufacturing. The change has been driven, in part, by consumer and manufacturer concerns over recycling and reuse as ways to curb the growing volume of post-consumer material waste. By making products easier to take apart in a way that is not destructive for the constituent components, elements can be reused directly - if they are still capable of meeting the performance requirements - or they can be readily separated by material type and treated as raw material for other products through recycling processes.

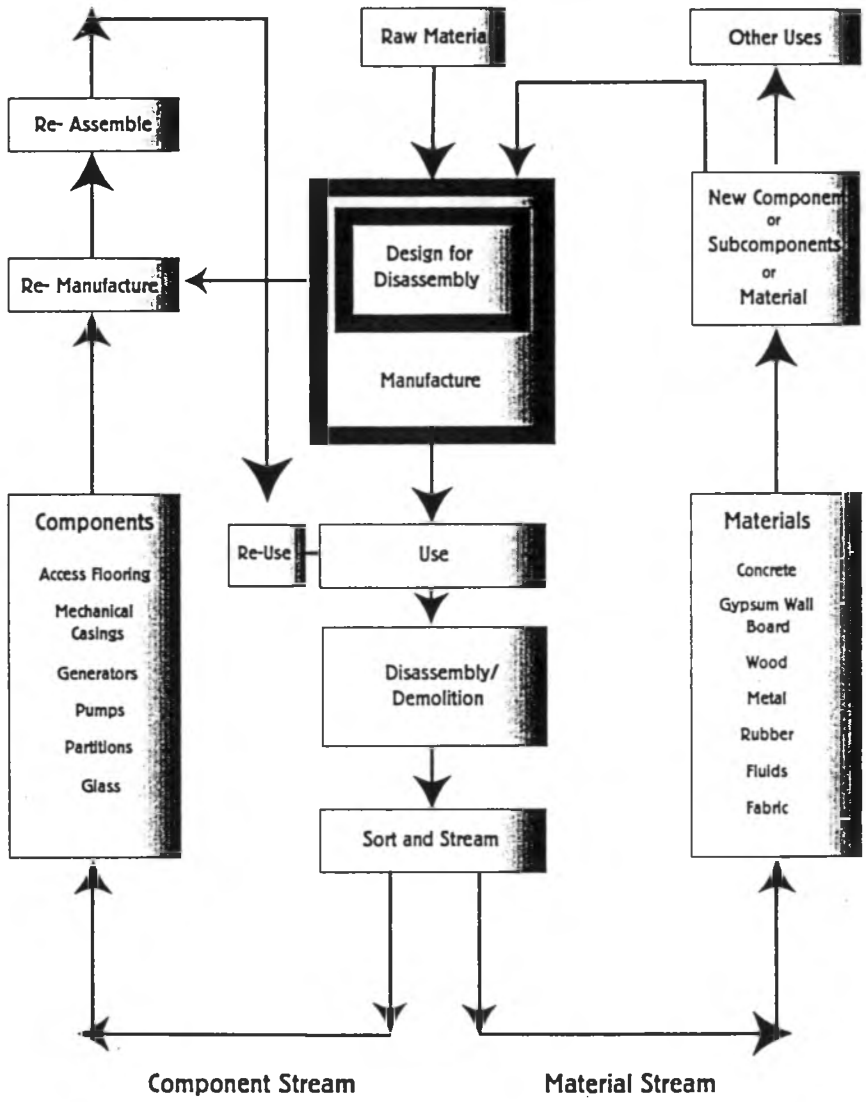
Easy disassembly as a design feature has the additional potential benefit of easy assembly, provided that the manufacturing process recognizes the natural similarities between the two and exploits this. For products such as furniture (eg. shelving, cabinetry) and some appliances (eg. barbecue) the ease of assembly and disassembly can be turned into a marketable feature for potential buyers interested in easy transportation or storage. Passing on some of the final steps in product assembly from manufacturer to end-user can expedite the process from the maker's point of view since these steps are often among the more labour-intensive.

The advantages of the design for disassembly approach have been recognized by European manufacturers such as BMW, Miele, and Ikea. In North America, the information technology industry is interested in disassembly design as a technique to facilitate the future upgrades of their product. Apple Computers, for example, are examining the nature in which the materials and components that constitute their products are connected. Design for disassembly in this context contributes to growth in the aftermarket for product customization and upgrading.

The construction industry has experienced an increase in the use of industrial technologies, and the making of buildings is becoming more and more like the manufacturing of products, according to Dr. William Lawson from Solarch at the University of New South Wales. If this technology transfer holds true, then it is likely that forces influencing design methodologies for product manufacturing also apply to building construction. The Building Owners and Managers Association (Australia, 1988) estimate that in some extreme examples the anticipated lifespan of some contemporary building types is less than twenty years - comparable to that of many consumer goods such as refrigerators, ovens, and dishwashers. The building designers who are prepared to view these projects in this way - as relatively short lived assemblies of manufactured products and systems - could use the DFD approach to address the issues of sustainability. Dr. Lawson has made the argument that buildings appropriately designed for shorter lifespans could actually reduce the amount of construction and demolition waste produced.

The potential for DFD lies in the ability of the construction industry to organize and agree on a number of protocols that would coordinate various items such as dimensional compatibility, standards of product performance, industry reuse, and recycling goals. An important part of such a program would require a method of labeling materials and components so that items could be properly identified and dealt with appropriately at the end of a service life. Explicit labeling of materials within the plastics industry, for example, is becoming a standard practice for consumer packaging and other goods. In this case, a code (eg. a shape

Model for DFD/Building Industry Integration



and a number) is physically embossed into the plastic product to assure proper sorting and recycling.

The present state of recycling of construction and demolition related materials is in its infancy. The major component is material recycling with an emphasis on diversion of waste materials from the landfill site. Materials such as concrete, glass, gypsum wall board, and steel are presently treated as source separated wastes and only recycled in relatively crude ways. For example, used concrete is crushed and reused as an aggregate in a new mix. This is a fairly low value second use. It does not recognize the embodied energy of the original materials. With such a basic approach to material recycling only recently accepted, the more complex disassembly approach to components and composites in buildings is certainly a long way off. **Priorities for incorporating DFD application in building industry should fall within skin, service, and space plan components and focus on materials with the highest embodied energy and labour components such as aluminum, glass, and synthetics, with an emphasis on petroleum-based products and other non renewables. This effort should parallel maximizing the use of renewable/sustainable materials.**

Developing material labeling and disassembly standards specifically suited to the construction industry is another priority. The challenge in doing this would involve in a significant way overcoming the high level of fragmentation in the construction industry.

3.8 Environmental Issues

Although it would seem reasonable to suggest that environmental concerns play an increasingly important role in defining the value of building conversions, **adaptability (conversions) as an environmentally desirable factor is not well documented in the general literature.** Perhaps the best expression of environmental value is contained in BREEAM and BEPAC building evaluation programs which both recognize reuse of existing building, structure or components.

Advocates for historic preservation and conservation of building stock have recently embraced the embodied energy argument (and the consequent greenhouse gas avoidance) viewing it as a positive additional benefit to the traditional and well expressed value of cultural preservation.

Indoor environmental issues may become an issue in adaptability where the compatibility of existing and new uses within a building conflict, or where the impact of rehabilitation of previously less benign uses may inhibit conversion. As the habitability of buildings from a health, safety, and comfort point-of-view gathers increasing significance, the indoor environmental concerns and the technology developed in response to these concerns become important factors in the evaluation process of determining feasible conversions. For instance, asbestos abatement and encapsulation or removal of other noxious material and waste can play an important role in the final decision whether to modify or convert an existing structure.

The future re-use of buildings may be expanded as the negative impacts of technology and processes lessen. Some industrial uses, for example, may become more compatible with residential use than was previously possible and provide increased opportunities for locating next to each other. The emergence of the industrial ecology principal with the waste stream from one process becoming the input (food) of another process is an example of new compatibility potential; providing new opportunities for previously incompatible uses to exist side by side.

Conversion Study

4. CONVERSION STUDY

4.1 Case Study Analysis

The results of the literature research showed that there exists a void in terms of defining adaptability in an explicit way or incorporating it as a primary goal for building designers. There are numerous accounts of building conversions fully documented and explained in a case-specific manner. Many of these studies examine the conversions of non-residential into living space that grew out of the urban culture and markets of the 1970's and 1980's primarily in New York and London. There is, however, very little discussion of specific building characteristics or attributes that make for eminently adaptable structures.

Nine Canadian examples of building conversion projects were identified as described earlier. Each of these case studies has been researched and documented in terms of the technological and design issues that affected the conversion. By looking at actual examples of conversions that have been completed or are in the process of being completed, some insight is gleaned with respect to the international discussion on developing technologies and theoretical efforts concerning adaptability and how this relates to real projects.

An analysis of conversion projects does not spell out a method for creating adaptable buildings. Each conversion project is a one of a kind enterprise with a unique combination of issues and opportunities. What the conversion study does is to provide actual accounts of how specific systems influence the change of a building from one thing to another. An understanding of how this change is accomplished in real projects begins to shed light on a design attitude for new construction where future adaptability is made a priority from the outset. Design for adaptability is not design for the unknown, but rather it is design for easy change.

Specific information on each of the nine conversion projects appears in the Case Study Data Sheets. The following is a general discussion of our findings:

Use

The nine case studies that were examined for this report constitute a diverse group of buildings representing a broad spectrum of conversion types. The pre-conversion buildings have original construction dates ranging from 1916 to the 1980's and feature a number of different building materials and construction systems. There are a variety of use categories involved with these conversion projects but each one includes some element of residential use. Four of the nine cases were originally built for office space, two started out as warehouses, one as a factory, another as a department store, and the final case was a conversion from a condominium residence to a hotel.

All cases underwent fairly dramatic changes in use. In cases where some of the original use category was maintained, it occurred only in the first few levels from the street. Specifically, the Ramsden retained its one level of retail at the street. The same is true for the building at 102 Bloor Street, and to some extent with the College Park redevelopment. The BC Hydro conversion to The Electra saw two levels of office space remain at the base of the tower while the rest of the building was changed from office spaces to residential units. In general, there was no change in use below grade, some change at the street levels, and total use change in the upper levels.

SIZE

It is important to note that there is a tremendous range in size within this group of mid to highrise buildings. A comparison of the gross floor area for each is one indication of this diversity. The amount of total floor space for each case is listed in Table 1.- GFA. There are a patterns that can be seen from the Table 1. and Table 2.- Floors, Parking. In each conversion case, the total GFA does not seem to change appreciably (even with Queen's Quay Terminal where there was substantial demolition and new construction). All nine cases show a post-conversion size that falls within ten percent of the original GFA. This may be in part due to the selection process that occurs when a potential candidate is being scrutinized for a particular re-use. With a specific programme of use in mind, the building that is going to meet the requirements is one that is comparable in size. It may also be true that the decision to adapt an existing building to a proposed plan is supported by the desire to avoid new construction. In other words, it may be a goal of the design team to find a building that will require as little new construction or demolition as possible.

There was a change in the number of floors in more than half of the case studies, ranging from one new level (Merchandise Building, 102 Bloor) to nine new levels (College Park). It is important to note that a change to the number of floor levels within the existing height of a building usually has to do with the manipulation of a mezzanine level rather than a typical floor (Metropole, Merchandise Building, 102 Bloor). This is because the mezzanine levels are often programmatically and structurally independent. A mezzanine, by definition, does not share the full building perimeter and can usually be modified without interrupting the structure around it.

STRUCTURE

None of the conversion case studies underwent significant change to the substructure. The foundations in each case were more than adequate for the new loading conditions. It is important to establish the load bearing limits of the foundations when there is vertical expansion, such as the Queen's Quay Terminal and College Park. In the former case, it could be said that the foundation's capacity was the determining factor in the amount of vertical expansion possible. College Park is a different situation in that there was an enormous load-bearing capacity incorporated into the foundation and podium structure in anticipation of a future skyscraper. The previous warehouse building simply had the structural capacity to cope with the unanticipated conversion 55 years after the building was first constructed.

Most of the case study buildings have a reinforced concrete structure. This is perhaps the most adaptable system. Some attributes of reinforced concrete structures which make them easily adaptable:

ï Reinforced concrete is a non-combustible material which can be designed to achieve a fire rating without any coating materials.

ï Solid reinforced concrete floor slabs have better
low frequency sound transmission reduction compared to other more lightweight floor framing systems.

ï Reinforced concrete structures which are designed and constructed in accordance with modern building codes are inherently resistant to progressive collapse.

This is especially significant when buildings are converted to residential use and natural gas appliances are proposed.

ï Solid reinforcing concrete flatslab floors offer minimal obstruction to mechanical service runs and can usually tolerate new openings of substantial size through relatively large areas of the slab.

ï Reinforced concrete gains strength as it becomes older. This is a natural result of the concrete curing process.

The structural system employed at Gotham Lofts is unique among the case studies but is by no means uncommon for early industrial buildings in Toronto. The post and beam construction at Gotham Lofts, although an important interior feature experientially, required a great deal of painstaking care to make a successful conversion. Special design expertise was necessary to create living and working spaces that are not compromised by internal sound and vibration transmission.

The two tower structures at The Ramsden were constructed in 1961 using a two-way lift slab system. This technique is not very common in commercial or residential mid rise construction, but it is still used in low rise and parking structures. Lift slab construction is not very adaptable in part because these structures tend to lack lateral load resistance. It is not surprising that both towers required additional structural bracing during the conversion to residential use.

The reinforced concrete tower in Vancouver (BC Hydro) features an unusually high core to floor ratio of approximately 30%. This property tended to make it undesirable for new office tenants but rather attractive as a residential tower with shallow unit depth and tremendous views. The high proportion of core makes for a fairly stiff and strong tower and this proved to be an asset when the building was evaluated for seismic performance.

Many of the conversion projects were greatly assisted by accurate and detailed as-built drawings from the original construction. This is particularly true for older and more unique buildings. The original structure at College Park was extremely well documented and over the years, it remained in very good shape structurally. The conversion at Gotham Lofts, although a very different kind of project, required numerous exploratory tests and atypical conditions needed to be solved as they arose.

Floor Plate

The physical properties of a typical floor plate is one of the key issues repeating throughout the case studies. All but one of the projects were conversions to residential use, and consequently there are a number of common issues relating to residential floor planning. Tables 3. and 4. - Floor Plate look at some of the important features of the various plates. Here they are compared in terms of size, geometry, material construction, core issues like size and location, etc. In general, the floors themselves did not undergo much transformation in terms of size or shape. With the exception of the two largest warehouse conversions, new uses were introduced to the existing floor plates without a lot of gross physical alteration. Queen's Quay Terminal and the Merchandise Building have very large overall floor dimensions which is not an unusual characteristic for warehouse structures (140.20 x 60.96 metres and 137.16 x 48.77 metres, respectively). These two examples had large portions of their floor removed in order to create more habitable space. For the Merchandise Building this was necessary to provide exterior wall area for the residential units located deep within the building's volume. With Queen's Quay Terminal, the removal of floor was a way of introducing natural light to the shopping and office area, and to make room for a dance theatre which required four levels of clear vertical height within the existing volume. Removal of portions of the horizontal structure compromised the lateral structural stability to some extent and concrete shear walls were introduced to offset this change. Where the floor slab was removed but the columns were retained in the south atrium of the Queen's Quay Terminal, new steel and concrete struts were put in place creating the horizontal elements of the three dimensional lattice.

Within the group of nine case studies, the size of a typical floor ranges from approximately 929.03 sq.m. (102 Bloor and each of the towers at The Ramsden) to more than 8,361.31 sq.m. (at Queen's Quay). Probably more important than the total area of floor is the depth across it. Existing floor plates that measured less than 30.48 m in depth where generally manageable in terms of planning for residential units (provided there was a central core and corridor). After considering the case studies, it could be said that most straight forward conversions involved floors that were rectangular in shape with a centrally located core that was not more than 15.42 m (and ideally less than 12.19 m) from the plate edge. The cases where floor to floor heights were quite generous (a fortunate feature of many buildings constructed for office use) enjoyed the greatest amount of design flexibility. In the case of the Merchandise Building, the planning challenge posed by a very deep floor plate was offset by floor to floor heights of 3.86 m.

The pattern and spacing of vertical structure across a floor plate is a critical factor in planning a new use for an existing building. The largest structural bay among the case studies is the 12.19 x 8.69 m grid at College Park. The base building for the vertical addition of nine levels of new residential construction was built in 1928 as a podium intended to receive a 39 storey tower. For the addition in 1971, the solution was to use steel construction on the existing grid. Although there was structural modification to the podium to deal with greater lateral loads associated with the increased height, there was no need for a special load transfer system from the new tower to the existing base. The layout of the residential floor plate in the tower shows the 12.19 m module quite clearly and subdivides it organizationally into three smaller bays (each at 4.06 m).

The structural grid at Gotham Lofts is the tightest of the nine cases with a bay size of 5.33 m x 3.96 m. This spacing is primarily a result of the heavy timber post and beam construction. The rest of the cases have bays that are in the neighbourhood of twenty feet. A comparison of floor plans for each of the cases reveals a substantial variety in unit size, proportions and overall layout. It is clear that the existing grid has had a major impact on these arrangements, but in every case there are successful solutions to space design within these constraints.

An important characteristic of the typical floor plate is the size and location of the core. For the case studies, cores have been reported in terms of number, location, and the amount of area in plan that they occupy with respect to the full floor plate. The distance from the core to the edge of the slab has also been reported as a measure of floor plate depth. Six of the nine cases have single cores and all of these are centrally located except for the south tower of The Ramsden and the tower at 102 Bloor. Gotham Lofts has two small cores and the larger warehouse conversions have multiple cores that are distributed throughout the floor plate.

In general, it is desirable to retain the core characteristics as much as possible since outright reconfiguration has a profound effect on the overall nature of the building. Aside from playing a role in the lateral stability, they are a site for vertical circulation between the floors and a place for service conduits to be routed. They also set up the basic pattern of horizontal circulation on a given floor plate. The case buildings that were constructed for office use tend to have ample core size for the conversion to residential (eg. Metropole, BC Hydro, 102 Bloor, Ramsden). The Metropole and BC Hydro in particular possessed fairly large central cores with more than enough elevator and vertical shaft space to accommodate the conversion to residential use. Part of the design strategy in both cases addresses this feature by incorporating excess core space into the residential programme. At BC Hydro, vacated core space created by the removal of office employee washrooms and a redundant elevator has been transformed into shared laundry and storage facilities for the new residents. At The Metropole, some of the new units have interior den spaces which penetrate into the central core area. A ranking of importance of the above characteristics in our view is as follows:

1. material,
2. floor plate depth,
3. bay size and configuration,
4. core and service configuration (location and ratio net/gross), and
5. floor to floor height.

ENVELOPE

Table 4.- Cladding and Table 5.- Fenestration show the changes that occurred to each of the case studies in terms of the envelope. A description of the existing condition is made, followed by a description of the post-conversion condition. In terms of cladding, the amount of change due to conversion seems to be an all or nothing proposition. Generally, in cases where the envelope involves a single, consistent system - it is either retained in its entirety or it is replaced completely. For example, the existing system of precast concrete panels at the Metropole were physically in bad shape and underwent 100% replacement. At 102 Bloor, the existing precast panels had integrated fixed windows and were generally inappropriate for the new use. The BC Hydro building was clad with an early curtainwall system (circa 1955) that was replaced by a similar but more advanced new one. In this case it was very important to retain the general appearance of the original envelope since it is designated as an historically significant building. It was possible to respect the existing curtainwall patterns and proportions while upgrading the actual components to enhanced contemporary performance standards in terms of visibility, thermal insulation and acoustic issues.

Almost all of the case studies involved the complete replacement of existing windows. This is not surprising when one considers the advances that have occurred in recent years with window technology. Glazing systems are therefore much quicker to obsolesce than other building components. Where a window is a discreet component within an envelope system, it is physically not difficult to remove it and replace it with a better unit. In the case of Gotham Lofts, glazing was not replaced since all of the windows were less than five years old having been upgraded during the prior conversion from warehouse to offices. In the north tower at the Ramsden, where all new residential window units are being installed, the existing condition of the cast in place concrete spandrels at the slabs' edge where too high for comfortable residential sill heights. The solution was to retain the spandrels but to cut the concrete down to a reasonable sill height.

With the exception of The Ramsden, creating the right amount of fenestration for a new use is not an obstacle if the entire envelope is being replaced. In this case, window dimensions and area are incorporated into the new envelope. For example, The Metropole and 102 Bloor both received new cladding and new windows designed specifically for the new use. The conversion from office to residential use generally involved a decrease in sill height (typically to 12") and an overall increase in glazed area. All of the new residential windows included some operable component for ventilation, and enhanced thermal performance.

Issues of fire safety and separation played an important role in determining window type and location in a number of the conversion cases. This is not surprising since many of the project have complete site coverage and close proximity to adjacent buildings. For example, glass block was used for natural lighting and adequate fire separation in part of the west facade of The Metropole. Some of the residential windows at 102 Bloor required special sprinkler coverage.

Conclusion

Building envelope change is important in change of use. In change of use scenario (i.e., office to residential), major alterations to building envelope can be anticipated. In change of configuration (without change of use) i.e., office to office, it is less likely that envelop will be changed unless thermal upgrading is required or exterior durability is questionable.

Parking

All nine cases involved the creation of new parking in some way or another. The availability of existing parking or the potential for creating new parking is an essential consideration in the conversion feasibility. The provision of surface parking on site or at a remote location often must meet local policy, economics and other contextual issues. Parking within the actual building at, above or below grade, however, is more directly influenced by the physical nature of the building itself. Five of the cases involved the creation of new parking within the existing building. This kind of intervention is major since it requires a great deal of space for the stalls themselves, room for access and turning, often a system of ramps, safety measures such as sprinklers, structural modification, etc. In the cases where new parking was created above grade (Queen's Quay, Merchandise Building, Metropole) it was made possible by the existing condition of large floor plates and generous floor to floor heights.

The difficulty of forecasting parking demand makes generating strategies to ensure adequate parking supply particularly troublesome. 50% of the case studies required re-assignment in addition to interior areas in order to meet resident demand and, in some cases (outside of our selection), lack of parking potential contributed to these buildings being by-passed for conversion. Vehicles impose loadbearing, spatial, and safety requirements which require limits to flexibility for planning grids, vertical circulation, and structure.

Providing a structural grid of, say, minimum 6.10 x 6.10 x to accommodate parking modules and driving aisles, as well as adequate height for safety systems such as sprinklers and ventilation on one or two lower floors would seem prudent, especially in commercial to residential conversion.

Height needs to be carefully addressed in this strategy as too much height in individual storeys will lengthen and therefore increase the spatial requirement for ramps. An interesting strategy might be the provision of double height space at grade capable of accommodating a common or externally related use in one scenario and two levels of parking (the intermediate floor being new) in another scenario. This would naturally need to be reconciled with other factors such as cost, height limitations, etc.

The key consideration in allowing for parking growth in the future is an awareness that it will re-emerge in any future scenario. Reducing parking supply is generally not a problem6increasing it demands attention to its particular needs in spatial, structural, and safety terms.

Service

Each of the case studies underwent substantial change in terms of heating and cooling systems, electrical service and plumbing. In general, decisions to retain or replace these system and their components where made by comparing the required performance standards of the new use with the capabilities of the existing systems.

With heating ventilation and air conditioning, some of the main plant equipment was retained where feasible, but generally the distribution was all new. Mechanical equipment sized for office use is usually adequate for the lighter residential use, but the routing, control and metering is inappropriate. In the case of Gotham lofts, office HVAC from the previous use was retained in the from of a rooftop unit for conditioning some of the common areas like corridors and the lobby. Each residential unit received a new heating and cooling unit which allows individual control and metering. Most of the new residential units received individual heat pump systems (Merchandise, Ramsden, BC Hydro) which also feature independent control and metering.

Even discounting the issues of aging, wear, and obsolescence, Mechanical and Electrical systems generally are the building systems suffering the most modification or replacement. With comfort standards and distribution requirements being radically different with different uses, it is unlikely that in most cases much can be transferred. Only in related uses (Delta Montreal) could the design be "biased" to take advantage of existing system (plumbing) location. The user requirements in commercial office and residential, for example, are simply too different in performance and distribution to allow systems to be inherited. Only the parts of systems designed specifically for common primary service are able to survive provided that they qualify in other criteria such as capacity and efficiency (central plants at Gotham, electrical transformation at Delta, Metropole, BC Hydro, and Gotham). The distribution generally has to be the flexible element and few systems reviewed in the case studies survived. This is clearly one of the areas requiring significant new development.

Unique among the case studies is the conversion of the Delta Hotel in Montreal from a residential condominium building. In this case, a mechanical system with an increased air handling capacity was required to heat, cool and ventilate the new suites and associated common spaces at the podium level typically associated with a hotel use.

At 102 Bloor Street, the existing mechanical mezzanine was completely removed to make a double height space for the residential penthouse units. New mechanical equipment is chiefly located on the roof.

Some electrical transformers were retained (Delta, Metropole, Gotham, BC Hydro) but overall distribution was typically new. In general, the changes to electrical transformation and distribution were not as dramatic as the changes to the HVAC systems.

New plumbing is a typical feature of the post-conversion buildings. Washrooms for employees in BC Hydro were removed from the building's core allowing new use for this space. In the Delta Hotel, one of the conversion design strategies was to retain the basic location of residential washrooms for the new hotel suites. This permitted the re-use of most of the plumbing stacks.

4.2 Case Study Observation Summary Conclusions

The case studies demonstrate tremendous variety of approach and result in dealing with the adaptation of building.

1. No substructure work was required in any of the conversions. This supports the observation that substructure is one of the most difficult adaptations to perform and, if required, likely makes a conversion unfeasible.

2. Most of the conversion structures were reinforced concrete which is considered per haps the most adaptable form.

   Post and beam (wood) and steel column/lift slab systems required detailed resolu tion and lateral load stabilization along with attention to fireproofing requirements.

3. A variety of floor plate configurations were addressed, some extremely shallow, such as the Hydro Building (Electric) and some deep such as the Merchandise building. Deep floor plates required cutaways to alter configuration and/or ingenious space planning of units to offset narrow proportions.

4. Clear interior height, when available for use, is a positive attribute capitalized on by designers.

5. Structural bay sizes varied greatly with designers able to "respond" to these condi tions.

6. Envelope change is generally related to factors: i) fenestration requirements (i.e., size) desired for "market" positioning of new project; and ii) condition and thermal performance of the existing envelope (wall) assembly.

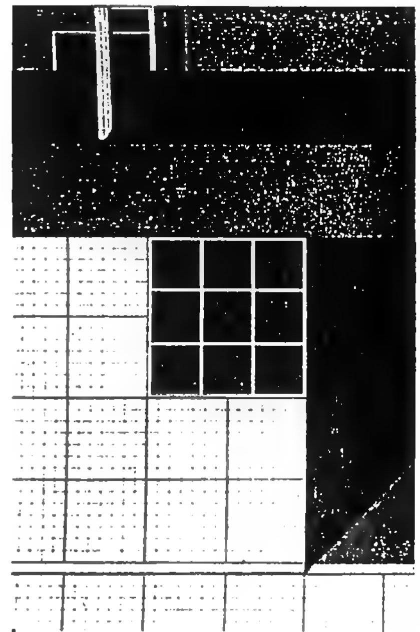
   Owing to advances in window technology, reglazing is a minimum anticipated change to the envelope.

7. Buildings with existing lightweight or curtain wall systems (20-30 yrs) were totally replaced.

   Buildings with a non-curtainwall or "mass type" envelope system were upgraded either internally or externally for thermal performance.

8. Mechanical and electrical servicing generally was totally replaced.

9. Little significant change (before and after) of building GFA resulted from conver sion. It appears that adaptation focussed on function change in use rather than increasing floor area.



Adaptability Principles

5. ADAPTABILITY PRINCIPLES

This section contains principles for developing the adaptability potential in new construction as well as in building reuse projects. They are based upon analysis of case studies along with general overview and consideration of design in practice. These are preceded by definitions, some of which appeared in the Introduction section but are reiterated here to make the ideas more clear and to set up a discussion of Adaptability Principles and Adaptability Guidelines.

5.1 Definitions

Adaptability in its most general sense is the ability to fit or to modify for a new use. In terms of design and construction, it can be said to be the capacity of a building to accommodate substantial change. The adaptability of any building is determined by two things: the **amount** of change and the **ease** of change. If a proposed transition in use represents an enormous magnitude of change and/or it is extremely difficult to perform for whatever reason (technically, economically, etc.) that building is not adaptable.

Adaptability can exist as a feature at a number of scales: the building as a whole, a system or subsystem of the building, a component of a system or subsystem, or an element within a component. In most cases, it is a combination of these levels working together to accommodate change.

Non-adaptable buildings do not allow a change in use beyond the original use for which it was specifically intended. Non-adaptable buildings are dedicated and committed to a very narrow kind of use in which form follows function so specifically that conversion to another use becomes materially difficult or prohibitively expensive. Buildings used for research or manufacture of biological, chemical, or nuclear material; buildings built for or incorporating power generation as heavy primary manufacturing are good examples of building types which are fundamentally inflexible. Specific examples are grain silos and elevators, steel plants, power plants (mid to late twentieth century), biological laboratories, nuclear processing facilities.

Inherent Adaptability is the capacity of a building to absorb change to a greater or lesser degree without any built-in program intended to accommodate this. An example of this kind of adaptability can be found in any existing conversion where a conventional building has successfully been reused.

Programmed Adaptability is the provision of a strategy for change embedded in the design and construction of a building. **This is the kind of adaptability the following Guidelines are intended to promote.**

5.2 Principles for Programmed Adaptability

Before considering a set of guidelines for adaptable design and construction, it is necessary to identify the recurring characteristics of adaptability. These principal qualities are presented below in the form of general rules or **principles.**

Information drawn from the literature search, the conversion case studies, and from the experience base of the researchers resulted in a large list of adjectives and phrases that described the key features of adaptability as they relate to built form. These ideas have been grouped into a set of nine major issues and are expressed as "broad rules" which are intended to foster and promote an attitude toward adaptability at all stages of the project. It is important to realize that there is some overlap between the issues and that the principles are interrelated in many ways.

1. DESIGN FOR VERSATILITY.

Versatility is the ability of an element, component, or system to cope with different uses or users with little or no change. Versatility and flexibility are similar words (from the Latin roots for turn and bend, respectively) both describing an ability to accommodate a new use easily and with little change.

2. DESIGN FOR DURABILITY.

Durability is the ability of a material or system to remain unchanged over its theoretical life while performing its intended function. This implies a full lifespan within a service environment without the need for modification. Choosing high quality materials and proven details or assemblies, for example, can greatly influence the durability of something. Durable components invite reuse possibilities and on a larger scale may make the case for a building's adaptation over demolition. ASHRAE's definition for durability reads "the average expected service life for a system or facility; also the design service life".

3. PLAN FOR EASY ACCESS.

Accessibility allows the element, component or system to be easily approached with a minimum amount of effort or impact on adjacent or interdependent systems. Access may be required to performed service, upgrading, or replacement tasks.

4. FAVOUR SIMPLICITY.

Simplicity requires the reduction of elements, components, or subsystems to the minimum complexity required to execute a function. Experience shows that simplicity will generally reduce the likelihood of failure or breakdown and facilitate repair.

5. FACTOR IN SOME REDUNDANCY.

Redundancy refers to the generous capacity of elements, components, or systems to absorb additional load. For example, this may mean "over-sized" or "backup" elements, components or systems. Redundancy allows for reuse or change in function(ality) to occur without modification. Redundancy can be a characteristic of a single element or a feature of a group of elements forming a system. Structurally speaking, redundancy is the capacity of members or systems to resist excess loading beyond their intended function. Redundancy can be intentionally incorporated into a design (programmed adaptability) or it can be an unintentional by-product of design.

6. ALLOW FOR UPGRADES.

Upgradability is the ability to enhance the performance of systems or components to meet change. Traditionally, this principle has been applied to manufactured equipment such as automobiles and computers where there is a clear design strategy to accommodate new components with a different (usually improved) performance capability.

7. Opt for independence.

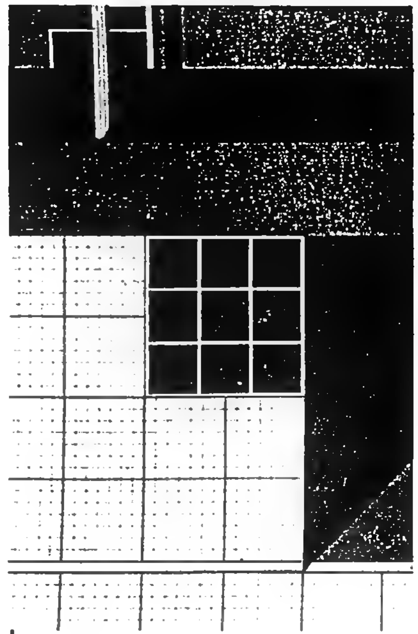
Independence is the extent to which an integrated system can be modified or removed without negatively affecting the performance of an adjacent or connected system.

8. Minimize destructive change.

Minimal destructive change involves selection of systems that undergo modification which minimizes non re-usable components or elements. This reduces the need for recycling through remanufacturing and reduces non-recoverable waste.

9. Make important information explicit.

Explicit Information means the provision of useful information on elements, components, and systems in a building. This information may have to do with design, operational, or maintenance instruction as with a mechanical or electrical system. Some other examples: coded part, serial number, performance certificate, warranty, CSA label, I.D. stamp, as-built drawings, maintenance log, design briefs, commissioning and balancing reports, etc.



Guidelines for Adaptability

CMHC Adaptability Study

6. GUIDELINES FOR ADAPTABILITY

The Guidelines in this section form a reference tool that promotes the ideas of adaptability during the design and construction process of a building and throughout its life. Although the Principles and Guidelines are applicable to many building types, this report is primarily concerned with mid to high rise construction for multiple unit residential, office, retail, and mixed uses. It is important to realize that adaptability within a single use category is fundamentally different from adaptability between use categories. The idealized totally adaptable building approaches the condition where zero effort is required to make any adaptation possible. Experience shows that although this condition is not achievable, it is worthwhile to make new construction as adaptable as is reasonable.

Building design can be made more adaptable using existing technology (conventional construction) and by following established design methods through all stages of the project (conception, design, construction, operation). Increased awareness of the potential for adaptability and a conscious approach through the design process can radically increase most projects' ability to accommodate future change.

Each design decision is made with a large number of issues (often contradictory) in mind. The purpose of these Guidelines is to cultivate an awareness of adaptability at all stages of the project and to promote the idea of adaptability as a strategy or critical tool for making better building decisions. It is assumed that each construction project is a one-of-a-kind enterprise and that it is impossible to prescribe a precise algorithm or infallible recipe for adaptability that will work every time.

6.1 Structure

FOUNDATION and SUBSTRUCTURE

The following guidelines are suggested for the foundation and substructure design of adaptable buildings:

1. Design foundations to allow for potential vertical expansion of the building. The extent of any future expansion will depend on many technical, economic and political factors. A rational analysis should be done taking into account as many of these factors as possible to arrive at a reasonable estimate for the extent of possible future expansion. It may not always be feasible to expand a structure vertically, however, the foundation design should always establish and clearly record the technical limits to expansion.

2. Be aware of the potential for differential settlements of portions of the foundation as a result of future modifications involving vertical expansion of the building. A new major vertical addition over part of a building's area can result in a significant movement of the more heavily loaded part of the foundation. Isolation joints can overcome this potential future problem.

3. The potential for progressive collapse due to accidental loading should be checked. Gravity loads may take different load paths to the foundation as a result of an explosion which eliminates part of the structure. The foundation should be adequate to withstand these e redistributed loads. Note that in the case of accidental loading the allowable soil bearing pressure may be increased due to the fact that for short term emergency loading the foundation must be safe with respect to shear failure of the supporting soil and differential settlement is not a controlling factor.

4. Be aware that deeper subsurface investigations may be required based on loading due to a vertically expanded structure.

SUPERSTRUCTURE

The primary structural materials used for the aboveground construction of mid to high rise buildings are concrete, steel, and masonry. A driving factor for the use of these materials is the requirement of the National Building Code for non-combustible construction for buildings exceeding three storeys. Concrete, steel, and masonry, when manufactured and used in accordance with modern standards and codes, have the potential for very long physical lifespans. The physical life spans of these materials and, consequently, of the structures supporting them, generally exceed the economic life spans of buildings with respect to their initial occupancies. Therefore, it is reasonable to assume that adaptable structures will have greater social utility in the long run than non-adaptable structures which must be demolished once they are no longer suitable for the occupancy for which they were originally designed.

The most adaptable structure is the one which imposes the fewest restrictions to a building's functional programme with respect to its interior partitioning. An adaptable structure will also allow for the efficient redistribution of new mechanical and electrical services.

A structure with the minimum number of vertical structural elements, either columns or walls, will be the most adaptable, since it will have minimal interference with new interior partition layouts.

For the distribution of mechanical and electrical services, floor framing of uniform thickness and of minimum depth is the most adaptable, since it will impose the least structural restrictions on duct and conduit runs.

Buildings which rely on a central core for lateral load resistance can usually easily accommodate local modifications to the structure surrounding it as may be required for a change in building use. A centralized core also allows for the efficient transportation of people and services for a variety of building occupancies. This becomes very important as the number of storeys in a building increases.

The efficiency of a structural frame can often be improved with the use of composite construction such as composite steel beams with concrete on composite metal deck or with the use of prestressed concrete construction. The cost of this improved efficiency, however, is a reduction in flexibility, in the sense of adaptability, of the structural framing system. This reduced flexibility will affect the structure's ability to accommodate modifications in terms of new openings which may be required or revised distribution of new mechanical and electrical services.

The use of composite construction tends to reduce the weight of the structural floor framing. This generally translates into savings in the initial cost of construction. The lighter floor framing, however, may have adverse effects on the acoustic performance of the floor and may also be susceptible to objectionable vibrations. These are important considerations when converting buildings to industrial use.

Buildings being considered for conversion to multiple family residential use must have structures which are resistant to progressive collapse. This is now a requirement of the Ontario Ministry of Consumer and Commercial Relations with respect to design, installation, operation, and maintenance of in-suite natural gas systems in multi-family buildings over four storeys. Cast-in-place, continuously reinforced, concrete structures which are building in accordance with modern codes are inherently resistant to progressive collapse. Consequently, these types of structures are very adaptable to future residential use.

Loads

Floors designed for the greatest live load specified in the National Building Code due to use and occupancy would be the most adaptable. The construction cost added to a project to achieve this level of adaptability would be prohibitive in most cases. It is possible, however, to achieve a very high level of adaptability with careful planning using less severe floor live loads.

For interior spaces a live load allowance of 4.8 kPa is generally sufficient for all occupancies except for stack rooms of libraries, factories, and some warehouse facilities.

For floors above the ground floor, a live load allowance of 2.4 kPa is sufficient for all occupancies except for those listed above and some assembly, retail, mechanical rooms, hospital operating rooms, laboratories, and recreational rooms.

Buildings with the lower floors designed for 4.8 kPa live load and the upper floors designed for 2.4 kPa live load will generally be able to accommodate most mixed use occupancies.

EARTHQUAKE LOADS
In terms of adaptability, the post-disaster level of earthquake loading should be checked at the design stage as this may be the controlling lateral load case over the entire extended life of the building.

In areas where earthquake loading controls, or is close to the controlling wind level, the adaptability of a structure for use as a post-disaster building may be difficult to justify economically or even from a social utility viewpoint.

The following guidelines are suggested for the superstructure design of adaptable buildings:

1. Consider the possibility of vertical expansion in the design of the columns and walls.

2. Consider designing at least the lower five floors, or as many floors as possible, with 4.8 kPa live allowance.

3. Consider structural framing systems with the least vertical structural elements and with lateral loads resisted by a central core.

4. In the design of the structural floor framing consider a number of different mechanical and electrical services distribution schemes based on different occu pancies.

5. Consider the acoustic and vibration performance of the structure as they relate to different building occupancies.
6. Consider earthquake loading as it relates to post-disaster building for any particular site.

6.2 Envelope

The primary role of a building's envelope is the mediation between interior space and external environment through built form. The envelope includes the roof and an exterior wall system with cladding and windows.

Unlike low-rise residential construction, which uses traditional platform framing with tilt-up stud walls, contemporary exterior walls for mid to high-rise construction do not act as a part of the building's overall structure. The main functional requirements for exterior walls are:

1. Weather exclusion - keeping precipitation and wind out.

2. Control of heat flow through the wall in both directions.

3. Light control.

4. Sound control.

5. Accommodation of systems and services at the interior, within the wall itself; on the exterior and penetrations, which include all three.

Independence of an exterior wall system from the structure will ultimately make for a more adaptable building.

Structure and envelope are functionally discrete systems; the situation where these two layers are conceptually and physically independent, yet integrated, is the one which will yield the most adaptability.

For typical mid-rise or high-rise construction, the design life span for structure and therefore the building itselfóexceeds that for the cladding by a factor of two or more.

Very few contemporary buildings are constructed with the "shell" approach where structure and envelope are fused into a single system. Load-bearing masonry and cast-in-place concrete exterior wall systems are examples of non-independent structure/skin systems. A structural system which is doing double duty as a major part of the envelope makes modification to the skin (e.g., changes in fenestration size and location, service penetrations) very difficult to achieve without impacting on the structure.

Design the exterior wall system for durability.
Adaptation within a use category (or from one to another), is made much more likely in the future if the building includes a cladding system which is salvageable. An exterior wall system that continues to perform as an effective weather barrier and is physically sound in terms of connections to the structure, joints between cladding elements, and is overall performing its intended function as a part of the envelope is likely to be retained and modified rather than demolished. This increases the value of the "original" building.

For a typical office or MUR mid-rise to high-rise building, the cladding system accounts for a large material portion of the total building mass. The case for direct re-use of it is strengthened by giving consideration to the amount of solid waste generated by removal and disposal of the system.

Consider maximum accessibility of the exterior wall system from within the building and from the outside as well.

Accessibility enhances the opportunity to modify and upgrade existing components (e.g., thermal insulation).

Design a versatile envelope capable of accommodating changes to the interior space plan.

This would be an easy task if there existed a universal standard for "The Fundamental Relationship of Window and Wall" that applied to all building types. It is the use of space which dictates the suitability of the envelope. The amount of fenestration and its location within the exterior wall is generally not an easy thing to change.

Critical dimensions such as sill height and head height are generally fixed and unchangeable within the conventional envelope. It is possible (and fairly common) to upgrade individual window units to enhance thermal performance (increase the RSI-Value) or to provide an operable unit where there wasn't one. To increase the size of the window or its location within the wall requires a great deal of effort and "destructive change" for most exterior wall systems.

The open building system addresses this need for versatility in the adaptable residential unit by including the envelope at the level of "infill" or "fit-out". In this approach, the exterior wall and windows can be installed onto the base structure and subsequently disassembled according to needs dictated by the interior space plan.

Some common technologies for envelope construction in mid to high rise buildings are:

- Precast concrete
- Masonry
- Curtain wall
- Metal panels
- Exterior insulation finishing system
- Some combination of the above

A modular or panellized system where transparent and opaque units can be interchanged easily would be a versatile envelope system.

To some extent, this is the case for curtainwall systems although they are not typically designed for this purpose. A brick wall, for instance, can have a window opening enlarged or reduced fairly easily by removing or adding courses. A precast element, however, is difficult to manipulate and may need to be replaced if the existing fenestration is not appropriate to the new use. Similarly, a cast-in-place concrete wall would need to be cut (destructive change) in order to accommodate a new window location.

6.3 Services

Design concepts for adaptability of the mechanical and electrical systems of a new building can take two approaches:

Type I: Distributed Energy System - Energy sources are brought to the occupied space for conversion into heating, cooling, lighting, or other uses.

Type II: Central System - Pre-conditioned media are brought to the occupied space from a central plant for space and/service water heating, and space cooling.

Type 1 - Distributed Energy System

The Distributed Energy System offers the designer individual space temperature control, smaller overall building space allocation for piping, and the potential for individual tenant utility billing. The designer would be obligated to design the energy service distribution system to handle the maximum load which would be placed on the system by anticipated future uses of the space, resulting in oversizing of the energy distribution systems for all other uses. This is a relatively small penalty to pay for adaptability. Terminal units and air distribution systems would be selected for the current space use, to be replaced by larger or smaller units and systems as necessary to accommodate occupancy changes. This would parallel changes currently made to lighting systems for differing tenant needs.

TYPE II -- CENTRAL SYSTEM

The Central System requires the designer to size both the central plant and the energy transfer media distribution system to meet the maximum anticipated load. Control of the space conditions is by a combination of central plant and space control. Central plant equipment is generally more reliable and durable than packaged equipment, and less expensive to maintain.

GUIDELINES SERVICES:

SERVICE LIFE OF MECHANICAL, ELECTRICAL, AND LIGHTING EQUIPMENT

The service life of mechanical, electrical, and lighting equipment has a direct impact on the decision to reuse or replace existing heating, cooling, and lighting systems in a renovation.

The Illuminating Engineering Society of North America (IESNA) estimates that the average market life of a new lighting technology is seven years, after which it is replaced by a more effective and efficient technology. While many light fixtures may remain in existence for considerably longer, a major renovation is a good time to upgrade to newer lighting. Government regulations are now forcing older, less efficient lamp technologies to be replaced by removing replacement lamps from the market, which will shorten the useful life of many luminaires.

ASHRAE has provided estimates of the useful life of HVAC equipment, based on surveys with building owners and managers. Some examples of central plant and distribution equipment are shown below:

Equipment Item
Median Service Life, Years

Hot water boilers, steel water tube	24
Hot water boilers, steel fire tube	25
Hot water boilers, cast iron	35
Steam boilers, steel water tube	30
Steam boilers, steel fire tube	25
Steam boilers, cast iron	30
Chillers, centrifugal	23
Chillers, reciprocating	20
Cooling towers, metal	20
Cooling towers, wood	20
Rooftop air conditioners, single zone	15
Rooftop air conditioners, multi-zone	15
Pumps, base mounted	20
Pumps, pipe mounted	10
Fans, centrifugal	25
Fans, axial	20
Electric motors	

Where a designer is faced with a major renovation of a building more than 20 years old and with a mandate to change the use of the building, it is therefore an easy decision to consider almost all of the equipment and systems as being at the end of their useful life and in need of replacement.

The case studies demonstrate three important factors for the mechanical, electrical, and lighting designers.

- the change in use of the building will always necessitate a change in the electrical, HVAC, and lighting terminal units

- the change in use of the building will always necessitate a change in the electrical and HVAC distribution systems

- the change in use and age of the building combined with the availability of new, usually more efficient distribution and terminal systems, will usually lead the designer to replace the central plant, including the electrical service.

In an interior renovation, the terminal units are readily accessible as part of the removal of ceiling and wall elements. Distribution systems are also readily accessible, enabling the designer to plan for their complete replacement.

Removal of major central plant equipment may require the removal of some building components to gain access.

6.4 Interior Space Planning

The design of interior space with a built-in capacity for accommodating change within a specific use category is fairly well established for many building types such as offices and retail space, and to a lesser extent with MUR. Standard practice for office design, for instance, recognizes the turbulent nature of tenant churn and a number of strategies have evolved to deal with new occupant demands for spatial reconfiguration and partitioning, service requirements, power and cabling, lighting, environmental controls, etc. There are a number of proprietorial and generic approaches to integrating various systems to meet changing requirements.

Much of the spatial planning for industrial buildings is dictated by the actual processes that are required to take place. In the manufacturing sector, the best solution is often a large span/open space where process machinery and equipment are free to be rearranged, upgraded, or replaced without encumbrance from structural walls and columns. In other buildings where the scale of workspace remains relatively small but the service requirements are complex and dynamic (such as with laboratories) flexibility is achieved by dedicating horizontal and vertical service space (servant space) in close proximity to the place of work (served space).

Warehouse structures designed for storage and handling of industrial or commercial goods have evolved a kind of flexibility that is specific to that use category. Large span spaces are typical for industrial warehouses, and on a smaller scale, the same is true for commercial warehouses. Convention centres and assembly halls, schools, performance spaces for the arts and for sports all have their own tradition of accommodating flexibility within their particular use category.

MUR as a mid or high-rise building type has not evolved in terms of flexibility within a use in the same way other categories have.

This is not surprising if habitation is seen as the most conservative kind of building use. The act of dwelling is, in general, culturally determined. The individual units, despite high density, have remained very much unchanged in spatial terms, especially when compared to the changes of building types and forms in this century. One current development in residential design is the combination of live/work functions into a single unit, usually in the form of an urban condominium. This change is more a reflection of the new workplace made possible by information technology rather than a desire to improve habitation.

The Open Building System as a building philosophy for residential construction has begun to address the issue of domestic space flexibility, although most of the projects embracing this approach are in the realm of low-rise construction.

Strategies for accommodating easy change from one use category to another, on the other hand, are much less evolved. This kind of adaptability is a focus for these Guidelines. The literature search did not identify any set of existing principles or guidelines for new construction that places a priority on making the future transition between one category and another. A survey of case studies where a use conversion takes place (office to MUR, warehouse to MUR, MUR to hotel) in a mid-use or high-rise building, however, did identify a number of key issues in terms of adaptable interior spaces.

Loose Fit Versus Tight Fit

A discussion of structural adaptability shows that buildings which are built to minimum gravity loads according to occupancy favour a one-way kind of adaptability. Structurally speaking, a warehouse could eventually serve as office or retail space, and these in turn could fulfill the requirements for a MUR. The reverse, however, is not true. This is an example of **inherent adaptability** where there is no built-in strategy put in place specifically to accommodate the transition. By designing the floor load allowance of a new building to 4.8 kPa, the structure would have sufficient **programmed adaptability** to serve a number of uses in any sequence of occupancy. If the project team can make the case for investing in an oversized structure, that building may enjoy a second or third life in another use category. Interior space planning decisions are equally important in determining the potential for future adaptability. These decisions are often very complex and involve, among other things, consideration of all physical systems and the spatial relationships among them.

Versatility and accessibility, as principles for adaptability, can be achieved in a project by designing a "loose fit" between building and program.

Providing more than a spatial minimum, both horizontally and vertically, will ultimately make for a more adaptable building.

Space planning involves making very permanent decisions such as floor heights, plate size, core location, etc. which are likely to last the life of the building. These issues are often closely tied to structural issues, and future modifications may be prohibitive. Other space planning decisions such as interior partitioning, dropped ceilings, location of fixtures, etc. are not as deeply connected to the fundamental characteristics of the building. Programming the capacity to accommodate change into the interior space plan requires careful consideration of the most permanent decisions.

Building types each have their own basic territorial unit. A five foot module for planning workstations, for example, may not be appropriate for configuring living space. It is not possible to dictate a universal space plan that will easily adapt to accommodate retail shops, offices, residential units, hospitality suites, etc. It is possible, however, to make some general statements about space planning issues and adaptability.

The most adaptable floor plate seems to be a narrow rectangle with a centrally located core that is single or distributed. The depth of the floor plate the distance from circulation route or core to the slab's edge is one of the most important dimensions. A plate depth from 7.62-10.66 metres seems to be appropriate for most uses. In cases where this distance is substantially larger, such as with typical warehouse structures, removal of a part of the floor plate is one way to reduce the total depth. It may also be possible to bring the building's perimeter in from the slab's edge by creating a balcony condition.

The horizontal grid is an important dimension for accommodating spatial change. Generally, the larger the grid, the more adaptable it is. A 6.10 metres module, for instance, can be subdivided into smaller units of 1.22, 1.53, or 3.05 metres. Moving up to a grid size beyond say 7.62 metres, may require deeper horizontal structure which impacts on the ability to run overhead services.

The number or cores, their location, and the percentage of floor area that they occupy are all important features of the adaptable typical floor plate.

Large, centrally located cores provide the most flexibility, particularly with respect to servicing the surrounding floor area. For a long and narrow rectangular floor plate, the more adaptable core configuration has, as a minimum one at each end. Intermediate cores distributed at or close to the long axis create more possibilities for servicing and vertical circulation. A ratio of core to floor area beyond 20% is likely to suit the requirements for most usages, although the reduction of net floor area has to be weighed against the future capacity to accommodate change.

As a general strategy for gauging the adaptability potential of a given floor plate, the project team could evaluate several configurations of use by superimposing each onto the proposed plate to identify the areas of compatibility and incompatibility. This information could be used to resolve the space plan in an adaptable way. A large floor-to-floor height increases the building's adaptability potential.

The increase in vertical height between floors will obviously provide many more possibilities for routing services, such as the use of dropped ceilings or raised floors. This advantage has to be weighed against the increase in material and construction costs. For example, a 10-storey building with a standard residential floor height of 2.74 metres will be 27.43 metres in total height. Using an office building standard of 3.8 metres for the same 10 storeys will result in an additional height of 10.97 metres. This would mean 40% more envelope and additional costs for more structure, services, and finishes.

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Appendices

QUEEN'S QUAY TERMINAL

The Terminal Warehouse was built in 1927 at the foot of York Street toward the east end of Toronto's Harbourfront area. This was one of the very first cast-in-place concrete structures in Canada. It was a considerable undertaking, providing 92903 square metre of floor space within the eight storey structure. This made it the largest warehouse facility in the country at that time. It provided cold and dry storage for goods moving through the city's harbour and fronted a thousand feet of dockwall with CNR trains servicing the south side and penetrating 115.82 metres into the building's shell. The original building was L-shaped. The short leg of the "L" was oriented along the lake's shore and it provided cold storage for material. This part of the building was completely removed, leaving the large rectangular footprint of the Queen's Quay Terminal that remains today.

The structure features a repeating 6.10 m. by 6.10 m. grid of mushroom cap columns that are visually and physically very strong. Since the floor plates were designed for enormous loads the building was seen in the early 1980's as a candidate structure to house other Harbourfront activities.

The new program involved the conversion of the two lower levels into retail space, with offices and a 450 seat dance theatre occupying the third through eighth floors. On top of the existing structure, four newlevels of luxury condominiums were built. These units are arranged into two blocks running north and south along the perimeter of the roof and step up from behind the parapet leaving the mid section of the plate open for deep light wells. The arrangement of the residential units on the roof generally did not correspond to the existing structural bays below. The solution was to introduce an intermediate plenum level situated directly above the existing roof and below the new first floor of condominiums. The plenum has a 1.22 m. clearance typically and the space is occupied by reinforced concrete transfer beams. These members transfer the load from the columns of the resident addition back onto the existing structural frame and ultimately to the foundation piles.

The foundation consists of 8,000 timber piles arranged in groups of one to two dozen, with a reinforced concrete pile cap on each group. The piles are driven approximately twenty feet down through reclaimed fill material to bear on bedrock. The original live load allowance for the warehouse floors was 12 kN/m2. This is a tremendous load allowance compared to current code office requirement of a minimum of 2.4 kN/m2. This built-in capacity of the floors is five times greater than would be required for similar new construction. It is clear to see how vertical expansion could be added to the existing structure without any work needed to the foundations.

The conversion process to the new mixed use was a complicated one. In order to provide space for the theatre and also to allow natural light into the lower levels, large portions of the reinforced concrete slabs were removed. At the southeast corner of the building, much of the slab was removed from around the columns while keeping the shafts, flares and drops intact. The result is a remarkable three dimensional lattice of columns and thin horizontal elements. Courtyards have been created at the roof level between the blocks of condominium units. These feature landscaping and bridges that link the blocks of units together and allow the light wells to penetrate the roof. The residential addition itself is generally about 15.42 m. wide with exterior walls on two sides making for well-lit apartments.

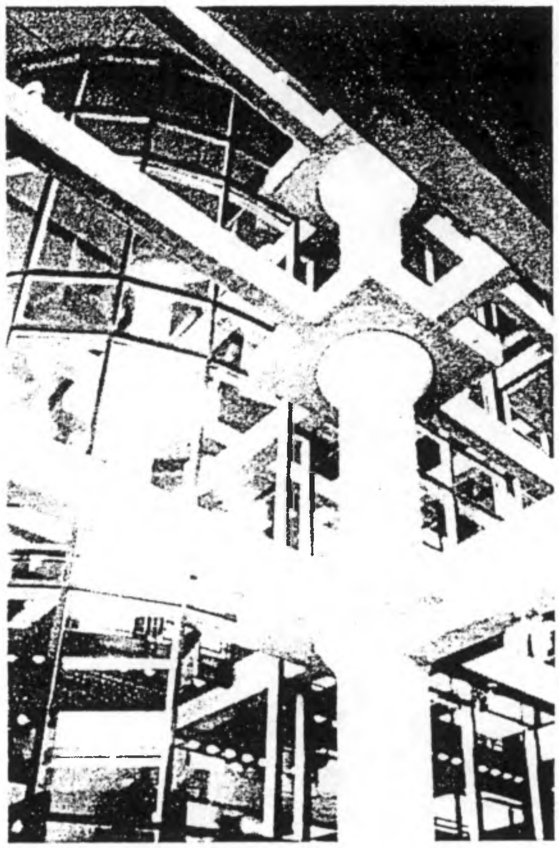
There were some structural interventions that took place in order to deal with changes in the lateral loading. New reinforced concrete shearwalls had to be introduced at various locations and levels throughout the original building due to the following three renovation requirements:

1. added height from the residential addition,
2. some removal of perimeter infill walls which provided lateral stability, and
3. removal of portions of the existing floor slabs for the southern atrium and dance theatre.

The third floor of the building has some parking for the condominium residents (126 spaces) built in at the northern half. New ramps were built for vehicle access to the level.

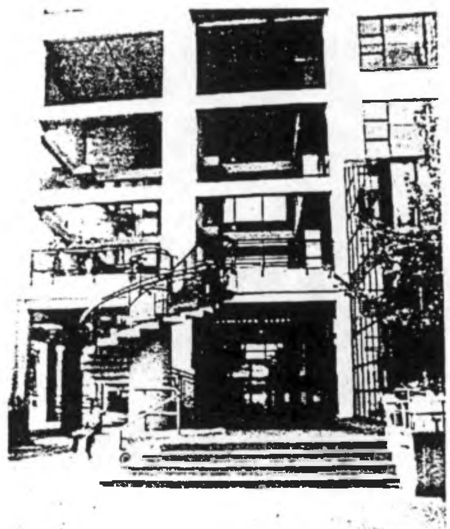
One of the key benefits of using the existing building as a starting point for the conversion is the robust warehouse structure itself combined with the fact that it was used as a dry storage space. This means that building has already enjoyed fifty years of use without detrimental interior environmental loads such as mechanical pressurization and humidity.

South West Corner Showing External Access and "Solarium" Spaces



Floors Removed to Create Atrium

West Elevation Showing Original Warehouse Structure. Note window glazing infill of lower retail/office with residential units on upper 4 floors



Entrance to New Atrium Space at South-East Corner

TECHNOLOGICAL INFORMATION

PROJECT: **QUEEN'S QUAY TERMINAL**
ADDRESS: **Queen's Quay West, Toronto, Ontario**
OLYMPIA & YORK
ZEIDLER ROBERTS (ARCHITECTURAL)
YOLLES (STRUCTURAL)
MITCHELL PARTNERSHIP (MECHANICAL)
MULLVEY ENGINEERING (ELECTRICAL)

			Previous (1926)	New (1981)	
				Base Building (8 levels)	Residential Addition (4 levels)
Structure	Substructure	Footings Piles Caissons	• 10,000 wood piles (20' long)	• No change	• No change
	Structural materials and framing systems	Horizontal Vertical	• Early reinforced concrete construction of slabs and walls • Reinforced concrete columns with mushroom caps and bearing plate.	• Same base structure (some structure removed; therefore, shearwalls and bracing added as required).	• Steel and conc. framing, conc. suspended slabs (concrete transfer structure to existing grid).
Skin	Exterior Cladding	In situ Prefab	Cast in place concrete (some masonry block)	• Original concrete spandrels & verticals. • New Infill panels (metal and glass).	• New residential curtainwall.
	Fenestration	Windows - fixed/operable Curtain wall	• Single pane glass, operable vents	• All new glazing. • Some curtain walls.	• All new construction
	Insulation	Interior Exterior Composite	• Exterior wall and roof slab (conc.).	• New panels.	• Largely integrated with cladding.
Circulation	Vertical Circulation	Elevators - # multiple use - # dedicated use Escalators Stairs	• 14 freight elevators. • 2 passenger elevators. • 5 stairs.	• 9 total	• Stairs and elevators.
HVAC	Mechanical systems	Heating Ventilation Cooling	• Cool and dry.	• New mechanical systems.	• New heating & cooling.
Plumbing		Sanitary Water supply Stormwater		• New plumbing.	• New construction and new plumbing.
Power	Electrical systems	Transformation Distribution Emergency		• New electrical.	• All new electrical
	Other				
Lighting		Lighting - public areas - private areas	• Mostly incand. bulbs.	• Variety of lighting.	• Fluorescent + incandescent.
Safety	Fire Safety	Ratings Stairs Alarm and Evacuation	• "Fireproof Conc." fully	• To 1981 Code.	• To 1981 Code.
Interior	Partitionong	In situ Demountable	• Open warehouse with E-W walls every 6 bays.	• Various constructions.	• Fixed GWB const.
	Ceiling Systems	In situ Demountable	• U/S structure	• Dropped GWB ceiling (some exposed structure).	• GWB with various finishes.
	Floor systems	~~Elevated~~	• Top of slab	• Finish on slab.	• Finish on new deck.
Sound	Sound control	Floors Walls Special	• Ample slab.	• Ample slab thickness.	• Acoustic batt and hardware used.

ARCHITECTURE/PLANNING DESIGN INFORMATION

PROJECT: **QUEEN'S QUAY TERMINAL**
ADDRESS: **Queen's Quay West, Toronto, Ontario**
OLYMPIA & YORK
ZEIDLER ROBERTS (ARCHITECTURAL)
YOLLES (STRUCTURAL)
MITCHELL PARTNERSHIP (MECHANICAL)
MULLVEY ENGINEERING (ELECTRICAL)

			Previous (1926)	New (1981)	
				Base Building (8 levels)	Residential Addition (4 levels)
	Use	Single ~~Multiple~~	• Warehouse - Port of Toronto cold and dry storage	• MULTIPLE	• Residential condominium units.
	Use & occupancy		• Industrial (with a small office lobby)	• Commercial/retail • Office • Dance Theatre	• Residential condo.
	Gross Floor Area	Major Use ~~Minor Use~~	• 74,322.73 s.m. dry storage • 1,858.07 s.m. cold storage (demo'd).	• 3,716.36 s.m. offices • 9,290.34 s.m. retail	• 74 condo units (11,148.41 s.m.)
	Site Ratio		>50,585.91 s.m./5.059 ha (?)	↓ 18,580.68 s.m. = ?	↑ 11,148.41 s.m. = ?
	Coverage				
	No. of Storeys	Above grade	8	• Same	• 4 residential floors added
		Below grade	0	• Same	• N/A
	Floor Plate Configuration	Shape	• L-shape	• Rectangular (SW wing demolished).	• Two narrow blocks running N-S.
		Atrium	• None	• Large atria cut into plates (plus one above theatre).	• Central open space on roof.
		Other features	• CNR trains penetrated 115.82' into Bldg. • 304.80' of dock wall at N + S perimeter	• 450 seat dance theatre (through 4 floor levels).	• Pedestrian bridges link residential blocks. • Roof terraces, waterfall.
	Structural Grid Dimensions	Column spacing Shear walls	• 6.10 m O.C. <TYP>	• 6.10 m O.C. <TYP>	• Varies.
	Floor Plate Depth	Exterior wall to core	• 18.29 m max	• Varies	• <12.19 m
		Length	• 140.21 m	• 460'	• 121.92 m
		Width	• 128.02 m (max)	• 200'	• 15.24 m wide (typ)
Service	Service Core Type	Single Split	• Split	• Split	• Split
	Core Location	Centre Side Off-Centre Multiple Core to floor ratio	• Multiple (11 major cores)	• Multiple	• Multiple
	Fire Safety	Active -sprinklers Passive -shutters/dampers Smoke extractor Fire walls Rated assemblies	• Sprinkler system with large H_2O reservoir housed in clock tower at north end. • Block walls every 5 bays.	• New sprinklers, etc. (to 1981 Code).	• New sprinklers and rated assemblies.
	Typical Floor to Floor Height	Basement Floors	• N/A	• N/A	• N/A
		Lower Floors	• 6.17 m (1°)	• No change	• 1.40 m plenum above existing roof.
		Upper Floors	• 3.35 m (2° → 7°) 3.28 m (8°)	• No change	• 2.92 m flr. to flr. for res. levels.
	Aspect	Single Double Multiple	• Multiple	• Multiple	• Multiple
	Fenestration	Glazing to wall ratio	• 10% approx.	• 30% approx.	• >50%
		Glazing to floor ratio	• Very low.	• Low	
		Head height	• Varies	• Varies	• Typ. res.
		Sill height	• Varies (1.2 m min)	• Varies	• Typ. res.
	Vertical Circulation	Elevators Stairs	• 17	• 8 passenger/1 service	
	Parking	Surface Basement Above grade Separate Structure Remote	• Surface, NW of Bldg.	• 126 surface spaces • 50% 3rd floor is parking for residents (new ramp).	• No parking in res. addition.

The Merchandise Building

What is now The Merchandise Lofts started out in 1910 as a five storey wagon storage and harness shop on Dalhousie Street in Toronto's downtown. An eleven storey addition was built in 1916 and this in turn was expanded to the north in 1928 and to the west in 1948. Until 1992 this building served as a warehouse for shipping and catalogue distribution for the Sears Company. After several years of discussions and proposals, a scheme is now well underway to transform nearly a million square feet of urban floor space into a very large condominium residence. The plan is to create between four and five hundred loft units zoned for living and working along with associated amenities within the twelve storey building. Features of the building will include a landscaped roof with a pool and party room, a grand fourth floor lobby and library, landscaped atria, a partial basketball court, climbing wall, exercise room, steam and sauna rooms, billiards room, cafe, etc.

The existing building is a very large warehouse (289,545.87s.m.) with a deep floor plate. It was built to store large quantities of goods in a cool dark environment safe from weather and fire. This function called for strong floor plates, lots of headroom and low surface to volume ratio. The loading capacity of the substructure and structure greatly exceeds the minimum requirements for a residential use. The building's internal space reflects this utilitarian character throughout with the existing spaces defined by bare columns, exposed structure overhead and long bands of factory glazing. A chief goal for the design team is finding a way to preserve and enhance these industrial qualities while creating good space to live and work in.

The conversion to approximately 440 loft apartments zoned for live/work takes place in five phases, each one including around 85 units. The range in size for the units is anticipated to be from 55.74 s.m. to upwards of 278.71 s.m. The typical residential floor plate will have around sixty units. When the conversion is complete, each floor will be serviced by nine elevators and six stairways distributed throughout. There is a consistent structural grid (6.71 m. by 6.71 m..) of reinforced concrete columns that feature a flared capital and rectangular drop. On closer inspection, it can be seen that the slight grid variations correspond generally to the four original phases of construction spanning 38 years. The building measures twenty bays by eight bays with the south west corner jogging in where the original five storey structure remains. With a breadth of almost 16.72 s.m. (the south one-third is about 10.22 m.wide) it was necessary to introduce a pair of light wells into the northern two-thirds of the plate. These openings measure 0.6 m. by 0.6 m.bays each and extend from the existing roof level down to the fourth floor. The lower two levels become an interior space with overhead skylights and landscaping above.

The scale of this ambitious conversion is unprecedented. As of late 1996, the project is in its second of five development phases. In order to accommodate the transition from warehouse to residential building over several years, the designers have addressed a number of issues relating to flexibility over time. The size and mix of residential units for the later phases are subject to change based on the sales and market demands established early on in the project. The first occupants will likely be moving in at a time when the later building phases are not yet complete. This may mean several interim solutions are necessary for horizontal and vertical circulation, access to certain parts of the building and amenities, etc.

Portions of the existing floor slab were removed to provide natural light to a number of internalized units. Five or six suites on each floor rely on the atria to provide some amount of exterior wall surface. A typical unit is about 16.76 m. deep and the smaller ones (55.74 s.m.) are consequently quite narrow. A number of strategies are employed to deal with these 5:1 proportions. Living spaces are pushed to the outer wall and are generally continuous with the other internal spaces. Partitions are often moveable so that walls can be swung or slid out of the way when less privacy is required. Many partitions toward the interior corridor are not full height and allow borrowed light to reach the inner zone. With the industrial warehouse structure comes generous floor to ceiling heights of twelve feet. The underside of the slab above is generally left exposed and a raised floor in some of the units provides a chase for plumbing and electrical conduits as well as storage. A number of innovative in-suite storage areas appropriate horizontal space rather than creating traditional closets that might further narrow the breadth of the space. From a sound isolation point of view, the existing floor slabs constructed with a minimum of 200 mm. concrete provide necessary acoustic isolation.

The adjacent suites are separated with a double-studded wall with four layers of gypsum wallboard, sound attenuation insulation, and an air space. This construction exceeds the minimum sound attenuation code requirements but may be warranted since the spaces are zoned for working space as well as residential.

Aside from the introduction of the two atria through the floor plates and some new steel construction on the existing roof, the only major structural change to the base building is the creation of a new floor level for cars. The original warehouse had no provisions for indoor parking so a mezzanine level and access ramps are being built within the existing height of the second level in order to provide approximately 330 parking spaces for the new residents. Another 70 stalls have been incorporated into the basement level.

North West Corner of Main Block of Existing Building showing large existing windows. All windows are to be replaced as the conversion is phased in. Existing buildings shall be restored. Some new infill panels will be used.

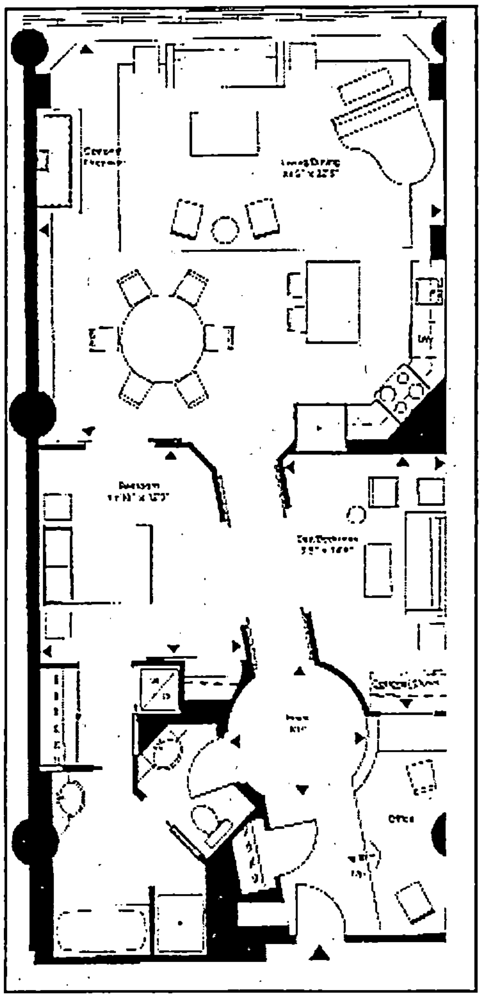
The Merchandise Building is in many ways an extreme case. The outstanding features of this conversion have to do with the physical scale of the existing building and its utilitarian properties. The challenge of adapting warehouse space for living is being met by making a feature of the robust structure and industrial aesthetic. Atypically long and narrow units are being created to deal with the large plate depth while keeping the total area of most units fairly low. Locating the office component of the live/work suite plan towards the interior also helps deal with the slenderness, as do a number of other planning and detailing strategies mentioned earlier. The real challenge for the Merchandise Building lies in the ability of the market to absorb such an ambitious intervention. If there are enough takers, the building "will be a real anchor for the residential area now developing in the east downtown. To see a 92903.41 s.m.building animated and lit up will have a very strong revitalizing effect to the surrounding neighbourhood."

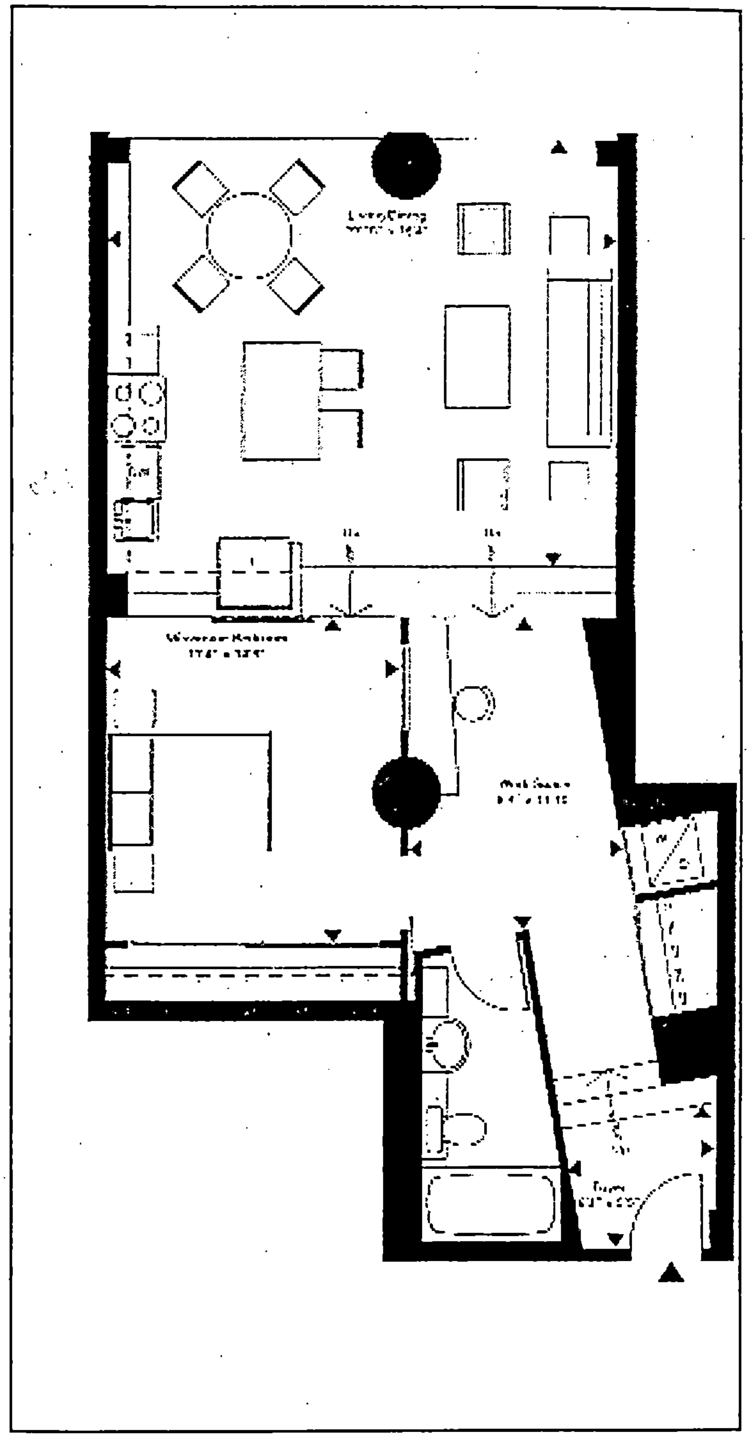
Context Shown From South West Corner showing th massive volume & area occupied by the building

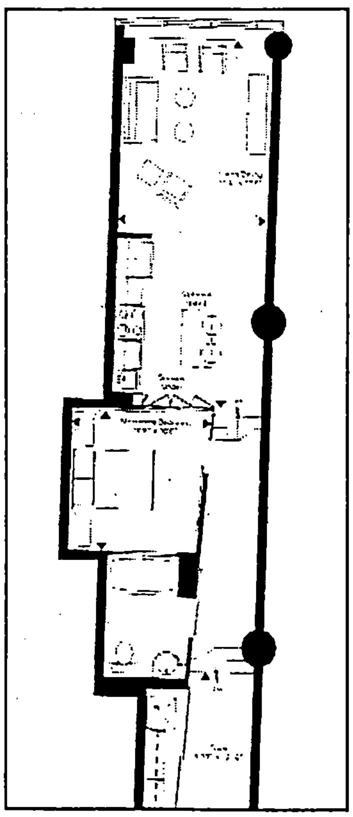
North West Corner of Main Block of Existing Buildings

Corner Low-Rise Building Used for Models. Note Unenclosed Stair Tower in Background

Three Examples of Typical Suite Plans







ARCHITECTURE/PLANNING DESIGN INFORMATION

PROJECT: **THE MERCHANDISE BUILDING**
ADDRESS: **155 Dalhousie Street, Toronto, Ontario**
CRESSFORD DEVELOPMENTS
PAUL NORTHGRAVE (ARCHITECTURAL)
KAZMAR (STRUCTURAL)
A&G (MECHANICAL + ELECTRICAL)

	Classifications and Divisions		Previous	Current
	Use	Single Multiple	• Retail warehouse for Sears.	• ±440 loft apartments. • ±400 car. spaces • ±50,000 s.f. retail
	Use & occupancy		• Warehouse and distribution centre.	• As above.
	Gross Floor Area	Major Use ~~Minor Use~~	• ±88,258.24 s.m.	• Residential lots ±60% of 950,000 s.f.
	Site Ratio		• Approximately 10.	• No change.
	Coverage		• 100% of site.	• No change.
	No. of Storeys	Above grade Below grade	• 11 above. • 1 (partial below).	• 12 (parking level added). • 1 (partial below).
	Floor Plate Configuration	Shape Atrium Other features	• L-shaped.	• L-shaped. • 2 large atria new (level 4 to roof).
	Structural Grid Dimensions	Column spacing Shear walls	• ±6.70 m o.c. concrete column, structural grid c/w column drops, concrete floor.	• As existing. • New steel structure on part of roof.
	Floor Plate Depth	Exterior wall to core Length Width	• Varies (48.77 m max.) • 137.16 m • 33.53 m and 48.77 m	• (Suite depth ±16.76 m on average.) • No change. • No change.
Service	Service Core Type	Single Split	• Split	✓
	Core Location	Centre Side Off-Centre Multiple Core to floor ratio	• Multiple	• Five cores for five phases of development.
	Fire Safety	Active -sprinklers Passive -shutters/dampers Smoke extractor Fire walls Rated assemblies	✓ ✓ ✓	• To current code. • "Open air" fire stairs removed, space incorporated into residential unit.
	Typical Floor to Floor Height	Basement Floors Lower Floors Upper Floors	• 2.95 m basement (varies) • 3.86 m upper floors.	• As existing, 12' clear on new roof structure.
	Aspect	Single Double Multiple	✓	✓
	Fenestration	Glazing to wall ratio Glazing to floor ratio Head height Sill height	• ±60% • Varies 0.92 m A.F.F. to 1.53 m A.F.F.	• 0.31 m (typ. suite) • Reduce sill height in lofts to 0.61 m A.F.F.
	Vertical Circulation	Elevators Stairs	✓ ✓	✓ 9 total ✓ 8 total
	Parking	Surface Basement Above grade Separate Structure Remote	• Some on surface only.	• ±70 cars basement. • ±330 cars new mezzanine leve.

TECHNOLOGICAL INFORMATION

PROJECT: **THE MERCHANDISE BUILDING**
ADDRESS: **155 Dalhousie Street, Toronto, Ontario**
CRESSFORD DEVELOPMENTS
PAUL NORTHGRAVE (ARCHITECTURAL)
KAZMAR (STRUCTURAL)
A&G (MECHANICAL + ELECTRICAL)

			Previous (1916, 1948)	New (1996-1997)
Structure	Substructure	Footings Piles Caissons	• Reinforced concrete caissons.	• No change.
	Structural materials and framing systems	Horizontal Vertical	• Reinforced concrete columns and slabs (200 mm min.).	• No change.
Skin	Exterior Cladding	In situ Prefab	. Clay masonry, concrete, stone.	• Refurbished masonry and conc.
	Fenestration	Windows - fixed/operable Curtain wall	• Single glazed, some operable.	• New double glazed, thermally broken, Low E windows.
	Insulation	Interior Exterior Composite	• Generally none.	• To current Code.
Circulation	Vertical Circulation	Elevators - # multiple use - # dedicated use Escalators Stairs	✓ • No	• New elevators (cab + shafts) • 8 passenger plus 1 freight. • No • 8 stair towers (most new)
HVAC	Mechanical systems	Heating Ventilation Cooling	• Gas fired boilers/rads. • Fans. • Fans.	• Gas fired heat pump system (new) (individual metering and control).
Plumbing		Sanitary Water supply Stormwater	✓ ✓ ✓	• New • New • New
Power	Electrical systems	Transformation Distribution Emergency	. Multiple transformers.	• New transformer. • New distribution.
	Other			• IBM infostructure network
Lighting		Lighting - public areas - private areas		• New, mostly fluorescent. • New (fluor., incandescent, halogen).
Safety	Fire Safety	Ratings Stairs Alarm and Evacuation	✓ ✓ ✓	• Current code for "C" type.
Interior	Partitioning	In situ Demountable	• Yes • Yes	• 4x GWB between suites. • Many moveable partitions.
	Ceiling Systems	In situ Demountable	• Generally	• U/s structure (some public areas with drop ceiling).
	Floor systems	Elevated	• Conc. slab.	• Concrete on metal pan, ±15% of renovated space.
Sound	Sound control	Floors Walls Special	• 200 mm Concrete • None	• 200 mm concrete • ±60 DB between suites (4x GWB + acoustic batt) • Bathrooms

Gotham Lofts

The Gotham Lofts Building at 781 King Street West in Toronto was originally built in 1917 as a harness factory. It is a 6 level structure with the first floor partially below grade. The exterior walls are load bearing masonry and it is framed with heavy timber post and beam members organized to a typical 5.33 metres by 3.96 metres bay. The narrow end of the rectangular floor plate fronts King Street and occupies a footprint of roughly 1031.23 s.m.

The first conversion for this building took place in the 1980's changing the programme to commercial office space. By the end of 1996 the second conversion will be complete. The 4273.56 s.m. of floor space are being converted to 54 condominium residence units zoned for live/work. Units are organized along a central corridor that terminates with a stairway and two elevators at the northeast corner and a single stair at the southwest corner. Approximately twenty of the units are occupying two levels and most of these are the smaller units having less than 65.03 s.m. of floor space. Depending on the location of columns (spaced 3.96 m. apart) within the units, more compact rectilinear stairs were occasionally installed rather than the spiral stairs generally preferred by the condominium purchasers.

A great deal of the structure is left exposed within the units. Both the inside and outside face of the solid exterior masonry wall has been left bare. An insulating system for the exterior was considered in order to increase the skin's RSI-value and therefore lessen the mechanical heating and cooling loads. Ultimately, though, this was abandoned in part to retain the bricks' visibility from the outside. Structural wood members have a sandblasted finish and the underside of the laminated wood deck above is revealed as much as possible. The topside of the decks received a new concrete topping, various sound control measures and a hardwood finish. The resulting ceiling heights are generous compared to typical new construction, ranging from 2.89 m. to 3.65m. A number of features in the new conversion are left over from the earlier renovation to office space, including the finished lobby and double glazed windows. There also remains a concrete block wall corridor at the lowest level which now services two residential units and several shared rooms (lockers, garbage compactor, etc.)

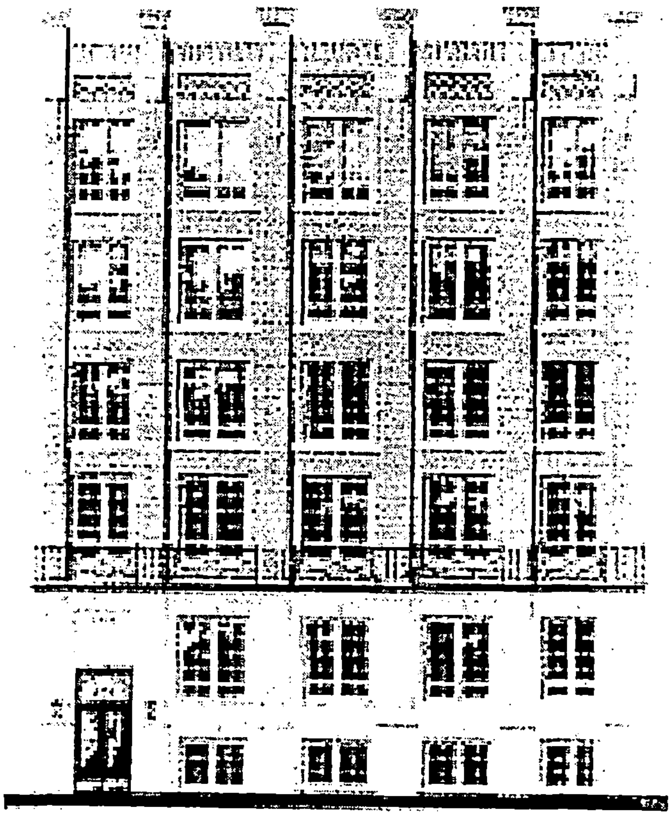
Balconies were added to some of the units along the east side but not to the west due to the tight fit of the building's footprint upon the site. There is no parking on the site but spaces have been set aside in the adjacent Citysphere condominium (an earlier project by the same developers with this need for parking anticipated).

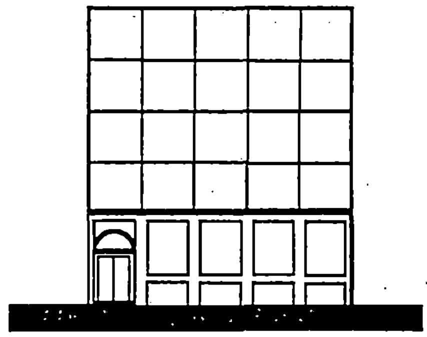
The physical dimensions of the building make for a straightforward and appropriate transition to residential units. Floor heights, plate shape and size, core locations etc. favoured a central corridor with suites along both sides and were generally not obstacles for the design team. Most units have a shallow depth (typically about 6.10 metres) from corridor to exterior wall allowing ample natural light penetration from the windows. The existing windows were re-used and in a few cases window openings were enlarged to allow greater area for light or to accommodate a balcony door.

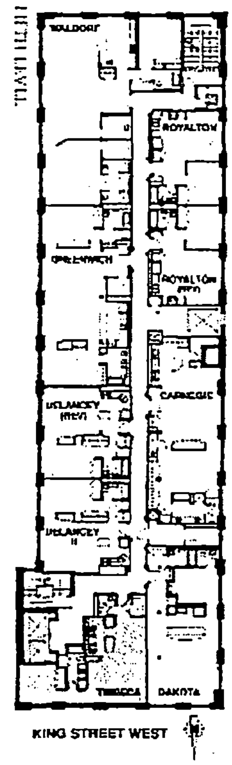
The main issues governing the conversion had to do with the material properties of the wood frame. The timber structure is fully strong enough for the new loading requirements but the sound transmission through floors, walls and structure warranted a great deal of attention. Strategies to control the sound dictated much of the corridor, wall and floor construction. Several acoustic tests were performed on the building in order to determine what interventions were necessary. A specialized consultant investigated sound isolation at the floor and wall boundaries as well as physical vibration of the horizontal members (low frequency deflection). Ultimately, a 75 mm. layer of normal weight concrete was added to the floor system in part to increase its mass and therefore sound-attenuating properties.

Little detailed or accurate as-built information was available to the builders and unique conditions were constantly arising. Dealing with the wood structure was technically complicated: penetrations in the floor had to be framed and supported with steel, and the structural members are not all uniform in size. Wood columns range from0 .33 m. square at the lower levels to 229 mm at the top floor. The masonry shell tapers from 0.92m deep at the basement piers to about a foot thick at the roof. These factors made for an unusually large number of on-site meetings to discuss complex and unforeseen conditions as they arose.

The conversion to loft units included the introduction of natural gas piped in for heating and cooking. Gas furnaces and air conditioning are individually controlled and metered for each unit. An upgrade from an electric to a gas stove in the kitchen is also available to the condominium buyers. Because of this new service, the structure was checked in accordance with the Ministry of Consumer and Corporate Relations' Guidelines for the prevention of progressive collapse due to a natural gas explosion.



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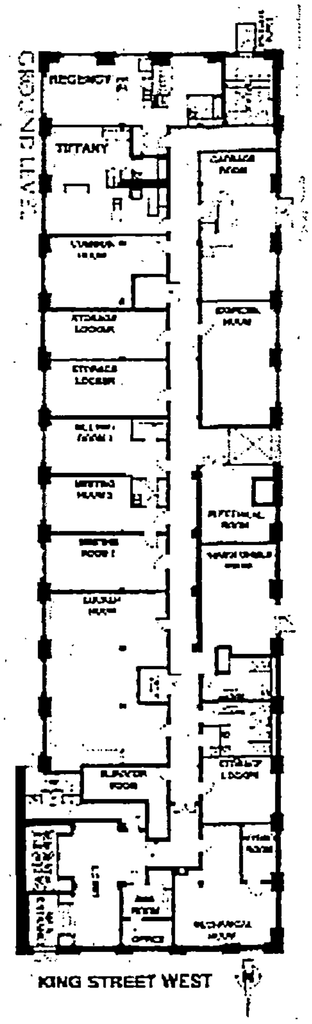
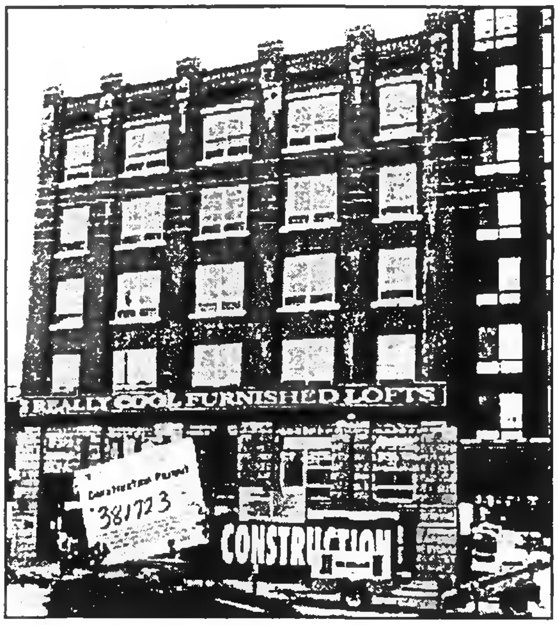
ROYALTON
GREENWICH
CARNEGIE
DAKOTA
KING STREET WEST

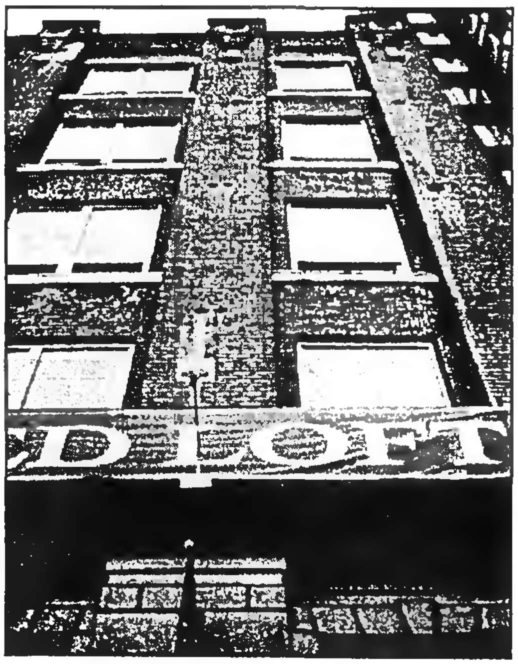

REGENCY
TIFFANY
KING STREET WEST

3

Full Elevation



Site of Building



Front Elevation

Construction Phase

TECHNOLOGICAL INFORMATION

PROJECT: **GOTHAM LOFTS**
ADDRESS: **781 King Street West, Toronto, Ontario**
CANADIAN EQUITY + DEVELOPMENT CORP.
PAPPAGEORGE HAYNES, STEPHEN WELLS (ARCHITECTURAL)
YOLLES (STRUCTURAL)
INTERSIGN (MECHANICAL + ELECTRICAL)

			Previous (1980s = built 1917)	New (1996)
Structure	Substructure	Footings Piles Caissons	Spread footings.	• No change.
	Structural materials and framing systems	Horizontal Vertical	• Exterior load bearing masonry. • Interior post and beam timbers. • Lateral wood deck diaphragm and masonry shear walls.	• No change. • Structure checked for resistance to progressive collapse due to natural gas installation.
Skin	Exterior Cladding	In situ Prefab	. Masonry walls.	• No change.
	Fenestration	Windows - fixed/operable Curtain wall	• 2x glazed, thermally broken aluminum frames, operable vent (originally single pane).	• No changes - all windows re-used.
	Insulation	Interior Exterior Composite	• Within double masonry wall (i.e., essentially none).	• No change.
Circulation	Vertical Circulation	Elevators - # multiple use - # dedicated use Escalators Stairs	• 1 service, 2 passenger • No. • 2 exit stairs.	• 1 service, 2 passenger • No. • 2 exit stairs retained.
HVAC	Mechanical systems	Heating Ventilation Cooling	• Central system for office (none for original factory).	• Individual heating and cooling for each suite. • Individual gas furnaces, cooking optional. • Rooftop unit for some common areas.
Plumbing		Sanitary Water supply Stormwater		• New distribution.
Power	Electrical systems	Transformation Distribution Emergency		• Most electrical re-used. • New distribution, panels.
	Other			• Pre-wired for cable and telephone.
Lighting		Lighting - public areas - private areas	• Mostly fluorescent	• Halogen track for suites, some fluorescents + incandescent fixtures for public places.
Safety	Fire Safety	Ratings Stairs Alarm and Evacuation	• To Code.	• 1 hour between suites and floors. • Smoke detectors throughout. • As per OBC Pt. 11 or required fire safety?
Interior	Partitionong	In situ Demountable		• Yes, exposed structure and painted GWB. Some GWB partitions <u>not</u> full height.
	Ceiling Systems	In situ Demountable	• Mostly exposed structure	• U/s and cols. structural wood. • Some painted GWB.
	Floor systems	Elevated	• No (top floor thin concrete topping to level)	• All suspended floors have new concrete topping, sound control, and wood finish.
Sound	Sound control	Floors Walls Special	• Top floor of office has thin concrete topping.	• Floor and walls include rigorous sound dampening features, new concrete on all floors.

BUILDING ADAPTABILITY STUDY
CASE STUDY

April 25, 1997
A96.029

ARCHITECTURE/PLANNING DESIGN INFORMATION

PROJECT: **GOTHAM LOFTS**
ADDRESS: **781 King Street West, Toronto, Ontario**
CANADIAN EQUITY + DEVELOPMENT CORP.
PAPPAGEORGE HAYNES, STEPHEN WELLS (ARCHITECTURAL)
YOLLES (STRUCTURAL)
INTERSIGN (MECHANICAL + ELECTRICAL)

			Previous (1980s = built 1917)	Current (1996)
	Use	Single ~~Multiple~~	• Offices (originally harness factory).	• Condominium lofts (47 units).
	Use & occupancy		• Commercial (originally industrial).	• Live/work (Group C).
	Gross Floor Area	Major Use ~~Minor Use~~	• 4,310.72 s.m.	• 4,310.72 s.m.
	Site Ratio			
	Coverage		• Footprint = 1,021.94 s.m.	• Footprint = 1,021.94 s.m. (close to 100%).
	No. of Storeys	Above grade Below grade	• 5 • 1	• 5 • 1
	Floor Plate Configuration	Shape Atrium Other features	• Rectangular. • No •	• Rectangular. • No. • 2x height front lobby.
	Structural Grid Dimensions	Column spacing Shear walls	• 5.26 m x 3.96 m (typ. bay) • Masonry shear walls.	• 5.26 m x 3.96 m (typ. bay) • Masonry shear walls.
	Floor Plate Depth	Exterior wall to core Length Width	• 15.90 m (inside wall to inside wall0 • 61.21 m • 16.46 m	• 15.90 m (inside wall to inside wall) • 61.21 m • 16.46 m
Service	Service Core Type	Single Split	• Split service passenger (originally single).	• Split service passenger (originally single).
	Core Location	Centre Side Off-Centre Multiple Core to floor ratio	• Service: At west wall near middle. • Passenger: NE corner	• Service: At west wall near middle. • Passenger: NE corner.
	Fire Safety	Active -sprinklers -shutters/dampers Passive Smoke extractor Fire walls Rated assemblies		• Throughout. • Walls between suites all suspended floors.
	Typical Floor to Floor Height	Basement Floors Lower Floors Upper Floors	• 3.10 m • 3.89 m • 3.35 m, 5.08 m, 3.33 m, 3.35 m	• 3.10 m • 3.89 m • 3.35 m, 5.08 m, 3.33 m, 3.35 m
	Aspect	Single Double Multiple	• All sides.	• All sides.
	Fenestration	Glazing to wall ratio Glazing to floor ratio Head height Sill height	• Near 50% • 2.74 m to 3.51 m • 0.76 m typ.	• 50% (typ ste.). • No change, except that grnd. level suites had windows enlarged.
	Vertical Circulation	Elevators Stairs	• 3 • 2	• 3 (one is freight). • 2
	Parking	Surface Basement Above grade Remote	• Some • None • No	• Adjacent building to provide remote underground parking.

College Park Redevelopment

The redevelopment of College Park in 1977 was a very large scale conversion project involving the Toronto city block located to the south and west of the College Street and Yonge Street intersection. The site was originally built up in 1928 to provide a flagship for Eaton's department store. This involved the construction a grand seven storey stone-faced department store along Yonge Street with a three level wing extending south along Yonge Street to Hayter Street. A single level wing of shopping space was also built along College Street and a two storey building for shipping and receiving was constructed behind the Yonge Street elevation.

After fifty years, the major changes of the redevelopment included the demolition of the College Street wing, addition of a nine storey residential tower on top of the existing structure set back from Yonge Street, and the conversion of three levels in the main building from retail space into offices. The were a number of associated changes on site including a new trucking area and heat storage tanks, the construction of a large mechanical penthouse on the main structure, and a number of revisions to the west facade.

One of the biggest challenges of the redevelopment was the introduction of a new apartment building on top of the existing building. Inspections revealed that the structure was generally in very good shape and there was excellent documentation available for the as-built conditions. In fact, the department store was originally constructed as the base building for a future thirty-five storey tower. This meant that the structural column and caisson system for the Yonge Street wing had been built with this additional loading in mind. Consequently, there was more than adequate capacity for the proposed nine stories of residences.

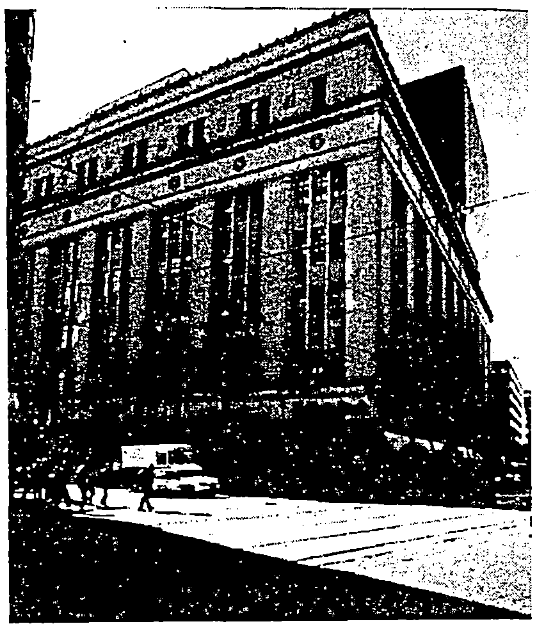
The basic structural frame of the original building is a 12.20m by 8.69m. bay with rivetted steel construction. The suspended floors use a reinforced concrete joist system spanning the short dimension of the basic bay. These concrete joists bear onto 0.915m. deep steel girders spanning the 12.20 m. dimension. The best solution for adding the nine levels above was found to be a lightweight concrete floor system between steel beams organized to the existing structural grid. This approach avoided the need for a load transfer system and allowed for an efficient layout of residential units.

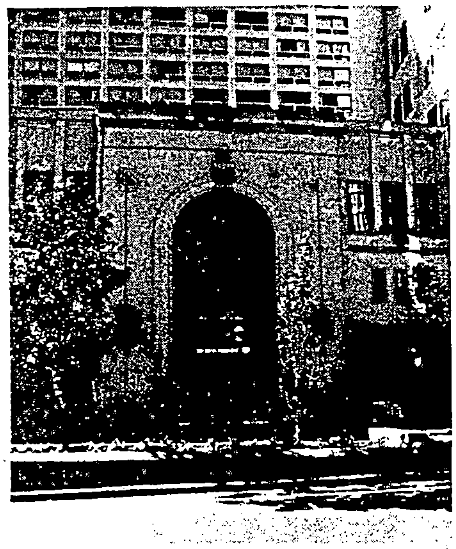
The new residential tower straddles seven 12.20m. bays from north to south and measures two 8.69m. bays across. There are typically 20 units per floor stretched out along the central corridor with stairs at each end and a central core with stairs and two passenger elevators. The long and narrow proportions of the plate dictated by the underlying structure make for fairly shallow and well-lighted units. These residential levels are accessed from the lobby directly below or from the adjacent building to the north with which it shares a cross-over mezzanine.

The residential addition to College Park is essentially new construction on top of existing structure. In this sense, the conversion issues where different form those encountered when appropriating an existing building from the inside out. In this particular case, it was very helpful to have detailed and accurate as-built information. Designers were able to see very clearly what the base building could tolerate in terms of vertical expansion.

Internal Courtyard Created by New Construction

North East Corner of Original Building Showing Floors Converted to Offices





Original Mid-Block Entrance Retained

South Elevation Showing Articulation Between Original Building and Residential Block

TECHNOLOGICAL INFORMATION

PROJECT: **COLLEGE PARK DEVELOPMENT**
ADDRESS: **Yonge and College Streets, Toronto, Ontario**
TORONTO COLLEGE STREET CENTRE LTD.
JOINT VENTURE ARCHITECTS (ARCHITECTURAL):
- ALLWARD GOUINLOCK
- A.M. INGELSON ASSOC.
- JOSEPH BOGDAN
- THE WEBB ZERAFA MENKES HOUSDEN PARTNERSHIP
YOLLES (STRUCTURAL)
EIL (MECHANICAL)
H.H. ANGUS (ELECTRICAL)

			Previous (Block C) 1928	New (1978 - Block "B")
Structure	Substructure	Footings Piles Caissons	• Conc. caissons on bedrock (designed for 30 storey tower)	• No change.
	Structural materials and framing systems	Horizontal Vertical	• Reinforced steel frame + reinforced conc. joists between 3' girders.	• Light weight steel frame organized on existing structural grid. • Conc. shearwall + slabs.
Skin	Exterior Cladding	In situ ~~Prefab~~	. Stone masonry	• Precast conc. panels.
	Fenestration	Windows - fixed/operable Curtain wall	• Fixed • No	• Large fixed 2x glazing with 2 operable louvres (typ.).
	Insulation	Interior Exterior Composite	• Some interior • None	• Rigid + Batt
Circulation	Vertical Circulation	Elevators - # multiple use - # dedicated use Escalators Stairs	• • • •	• 2 passenger elevators • 3 stair towers
HVAC	Mechanical systems	Heating Ventilation Cooling		• All new, self contained in units. • Old elevator shafts used on duct space.
Plumbing		Sanitary Water supply Stormwater		• New construction.
Power	Electrical systems	Transformation Distribution Emergency		• New construction.
	Other			
Lighting		Lighting - public areas - private areas		• Mostly fluorescent (some incandescent).
Safety	Fire Safety	Ratings Stairs Alarm and Evacuation		• As per Code.
Interior	Partitioning	In situ Demountable		• In situ
	Ceiling Systems	In situ Demountable		• In situ
	Floor systems	Elevated		• No
Sound	Sound control	Floors Walls Special		

ARCHITECTURE/PLANNING DESIGN INFORMATION

PROJECT: **COLLEGE PARK DEVELOPMENT**
ADDRESS: **Yonge and College Streets, Toronto, Ontario**
TORONTO COLLEGE STREET CENTRE LTD.
JOINT VENTURE ARCHITECTS (ARCHITECTURAL):
- ALLWARD GOUINLOCK
- A.M. INGELSON ASSOC.
- JOSEPH BOGDAN
- THE WEBB ZERAFA MENKES HOUSDEN PARTNERSHIP
YOLLES (STRUCTURAL)
EIL (MECHANICAL)
H.H. ANGUS (ELECTRICAL)

			Previous (Block C) 1928	New (Block B-New Residential Addition) 1978
	Use	Single Multiple	• Eaton's flagship retail store and offices (1928).	• ~200 res. condo units (on top of existing building)
	Use & occupancy		• Retail/Office	• Residential
	Gross Floor Area	Major Use Minor Use		• ~14,864.55 s.m. residential condos
	Site Ratio			• N/A
	Coverage			• N/A
	No. of Storeys	Above grade Below grade	• 3 • 2	• +9 atop 3 storey building
	Floor Plate Configuration	Shape Atrium Other features	• Rectangle	• Rectangle • No atrium
	Structural Grid Dimensions	Column spacing Shear walls	• 12.19 m x 6.25 m bay (typ.)	• 12.19 x 6.25 m bay (typ.) dictated by base building (8.68 m column spacing)
	Floor Plate Depth	Exterior wall to core Length Width		• 8.68 m (typ) • 85.34 m • 17.37 m
Service	Service Core Type	Single Split		• Single
	Core Location	Centre Side Off-Centre Multiple Core to floor ratio		• Centre • 5% (74.32 sm/1,482.74 sm)
	Fire Safety	Active -sprinklers Passive -shutters/dampers Smoke extractor Fire walls Rated assemblies		• Sprinklered • Yes
	Typical Floor to Floor Height	Basement Floors Lower Floors Upper Floors		• 10 floors + penthouse mezzanine
	Aspect	Single Double Multiple		 • (East and west)
	Fenestration	Glazing to wall ratio Glazing to floor ratio Head height Sill height		• 41% typ. suite. • 13% typ. suite • 2 m • 0.3 m
	Vertical Circulation	Elevators Stairs		• 2 • 3
	Parking	Surface Basement Above grade Separate Structure Remote	• All (shopping centre)	• Some. • Most.

THE METROPOLE

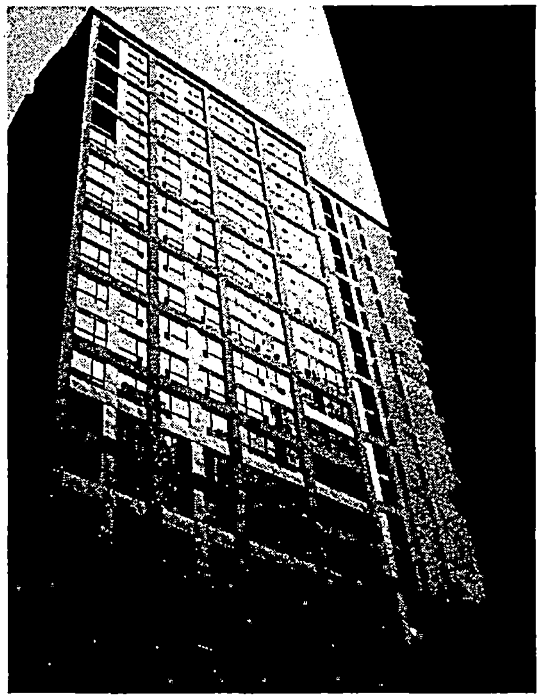
The Metropole at 7 King Street East is in the process of becoming a residential building with 316 units for living along with 6 retail condominium units at the street level. Prior to this conversion, the building was known as the National Trust Building. In this earlier form, it served as an office and bank tower with one prime tenant and several minor ones. It is a reasonably large building with a total floor area in excess of 37,000 m2 and it is built to the property line in the dense financial core of Toronto.

Built in 1961, it is a typical commercial construction for its era. With the change in use from office to residential, the loading requirements due to occupancy is now less severe and there were no structural changes necessary. The slabs' edge has a concrete perimeter beam making it rigid. The concrete frame and columns accommodated 21 storeys (plus a mechanical penthouse) on top of 3 levels below grade. The new residential programme inserts an additional two floors for parking in the podium where the existing floor to floor was 5.33 m. This was done by building two new slabs and a ramp system with access to the street in order to provide above grade indoor parking for the new residents. The original condition had one and a half levels of parking in the basement. This existing parking space had to be repaired and restored because of the corrosion damage resulting from decades of cars travelling in and out.

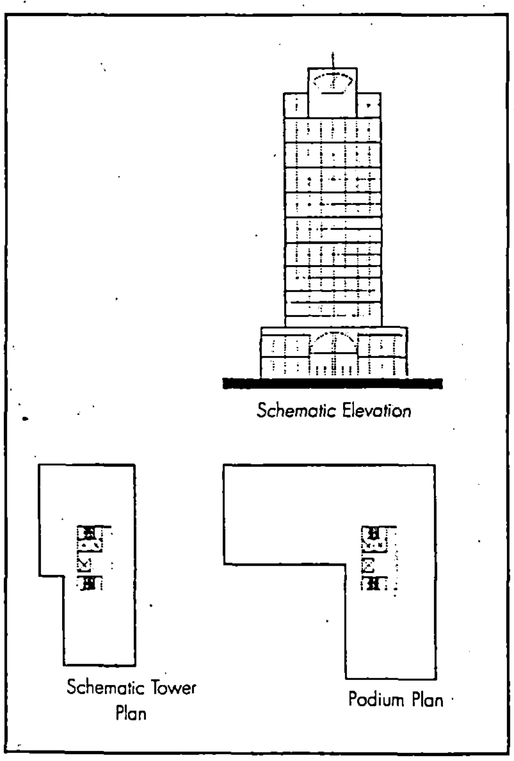
Thirty years after construction, the skin was in bad shape. Silica fragments, which were included in the precast panels to create a sparkling effect, were contributing to the degradation of the panels. As a result, scaffolding was erected to protect passers by from falling material and the original precast concrete panels were removed. The new cladding is a combination of precast panels hung on the same edge beam at new connections points, and a residential curtainwall system with integrated glazing and metal panels. The horizontal precast elements skip every other floor making two-level square zones for the curtain wall infill. Fixed single-glazed windows were replaced by double-glazed insulated thermally-broken sliding/opening windows. The new skin brought R-values in the walls and roof up to RSI-20 from a previous RSI-8 or less.

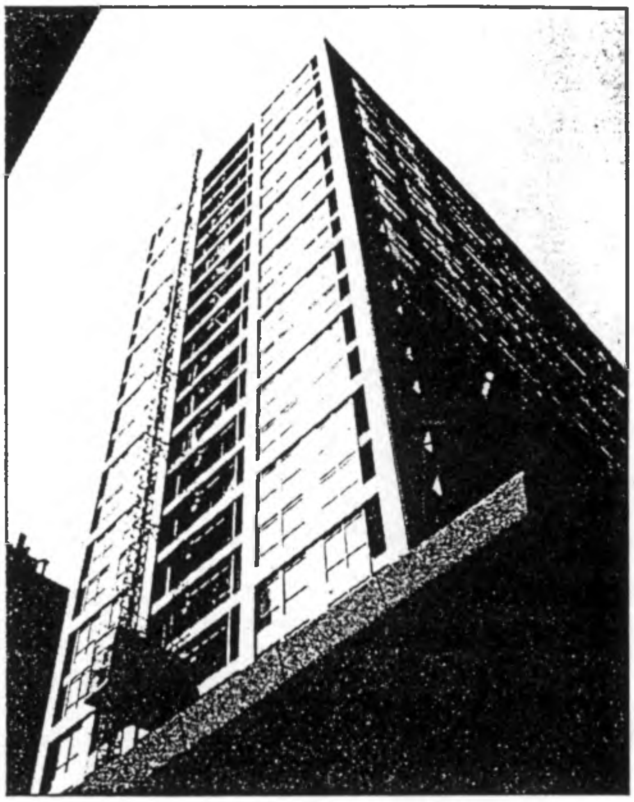
The dimensions of a typical floor plate in the tower are 54.86 m.by 25.30 m.The northern one half of the plate is eight feet wider than the southern half creating a shallow L-shape. The corridor wraps around the central rectangular core incompletely and short branches of the hallway extend towards the four corners of the plate. The units themselves range in size from bachelor suites up to two bedroom suites with a den. The floor was designed for office space and is somewhat deeper than ideal for residential units. The northern half of the plate has corridors on both sides of the core effectively shortening the depth of the units on either side. The other half has an off-centre hallway that jogs to the east before terminating. There are unrestricted views and access to daylight on all four elevations except for the southern portion of the west facade where there is close proximity to the neighbouring building. In order to provide natural lighting to some of these spaces and to meet fire code requirements dealing with separation, the solution was to use glass block.

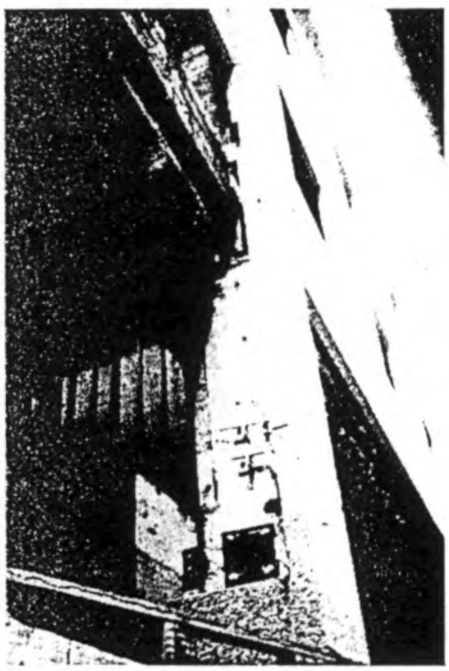
Some of the main issues with this conversion stem from the tight context within the urban fabric. Many of the buildings in this neighbourhood have 100% site coverage and are generally mid to highrise construction. Architectural solutions are needed to address the building code requirements relating to residential window location and construction. At the same time, there needs to be natural light in all habitable spaces and ideally windows are to be made operable. The tightness of the site has important ramifications for the sequencing of construction processes.



King Street - West Elevation showing new facade treatment.

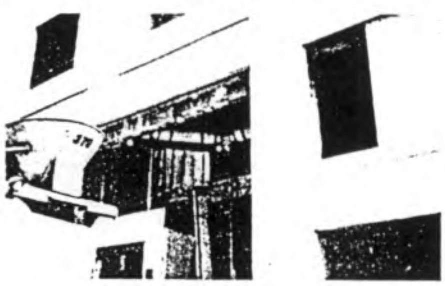






New Precast Anchors on Existing Frame

South Podium Elevation



Construction Staging and Access to Elevator

TECHNOLOGICAL INFORMATION

PROJECT: **METROPOLE**
ADDRESS: **7 King Street East, Toronto, Ontario**
PAGE & STEELE (ARCHITECTURAL):
JABLONSKY AST & PARTNERS (STRUCTURAL)
HIDI ASSOC. (MECHANICAL)
CBR (ELECTRICAL)

			Previous (1961)	New (1996)
Structure	Substructure	Footings Piles Caissons	• Poured IU • Place concrete footings and foundation.	• No change
	Structural materials and framing systems	Horizontal Vertical	• Reinforced concrete columns and frame	• No change 2 slabs added within existing) (no upgrade required)
Skin	Exterior Cladding	In situ Prefab	. Precast, panels	• New precast w/ residential curtain wall (metal panels + glazing)
	Fenestration	Windows - fixed/operable Curtain wall	• Fixed/single glazed.	• Insulated/thermally broken • Sliding opening unit.
	Insulation	Interior Exterior Composite	• Minimal - R8 max. • Within double masonry wall.	• Ashrae 90.1 compliance. • R18 walls, R20 roof
Circulation	Vertical Circulation	Elevators - # multiple use - # dedicated use Escalators Stairs	• 6 highrise • 2 tenant and 1 basement • None • Steel	• 3 highrise • 1 basement • None • 2 tower stairs retained
HVAC	Mechanical systems	Heating Ventilation Cooling		• Entirely new vertical fan coils with reheat coils in residential units.
Plumbing		Sanitary Water supply Stormwater		• New plumbing.
Power	Electrical systems	Transformation Distribution Emergency		• Some central equipment retained.
	Other			
Lighting		Lighting - public areas - private areas	• Mostly fluorescent (some inc. fixtures)	• Typ. mix for residential.
Safety	Fire Safety	Ratings Stairs Alarm and Evacuation		• Pressurized stairwells and elevators. • Sprinklered parking, retail, louvres, and garbage room.
Interior	Partitionong	In situ Demountable	• Typical office. • Drywall and demountable.	• Block and drywall (residential construction) demising/metal stud.
	Ceiling Systems	In situ Demountable	• Tee-bar	• Drywall suspended.
	Floor systems	Elevated	• Concrete slab.	• Finish directly on concrete.
Sound	Sound control	Floors Walls Special	• No special except concrete cast in place at mechanical room. • Ceilings (removed in "new").	• "Floating floor" at chiller "code" wall designs as per Coulter Associates.

ARCHITECTURE/PLANNING DESIGN INFORMATION

PROJECT: METROPOLE
ADDRESS: 7 King Street West, Toronto, Ontario
PAGE & STEELE (ARCHITECTURAL):
JABLONSKY AST & PARTNERS (STRUCTURAL)
HIDI ASSOC. (MECHANICAL)
CBR (ELECTRICAL)

	Classifications and Divisions		Previous (1961)	Current
	Use	Single ~~Multiple~~	• Office (multiple tenant with one large prime tenant).	• Residential (316 units) + Retail (6 units) condominium.
	Use & occupancy		• Office, bank retail.	• Residential/retail (ground floor only).
	Gross Floor Area	Major Use ~~Minor Use~~		• Residential 34,197 m² • Retail 895 m²
	Site Ratio		• 12.0	• 12.5
	Coverage		• 100%	• 100%
	No. of Storeys	Above grade Below grade	• 21 + mechanical penthouse • 3	• 23 + penthouse • 3
	Floor Plate Configuration	Shape Atrium Other features	• L-shaped site, 3 storey podium over entire site. • Tower at east.	• Same with 2 added floors within existing height.
	Structural Grid Dimensions	Column spacing Shear walls	• 22' x 22' (and small variations). • Shear walls at core.	• Same.
	Floor Plate Depth	Exterior wall to core Length Width	• East and west = 27' (38' maximum) • North and south = 445 • Overall tower = 179'-6" x 83 (91'-6" ATN)	• No change.
Service	Service Core Type	Single Split	• Single.	• Single.
	Core Location	Centre Side Off-Centre Multiple Core to floor ratio	• Centre.	• Centre.
	Fire Safety	Active -sprinklers Passive -shutters/dampers Smoke extractor Fire walls Rated assemblies		• Sprinklers at parking levels, retail units, and 2nd floor lockers only and garbage rooms.
	Typical Floor to Floor Height	Basement Floors Lower Floors Upper Floors	• 1 + 2 = 17'-6"; 3 + 4 = 12'-0" 5 to 23 = 11'-3"; B1 = 12'-0"; B2 + B3 = 9'-0"	• Same (2nd floor was added within original 17'-6" ground floor).
	Aspect	Single Double Multiple	• Multiple	• All directions (limited at south portion of west wall).
	Fenestration	Glazing to wall ratio Glazing to floor ratio Head height Sill height		• Approximately 25% glazing to wall in typical suite. • Sill = 12"; Head = 9'-2".
	Vertical Circulation	Elevators Stairs	• 6 core + 2 tenant + 1 basement	• 3 core (re-used) + 1 basement.
	Parking	Surface Basement Above grade Separate Structure Remote	• 1½ levels.	• 3 levels below grade. • 2 levels above grade (from converted office space). (Original parking slab restored.)

B.C. Hydro - The Electra

The British Columbia Hydro Building in downtown Vancouver was the site for the province's Hydro offices from 1955 until 1990. This twenty-two storey tower (112,770s.m.) was one of the earliest buildings in the Pacific Northwest to feature a curtain wall skin. The structure was considered advanced at the time of construction, featuring a floor plate in the shape of a narrow lozenge that is supported by concrete beams originating from a concrete central core. The edge of the slab supported vertical aluminium mullions that held in place large float glass panes (1.52 m. in height) and the edge of the slab itself received spandrel panels made of porcelain and steel. With a central core, open slab plan and large glazed areas the workspace was flexible and well lit with natural daylight and 360 degrees of view.

When B.C. Hydro left in 1990, the building was considered as a candidate for a number of re-use schemes. With a core-to-plate ratio of approximately thirty percent, the configuration was not very competitive as single or multi-tenant office space. The curtain wall was experiencing water infiltration and condensation within the spandrel panels, and the glazed areas had a film coating to reduce solar gain that had become scratched and limited visibility. Rust and failing connections meant that the curtain wall would have to be replaced almost entirely. The tower floor plate measures 67.06 m. long and varies in width from 22.86 m. at the ends to 27.43 m. at the centre. One of the features that made it an attractive candidate for conversion to residential use is the relatively short distance from central core to slab edge - this dimension is only 6.40 m.. Most highrise offices with a central core and open-plan tend to have much deeper plates and darker interiors.

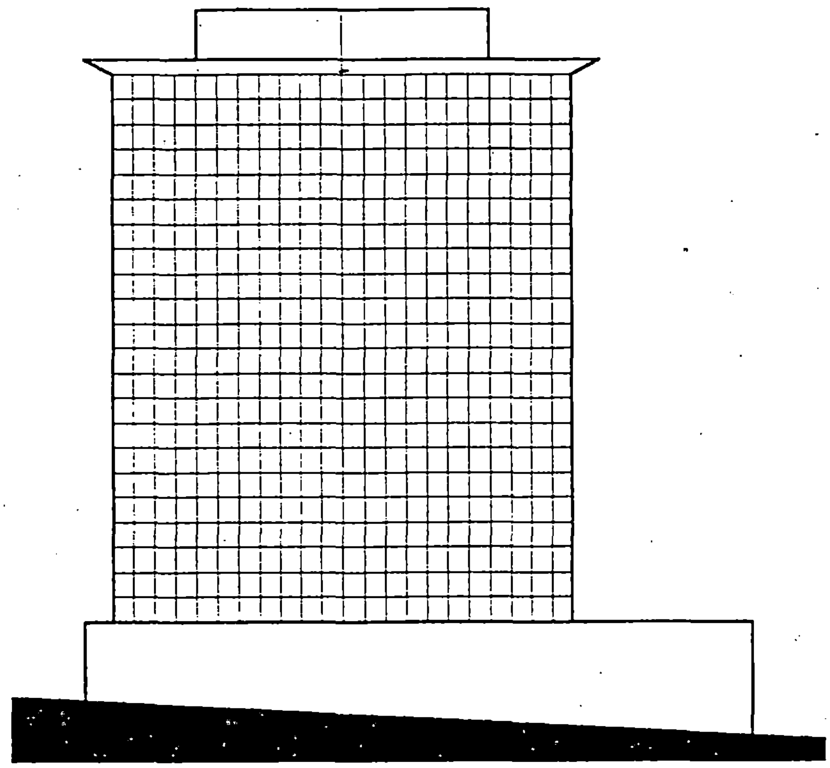
The decision was made to convert the building into a condominium residence with 242 units while retaining office space in the two ground floors and a small amount of retail space at the street. The building was not required to undergo any seismic upgrading during the conversion. In a computer test model, the building showed 85% compliance to the requirements compared to 75% which is the acceptable minimum. The proportions of core and slab were suitable for creating a perimeter ring of residential units along the plate edge serviced by the symmetrical cental core. A typical floor plan shows 14 units, each one occupying two, three or four of the ten foot modules in a row. Penthouse units wrap around the narrow ends of the plate to maintain an open plan and penetrate into the core where there is no public corridor. In terms of natural daylighting and views this arrangement is ideal.

The original office tower housed six passenger elevators, half of which where full height. In the new configuration of condominiums, one of the lowrise elevators has been removed along with employee washrooms on each floor in order to make room for shared storage and laundry facilities. By moving these common spaces to the core, there is for more living space freed up around the perimeter. What was the workers' cafeteria and food preparation area on the ground level is now a skylit garden court that continues outdoors to a terraced green area.

The replacement curtain wall maintains the lines of the original aluminium mullions and horizontal spandrels. The basic proportions of the original exterior are preserved, but the head height of the new windows have been raised by more than a foot to 2.36 m. and the sill has been dropped to 0.38 m. above the finished floor. These changes in the window dimensions result in a glazing-to-wall ratio increase from 37% to 57%. The new windows are double-glazed reflective glass with operable louvres. The replacement glass and metal panels have been coloured to the original scheme maintaining the overall appearance of this historically designated post-war facade.

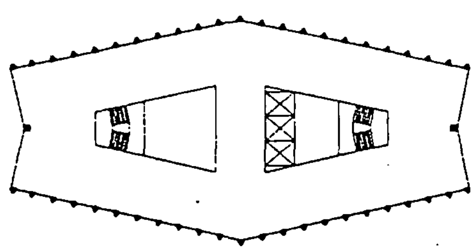
Availability of parking, which is often considered a key factor in condominium conversion, did not seem to be an obstacle despite there being none provided on site. Off-site parking spaces for 150 is provided. The basement level has accommodation for 366 bicycles.

A number of items were reused in the condominium conversion: emergency generators, the main electrical transformer, air conditioner pipe risers, five of the six original elevator cabs. A very memorable tile mosaic located at the ground level exterior and well known to passers by carefully restored to its original condition. From an interior air quality point of view, asbestos was removed from the pipe fittings, PCB from fluorescent light ballasts was removed.



Schematic Elevation of Tower

Schematic Typical Floor Plate



TECHNOLOGICAL INFORMATION

PROJECT: **BC HYDRO - THE ELECTRA**
ADDRESS: **Nelson and Burrard Streets, Vancouver B.C.**
PRIME TOWER/HARROWSTON DEVELOPMENTS
PAUL MERRICK (ARCHITECTURAL)
CWMM (STRUCTURAL)
QUADRA (MECHANICAL)
REID CROWTHER & PARTNERS (ELECTRICAL)

			Previous (1955)	New (1995)
Structure	Substructure	Footings Piles Caissons	• Reinforced concrete down to bedrock.	• No change
	Structural materials and framing systems	Horizontal Vertical	• Reinforced conc. floor slabs. • Central conc. core and perimeter conc. columns.	• No change
Skin	Exterior Cladding	In situ Prefab	• Early curtain wall panels (steel, porcelain, glass)	• New panels (restored elevations)
	Fenestration	Windows - fixed/operable Curtain wall	• Fixed - 1.53 m float glass glazing integrated into curtain wall	• New, larger windows installed (with companion sliders).
	Insulation	Interior Exterior Composite	• Part of skin.	• Increased RSI-value of metal panels (behind spandrels) 2x glazing.
Circulation	Vertical Circulation	Elevators - # multiple use - # dedicated use Escalators Stairs	• 6 passenger (3 lowrise and 3 highrise) • 1 freight • None • 2 stairs in tower + 3 podium	• 5 elevators (3 full height) (cabs upgraded) • No change • No change
HVAC	Mechanical systems	Heating Ventilation Cooling		• New HVAC system (air conditionner pipe risers re-used). • Heat pumps.
Plumbing		Sanitary Water supply Stormwater		• New plumbing (asbestos abated).
Power	Electrical systems	Transformation Distribution Emergency	• Typ for 1955 office.	• Main transformer and emergency generator re-used, all new distribution.
	Other			
Lighting		Lighting - public areas - private areas	• Mostly fluorescent (some incandescent)	• Fluorescents replaced or removed. (PCB ballast was captured and encapsulated.) • Incandescent fixtures, halogen track in suites.
Safety	Fire Safety	Ratings Stairs Alarm and Evacuation	• For 1955 Code	• For 1995 Code
Interior	Partitionong	In situ Demountable	• Open plan office	• GWB fixed with acoustic insulation.
	Ceiling Systems	In situ Demountable	• Drop ceiling panels on T-bar	• GWB fixed with acoustic insulation.
	Floor systems	Elevated	• Not elevated	• New finish on slab.
Sound	Sound control	Floors Walls Special	• Slab adequate	• New cladding features increased acoustic insulation from ambient city noise.

ARCHITECTURE/PLANNING DESIGN INFORMATION

PROJECT: **BC HYDRO - THE ELECTRA**
ADDRESS: **Nelson and Burrard, Vancouver, B.C.**
PRIME TOWER/HARROWSTON DEVELOPMENTS
PAUL MERRICK (ARCHITECTURAL)
CWMM (STRUCTURAL)
QUADRA (MECHANICAL)
REID CROWTHER & PARTNERS (ELECTRICAL)

			Previous (1955)	Current (1995)
	Use	Single Multiple	• B.C. Hydro offices	• 242 res. condo units with ground level retail, 1st and 2nd floor offices
	Use & occupancy		• Offices	• Res. (+ retail).
	Gross Floor Area	Major Use Minor Use	• Approx. 34,374.26 s.m. offices	• 23,690.37 s.m. of residential • 9,290.34 s.m. commercial
	Site Ratio		• ~6	• No change
	Coverage		• ~85%	• No change
	No. of Storeys	Above grade Below grade	• 22 + mezzanine • 2	• 22 + mezzanine • 2
	Floor Plate Configuration	Shape Atrium Other features	• Lozenge • No • Kitchen + cafeteria in podium.	• No change • Skylit garden court at podium
	Structural Grid Dimensions	Column spacing Shear walls	• 3.05 m x 6.40 m typical bay	• No change
	Floor Plate Depth	Exterior wall to core Length Width	• 6.40 m • 60.96 m • Varies 22.86 m to 27.43 m	• No change
Service	Service Core Type	Single Split	 • Split	 • Split
	Core Location	Centre Side Off-Centre Multiple Core to floor ratio	• Centre • 30%	• Centre • 30% (very low net to gross)
	Fire Safety	Active -sprinklers Passive -shutters/dampers Smoke extractor Fire walls Rated assemblies	• To 1955 Code	 • Sprinklered (to 1995 Code) • Gypsum ceiling membrane added
	Typical Floor to Floor Height	Basement Floors Lower Floors Upper Floors	• 4.57 m • 3.28 m • 3.28 m	• No change
	Aspect	Single Double Multiple	 • All sides	 • No change (enhanced)
	Fenestration	Glazing to wall ratio Glazing to floor ratio Head height Sill height	• Approx. 37% • 18% • 2.21 m • 0.76 m	• 57% • 26% • 2.54 m • 0.38 m
	Vertical Circulation	Elevators Stairs	• 3 full height, 3 low rise	• 3 full height original cabs upgraded, 2 up to 2nd floor (5 total)
	Parking	Surface Basement Above grade Separate Structure Remote	• Some originally • None • None • None • Some originally	• 366 bicycles below grade (no car parking at building) • 155 remote stalls (not all used)

102 Bloor Street West

The building at 102 Bloor Street West is presently undergoing a conversion from an office tower to 15 levels of condominium residences totalling 43889 s.m. with retail stores being maintained at the street level. The site is a block west of the Yonge Street and Bloor Street intersection in a prime area of the city's downtown. To the north of the site is a small urban park and high-end shopping and immediately to the east are the remains of a theatre facade. The fate of this spot to the east is unclear, but it will likely be developed at some time in the future. At the west boundary of the site is an equally tall office and retail building that stands less than a meter away all the way up.

Originally built in 1966, the offices at 102 Bloor occupied all 14 levels of the tower with a low mechanical mezzanine through the middle five bays of the fourteenth level. A single level was added for the conversion by removing the 1.68 m. mechanical mezzanine, effectively making the 3.51 m.level above into a 5.18 m. vertical space. This became a zone for two storey penthouse suites. The mechanical equipment was relocated to the rooftop. At the street level, the podium has been extended a few metres to the south with steel framing and precast panels. This serves to enlarge the retail floor space slightly and to provide an improved edge condition and canopy for pedestrians along Bloor Street. Other than these two modifications, the basic form of the office building has not been changed.

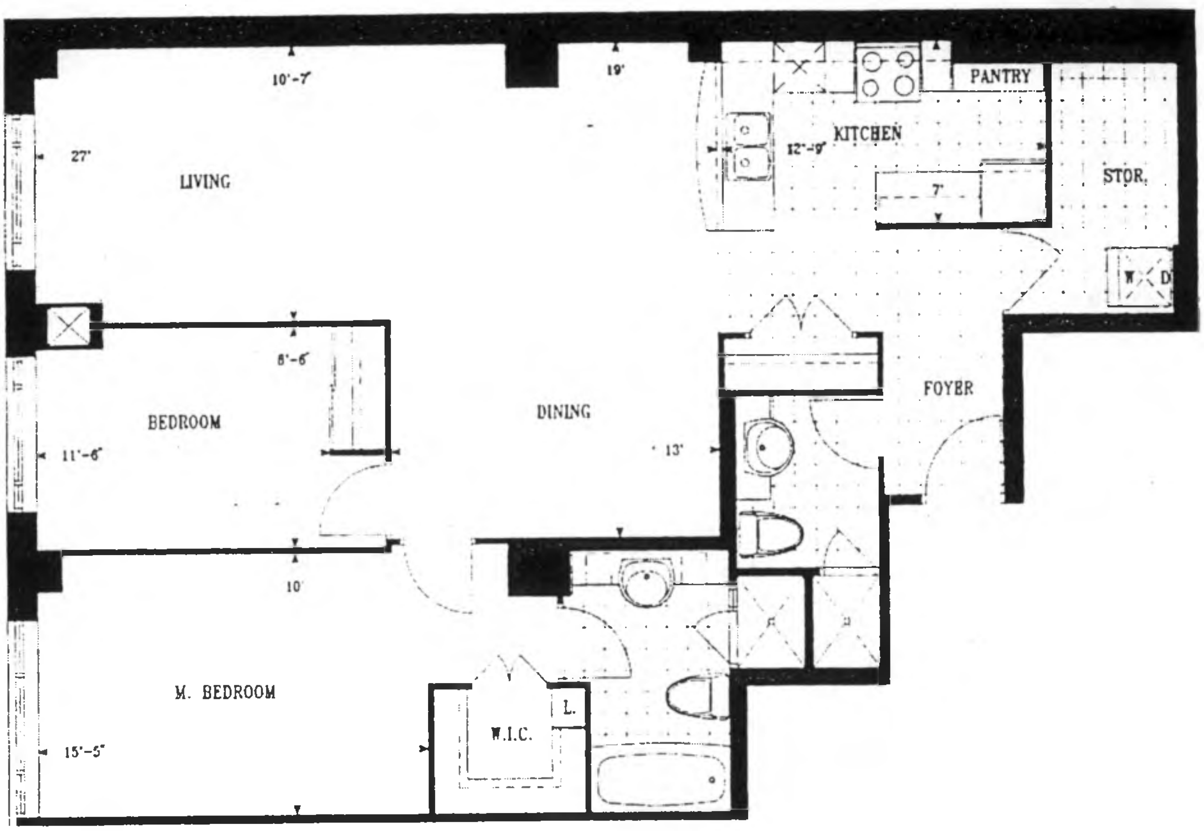
The original precast panels that clad the office tower have all been removed except for portions of the west elevation where there is very little space between buildings. The original panels were 9' high and 5' wide with protruding vertical edges (like an upright C-channel) and they had an inset central window with rounded corners (see photograph). The size, shape and thermal performance of the windows were not appropriate for the new residential use. The new cladding, for the most part, is made up of precast concrete panels with larger windows with operable vents. There are now also some curtainwall infill panels and glazing. The slab edge was generally in good shape to receive the precast with the original connection points showing a modest amount of degradation. Most of the new insulation is glass batand the new windows are double glazed with operable lovres.

The rectangular floor plate measures 18.24 m.by 12.20 with a single side core centred on the west side. The physical features of the floor plate and side core allowed for nine or ten suites to be integrated into the 6.10 m.by 6.10 m. bays in a horseshoe configuration open to the west. About half of the units on each floor are lined up along the east wall and are accessed by the corridor running north and south. Balconies at the east wall have been set in from the building's perimeter as a way to increase glazed area without encroaching on the property line. This strategy also shortens the total depth of the unit by effectively moving the exterior wall in from the plate edge toward the corridor. The slab edge has a downturn beam which dictated the routing of some services along the perimeter and it provided the substrate for the attachment of the new precast panels. The suites themselves have received enlarged glazing areas compared to the original office set-up by lowering the sill to 0.61m. above the finished floor. Approximately 50% of the north, south and east facades are glazed. Some of the units on the upper levels feature inwardly angled glazing and terraces at the corners of the penthouse level further increase the amount of light to these suites.

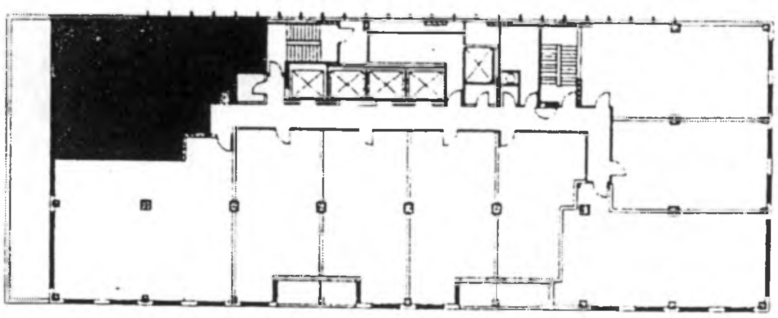
Most of the parking for condominium occupants is leased off-site. Nineteen parking stalls were created in the lowest level and these are accessed by a hydraulic vehicle lift that connects grade and basement levels. The remainder of the required parking is to be located in a surface lot 91.44 m. from the building.

Like many downtown building conversions from office to residential, parking was one of the most important issues. Great effort and expense was needed to provide just nineteen spaces within the building. Physically, the existing structure proved to be a good conversion candidate. Normal floor to floor heights for an office building translates to very good floor to floor heights for a residential building. A 18.29m by 45.72 m. plate is a good size and shape even with a side core. From a space planning point of view, the conversion at 102 Bloor was straight forward: retain retail and lobby areas at the ground level and divide the upper levels into suites according to the 6.10 m by 6.10mbay and existing core.

THE HAZELTON

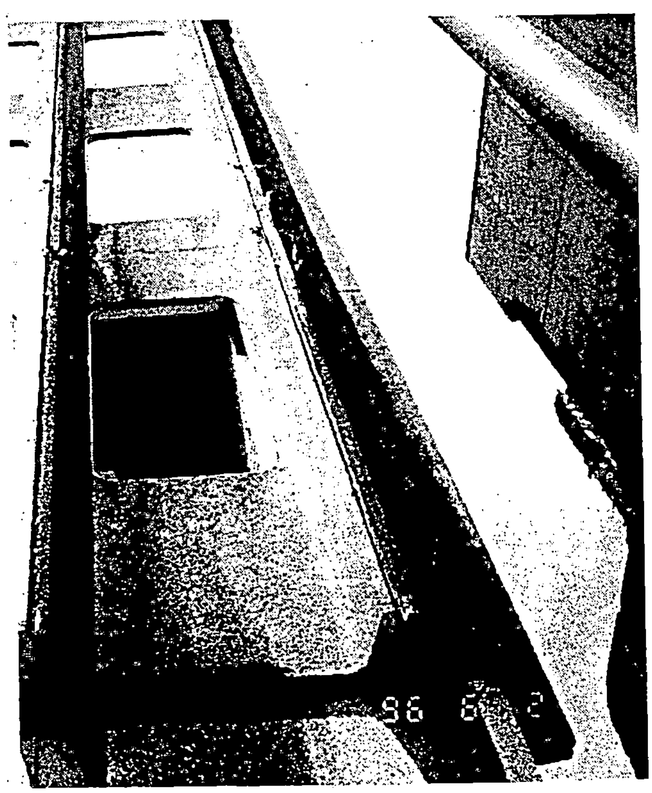


1235 sq.ft.

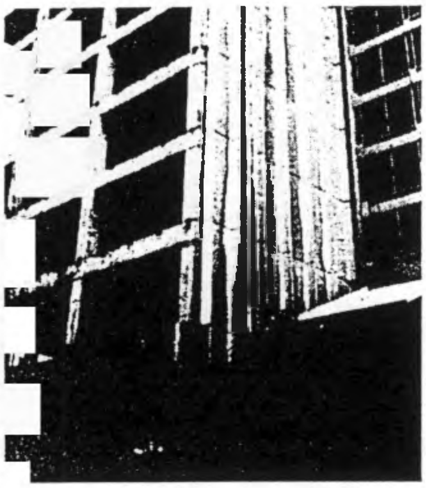


Suite-10 2nd to 8th floor
Suite-09. 9th to 16th floor

East Elevation Showing New Cladding System. Work in Progress on North Elevation



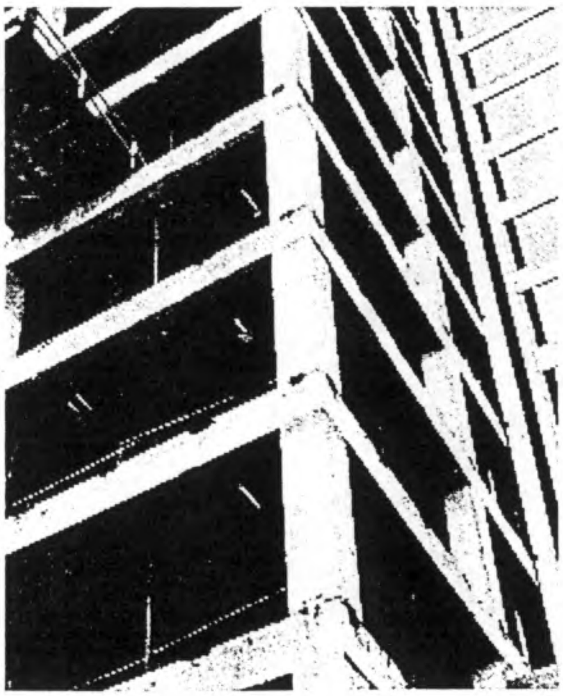
Original Wall and Window Precast Units Prior to Removal



Exposed Frame With Original Precast Still in Place

Bloor Street W. (South) Elevation

Installation of Windows



Exposed Structural Frame

Yonge Street Elevation South West Corner

TECHNOLOGICAL INFORMATION

PROJECT: **102 BLOOR STREET WEST**
ADDRESS: **102 Bloor Street West, Toronto, Ontario**
L+A DEVELOPMENTS CANADA
BURKA ARCHITECTS INC. (ARCHITECTURAL)
SIGMUND SOUDACK (STRUCTURAL)
A&G ENGINEERS (MECHANICAL AND ELECTRICAL)

			Previous (1966)	New (1996)
Structure	Substructure	Footings Piles Caissons	• Spread footings?	• No change
	Structural materials and framing systems	Horizontal Vertical	• Reinforced conc. slab • Reinforced conc. columns	• No change (Ground floor addition framed in steel)
Skin	Exterior Cladding	~~In situ~~ Prefab	• Precast conc. panels	• New precast panels + metal panels
	Fenestration	Windows - fixed/operable Curtain wall	• Fixed	• 2x glazed, tinted, operable louvres. • Yes (integrated)
	Insulation	Interior Exterior Composite		• Mostly batt, incorporated into cladding
Circulation	Vertical Circulation	Elevators - # multiple use - # dedicated use Escalators Stairs	• 4 • None • 2 towers	• 4 (one extended to basement) • No change • No change
HVAC	Mechanical systems	Heating Ventilation Cooling	• Central forced air • 14° floor mech. plenum removed.	• All new distribution. • Ensuite air con./heat control. • New large mech. p/h on roof.
Plumbing		Sanitary Water supply Stormwater	• Typ. for 1966 office.	• Some roof drain/risers re-used. • Some re-used storm pipes.
Power	Electrical systems	Transformation Distribution Emergency	• Typ. for 1966 office.	• New electrical distribution. • New emergency generated.
	Other			• Wired for cable and phone throughout. • No gas.
Lighting		Lighting - public areas - private areas	• Mostly fluorescents throughout office	• Combination (fluor., incandescent, halogen, etc.). All new.
Safety	Fire Safety	Ratings Stairs Alarm and Evacuation	• Typ. for 1966	• Some windows near property line sprinklered. • Pressurized stair and elevator shafts.
Interior	Partitioning	In situ ~~Demountable~~	• Combination	• Full ht. GWB, steel stud.
	Ceiling Systems	In situ Demountable	• Combination GWB/plaster	• GWB ceilings.
	Floor systems	Elevated		• Not elevated.
Sound	Sound control	Floors Walls Special	• No • No • No	• Not required. • To OBC between suites.

ARCHITECTURE/PLANNING DESIGN INFORMATION

PROJECT: **102 BLOOR STREET WEST**
ADDRESS: **102 Bloor Street West, Toronto, Ontario**
L+A DEVELOPMENTS CANADA
BURKA ARCHITECTS INC. (ARCHITECTURAL)
SIGMUND SOUDACK (STRUCTURAL)
A&G ENGINEERS (MECHANICAL AND ELECTRICAL)

			Previous (1966)	Current (1996)
	Use	Single ~~Multiple~~	• Offices • Street Retail	• 1,207 Residential condo units (+ Health Club, café, amenities).
	Use & occupancy		• Offices + Retail	• Residential and retail.
	Gross Floor Area	Major Use ~~Minor Use~~	• 13,378.09 s.m. • Street	• 13,378.09 s.m. • Approx. 929.03 s.m. retail @ at street.
	Site Ratio		• 15x	• 15x
	Coverage		• 100%	• 100%
	No. of Storeys	Above grade Below grade	• 14 • 1 basement	• 15 • 1 basement
	Floor Plate Configuration	Shape Atrium Other features	• Rectangle • No • No	• No change.
	Structural Grid Dimensions	Column spacing Shear walls	• 6.10 m x 6.10 m typical bay • No	• No change.
	Floor Plate Depth	Exterior wall to core Length Width	• 12.19 m • 45.72 m • 18.29 m	• No change.
Service	Service Core Type	Single Split	• Single	• No change.
	Core Location	~~Centre~~ Side Off-Centre ~~Multiple~~ Core to floor ratio	• Centre of west side • NA	• No change.
	Fire Safety	Active -sprinklers Passive -shutters/dampers Smoke extractor Fire walls Rated assemblies		• Sprinklered.
	Typical Floor to Floor Height	Basement Floors Lower Floors Upper Floors	• 3.51 m (typ)	• No change except mech. mezz. removed to make 2 level p/h.
	Aspect	~~Single~~ ~~Double~~ Multiple	• 3 sides	• 3 sides.
	Fenestration	Glazing to wall ratio Glazing to floor ratio Head height Sill height	• <50% • 2.67 m (typ) • 0.76 m (typ)	• 50% at N, S, and E façades (much less at W) • 2.54 m (typ) • 0.61 m (typ)
	Vertical Circulation	Elevators Stairs	• 4 passenger • 2 stair towers	• Retained and refurbished (1 extended to basement.) • Retained (new railings).
	Parking	Surface Basement Above grade Remote	• Yes, adjacent to building. • No • No • Yes	• 19 spaces u/g (car lift to be installed). • Some lower level bicycle parking. • More parking to be leased off-site.

The Ramsden

The two buildings at 950 and 980 Yonge Street located in central Toronto are collectively known as The Ramsden. They are presently being converted from office space into 45,717 s.m. residential condominiums with some retail space on the street level. The towers are ten and eight storeys and share a two level podium with a parkade below. The taller south tower has a single side core located along the north wall. The other tower has a central core with a corridor surrounding on all but the west side.

The project was first built in 1961 using primarily a waffle slab construction system. The two-way slabs were formed, cast and lifted into place and fixed using square section steel columns around the perimeter and a 6.45 m. by 7.62m. typical bay structural grid of steel columns. The foundations and footings are constructed with poured-in-place concrete.

The design for conversion called for the original skin to be almost entirely removed except for the cast-in-place spandrels on the north tower. These spandrels were cut down where required to make room for lower sills. The precast panel cladding system and fixed single pane glazing is to replaced with a new exterior insulating finishing system and double glazed windows with operable slides. The new windows are thermally broken with aluminium frames. The old precast was suffering from corrosion at the connection points to the slab and the sill heights that were appropriate to the office use were too high for the new residential windows. The old envelope was generally not up to current performance standards, particularly with respect to thermal insulation. Before recladding, the slab edge was inspected and after some minimal upgrading and cleaning the new skin could be installed.

Part of the rehabilitation for the building involved structural modifications to improve the lateral stability. Specifically, the elevator core in the north tower has received steel plates, and the south structure had additional steel cross-bracing installed.

Original construction documents and detailed as-built information were not readily available to the designers. As a result, a number of issues affecting the physical conversion had to be resolved as they became apparent. For example, early on in the project it was not clear that the steel perimeter columns were fully outside of the slab in plan view. When this became appar ent, the suite planning and construction details had to be reconfigured to deal with the additional 254 mm. band of area around each floor.

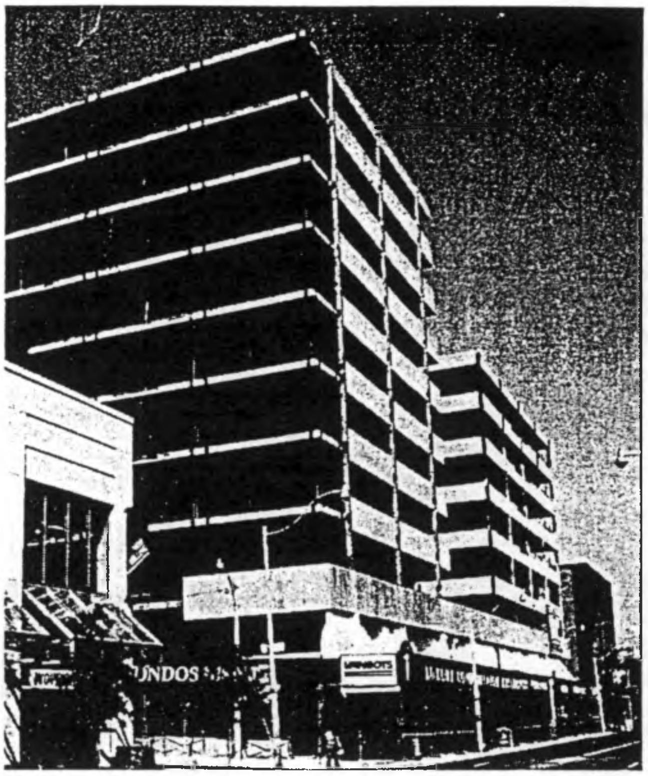
The location of vertical circulation has not been significantly altered, but a shuttle elevator connecting the two lowest levels is being installed. One of the existing stair towers has been extended to the roof terrace and equipped with a lift for wheelchairs.

The heating and cooling for the residential units is a new heat pump system. Previously, the office floor had a perimeter hot water system for heating that included some asbestos which had to be carefully removed. In terms of fire safety, the new building will be fully sprinklered throughout public and private areas.

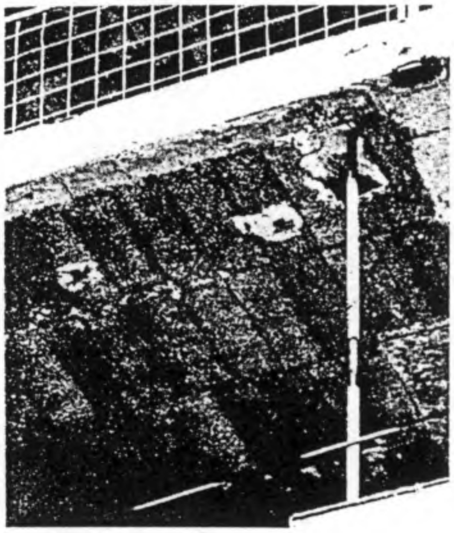
Acoustically, the sound attenuation provided by the relatively thin concrete floor slabs has been bolstered by installing a drywall ceiling system on acoustic hangers leaving 9' clearance from floor to ceiling.

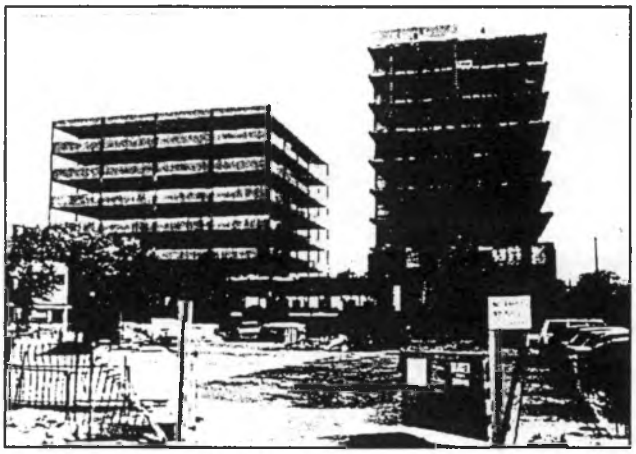
The supply of parking is being increased for the residential occupants by introducing a new vehicle ramp off of Frichot Street down onto the ground level parkade. This will provide parking on the west half of the floor plate behind the street level retail units. The alteration involves the removal of some existing structure, the addition of some new block wall, some lateral bracing and a new concrete topping on a waterproof membrane. The lowest level floor plate retains the parking throughout along with the two tower cores and some bank storage.

Removal of Precast on Yonge Street Elevation

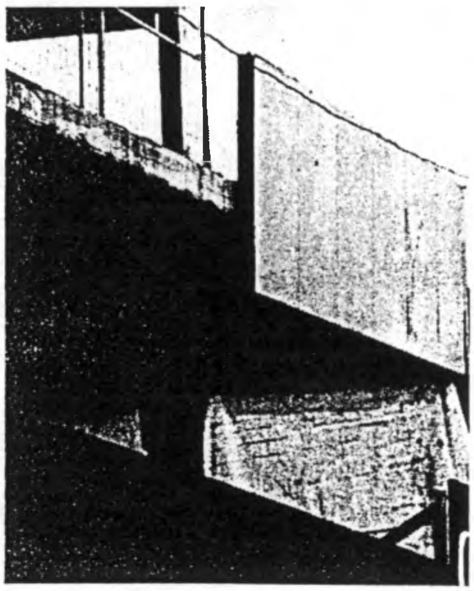


Underside of Exposed Composite Floor Slab
Note Brace



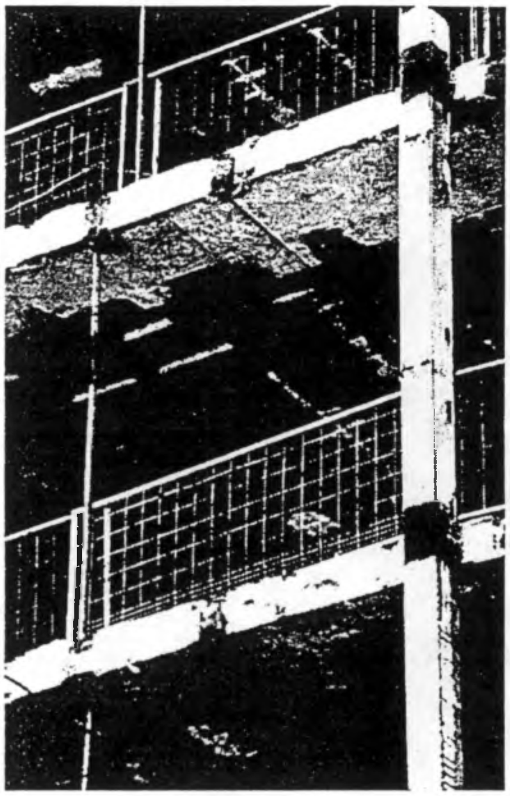


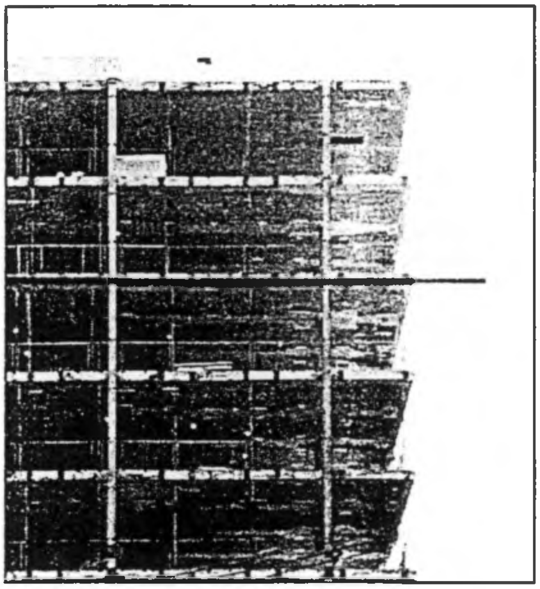
View of Towers From the West Showing
Partial Removal of Rear Extension to Podium



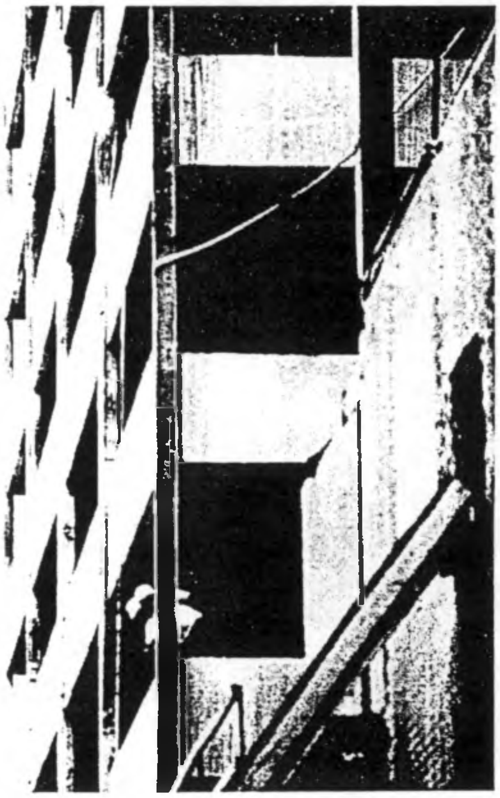
Original Precast Panel Prior to Removal

Detail of Slab Edge Showing Original Anchor Plates. Note External Perimeter Location of Steel Columns.

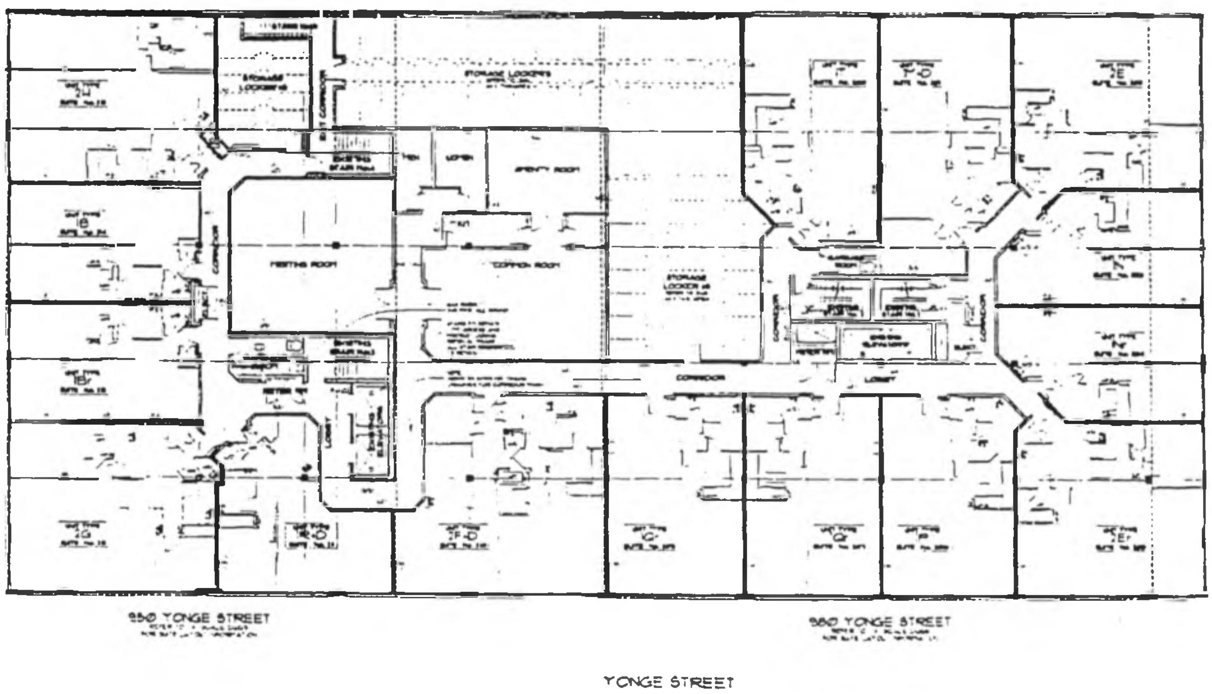




Perimeter Location of Structural R.H.S. Columns. Structure is Completely Exposed



R.H.S. Structural Columns - Note No Fireproofing to Steel



Floor plan

TECHNOLOGICAL INFORMATION

PROJECT: **THE RAMSDEN**
ADDRESS: **950 and 980 Yonge Street, Toronto, Ontario**
STANDARD LIFE ASSURANCE
YOUNG+WRIGHT (ARCHITECTURAL)
RJC (STRUCTURAL)
MCW (MECHANICAL + ELECTRICAL)

			Previous (~1961)	New (1996)	
				950 Yonge (south tower)	980 Yonge (north tower)
Structure	Substructure	Footings Piles Caissons	• Reinforced concrete footings and perimeter	• No change	• No change
	Structural materials and framing systems	Horizontal Vertical	• Two-way conc. slab • Steel columns.	• Existing • Some new lateral X-bracing	• Existing • Some new lateral bracing (steel plates at elevator core)
Skin	Exterior Cladding	In situ Prefab	• Pre-cast conc. panels.	• EIFS	• EIFS (precast spandrels retained/ modified).
	Fenestration	Windows - fixed/operable Curtain wall	• Single pane glass, operable vents	• New operable aluminum frame.	• New operable aluminum frame.
	Insulation	Interior Exterior Composite		• Part of EIFS.	• Part of EIFS.
Circulation	Vertical Circulation	Elevators - # multiple use - # dedicated use Escalators Stairs	• No • 4 total	• No • 2	• New P1→ground shuttle elevator added. • No • 2 (1 stair extended to roof with H/C)
HVAC	Mechanical systems	Heating Ventilation Cooling	• Hot water peerimeter	• All new - heat pumps with individual control	• Same as 950.
Plumbing		Sanitary Water supply Stormwater		• All new	• All new
Power	Electrical systems	Transformation Distribution Emergency		• New electrical room and equipment.	• Same as 950.
	Other				
Lighting		Lighting - public areas - private areas	• Mostly fluorescent	• Standard res.	• Standard res.
Safety	Fire Safety	Ratings Stairs Alarm and Evacuation	• To 1961 code.	• All res. units, retail and public spaces are sprinklered.	• Same as 950.
Interior	Partitionong	In situ Demountable		• Fixed GWB, steel stud.	• Fixed GWB, steel stud.
	Ceiling Systems	In situ Demountable	•	• 2.74 m ceiling hung off u/s slab.	• Same as 950.
	Floor systems	~~Elevated~~	• Top of slab	• Finish on slab.	• Finish on slab.
Sound	Sound control	Floors Walls Special		• Acoustic ceiling hangers throughout.	• Same as 950.

ARCHITECTURE/PLANNING DESIGN INFORMATION

PROJECT: **THE RAMSDEN**
ADDRESS: **950 and 980 Yonge Street, Toronto, Ontario**
STANDARD LIFE ASSURANCE
YOUNG+WRIGHT (ARCHITECTURAL)
RJC (STRUCTURAL)
MCW (MECHANICAL + ELECTRICAL)

	Classifications and Divisions		Previous (~1961)	Current	
				950 Yonge (south tower)	980 Yonge (north tower)
	Use	Single Multiple	• Offices	• 125 Condo (Res) plus retail	
	Use & occupancy		• Office Building	• Residential/retail	
	Gross Floor Area	Major Use ~~Minor Use~~	• 13,490 s.m.	• 13,063 s.m. residential s.f. • 836 s.m. retail • 13,808 s.m. total	
	Site Ratio				
	Coverage			• 13,900 s.m. (22 ha)	
	No. of Storeys	Above grade Below grade	• Same	• 10 • 1	• 8 • 1
	Floor Plate Configuration	Shape Atrium Other features	• Same	• Square • No • Roof terrace	• Rectangle • No • Same as 950 plus shallow 3rd flr. terr.
	Structural Grid Dimensions	Column spacing Shear walls	• 6.45 x 7.62 m <typ>	• 6.45 x 7.62 m <typ>	• 6.45 x 7.62 m <typ>
	Floor Plate Depth	Exterior wall to core Length Width	• Same	• 18.54 m max. • 32.26 m • 21.64 m	• 15.24 m max. • 32.26 m" • 30.48 m
Service	Service Core Type	Single Split	• Same	• No change	• No change
	Core Location	Centre Side Off-Centre Multiple Core to floor ratio	• Multiple	• Side core retained • 5.1%	• Centre core retained • 5.4%
	Fire Safety	Active -sprinklers Passive -shutters/dampers Smoke extractor Fire walls Rated assemblies		• Same as 980	• Sprinklered throughout (res. suites, retail, and common areas).
	Typical Floor to Floor Height	Basement Floors Lower Floors Upper Floors	• Same	• 2.79 m • 4.27 m, 3.73 m, 3.73 m • 3.43 m	• 2.79 m • 14', 4.27 m, 3.73 m, 3.73 m • 3.53 m
	Aspect	Single Double Multiple	• Multiple		• Multiple
	Fenestration	Glazing to wall ratio Glazing to floor ratio Head height Sill height	• <0.91 m	• Approx. 50% (3 sides) • 3.43 m • 0.56 m	• Approx. 60% (4 sides) • 3.43 m • 0.56 m
	Vertical Circulation	Elevators Stairs	• 4 total • 5 total	• 2 existing • 1 realigned • 2 existing	• 2 existing (plus one parkade shuttle added) • 2 existing (1 extended to roof with H/C))
	Parking	Surface Basement Above grade Separate Structure Remote	• Approx. 50 spaces in basement parkade	• 89 stalls in below grade parkage (1½ levels). • 94 bicycle parking	

The Delta Hotel

The Delta Hotel in downtown Montreal is a twenty-three storey tower with approximately 30658.135m. of floor space. At the base of the tower is a 6 level podium that occupies the site along Rue City Councillors bound by Sherbrooke Street to the west and Avenue du President Kennedy to the west. The street level drops down to the southeast revealing between one and two upper levels of the podium.

Over a ten a year period, the building underwent a number of substantial changes. In the early 1970's, three levels of underground parking were constructed along with some office and mixed use spaces. Later, the podium was completed and the first two levels of the tower were added. The third development involved completing the tower to 23 levels to be used as residential units. Although the concrete tower structure was topped off for this purpose, it remained essentially incomplete. A number of economic and political issues were at play and the residential condominium construction was halted.

The starting point for the conversion to a hotel was a basic concrete shell at the podium levels and an incompletely clad tower. The 6.10m. by 5.18m. structural grid built to receive residential units was ample space for the conversion to hotel suites. A typical tower floor plan has twenty-two units and a central corridor with stairs at both ends and a core with five elevators centrally located on the north side. When the conversion to hotel began, some of the floors had already been partitioned for condominiums. Generally, the single bedroom units were cut in half to make two hotel suites and the two bedroom units were cut into three. The resulting rooms are quite large by traditional hotel standards. The corner units were expanded into the balcony zone creating slightly more interior area per floor plate. This involved removing the existing wall, levelling the concrete floor which was originally outside, and then rebuilding the exterior wall.

In terms of suite layout, the strategy was straight forward. The washrooms were generally left in position allowing the reuse of plumbing stacks and some fixtures. Any floor finishes that had been installed were removed along with cupboards, vanities, tiled areas, the non-load bearing partitions, base boards, and so on. The major items retained for the conversion were the windows, exterior walls, some metal doors and frames, and sliding doors.

The podium, which was previously designed for smaller space partitioning than the hotel base required, needed to be opened up for new spaces such as the hotel kitchen and dining areas and the large banquet room. At the dining and convention level, columns were removed to create a larger span area just north and west of the tower footprint.

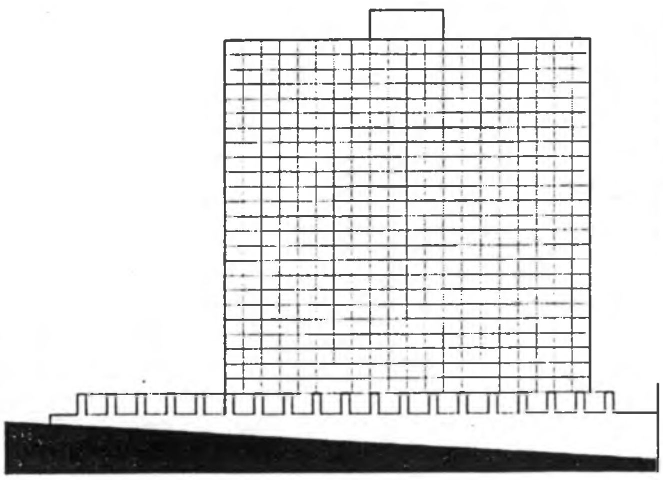
Internal circulation routes through the podium and tower were generally not changed. The increase of units and occupants per floor plus the more intense peak circulation times that come with the new use required greater elevator service. Two additional elevators were installed in the tower to cope with the change. These are located at the existing core which was expanded to the east. The tower fire exit stairs were not changed.

Cladding the tower was a matter of completing the unfinished installation of panels and windows. Precast concrete panels, insulation and glazing completed the tower envelope in much the same way as originally planned for the condominiums.

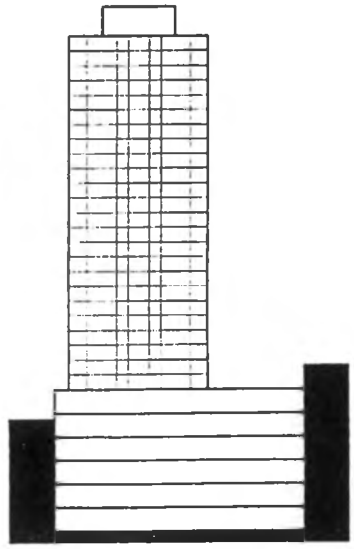
Mechanical equipment sized for the residential tower and lower levels all had to be upgraded in order to move more air through the hotel building. The conversion from residential use to hospitality use created a number of larger rooms for gathering and dining and consequently put larger demands on the services needed to ventilate, cool and heat these spaces. Changes in the electrical requirements were generally not as dramatic as the changes to the mechanical systems.

In general, the conversion of the residential building into a hotel was not difficult. In terms of spatial planning, the tower was simply repartitioned into a finer grain of units. In a sense, the reverse process happened in the podium where spaces needed to be enlarged. This presented difficulty where structure was interrupted. The overall circulation routes were not substantially changed. The decisions dealing with what to keep from the original use and what not to where made by continually calculating the cost and benefits.

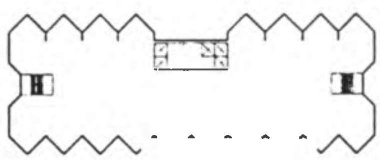
DELTA



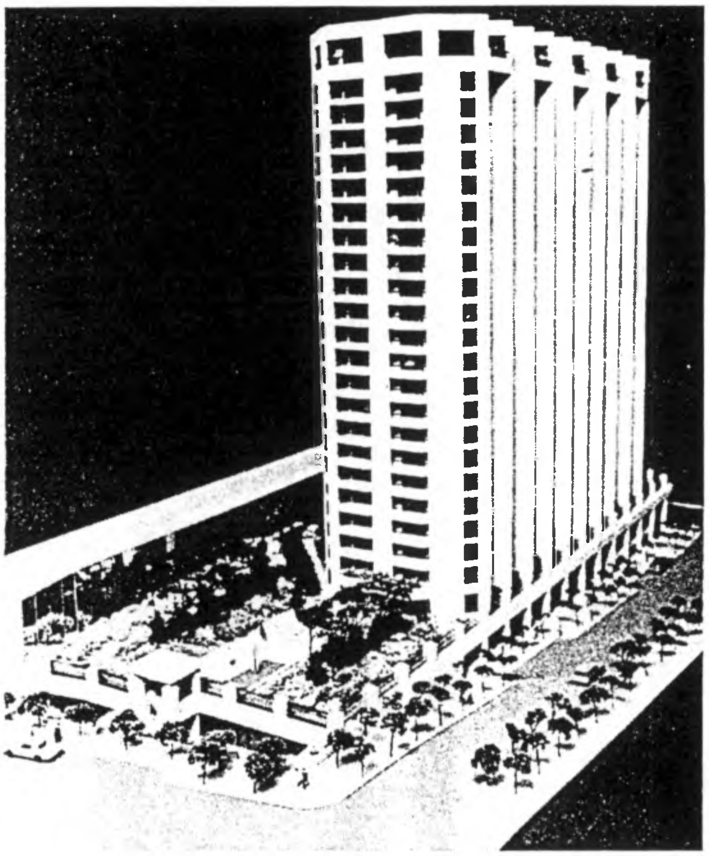
Schematic Elevation



Schematic Section Showing
Underground Parking Levels



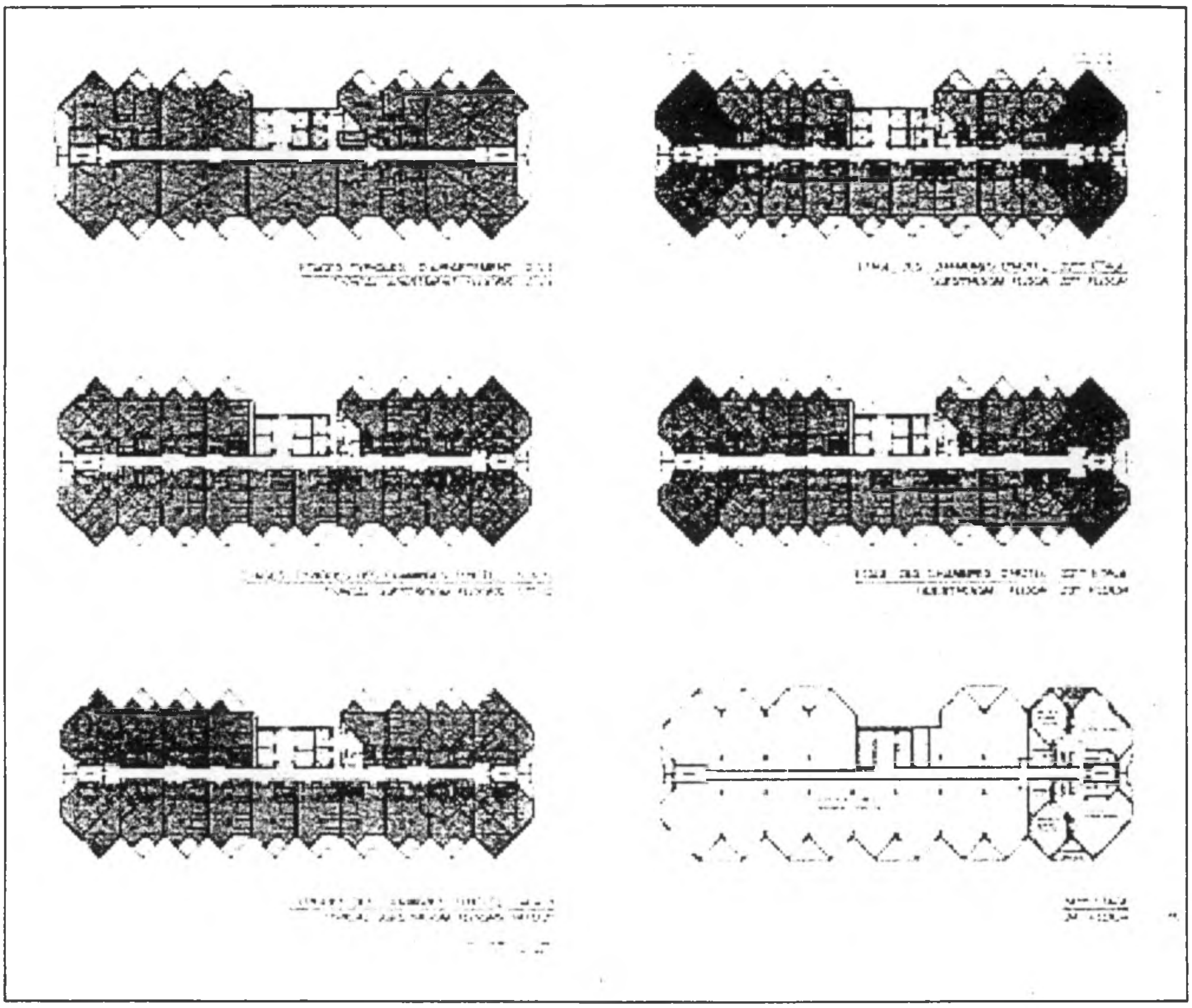
Original Plan Profile



Model Showing Overall Site Development

Original Condo Tower Following Conversion

Retail (Support) at Podium Level



Typical Floor Plan

TECHNOLOGICAL INFORMATION

PROJECT: **DELTA HOTEL**
ADDRESS: **Montreal, P.Q.**
CRESON DEVELOPMENTS/DELTA HOTELS
YOUNG + WRIGHT (ARCHITECTURAL)
JAB INC. ((MECHANICAL AND ELECTRICAL)

			Previous (1980s)		New (1986)	
			Podium	Tower	Podium	Tower
Structure	Substructure	Footings Piles Caissons	• Conc. footings		• No change	
	Structural materials and framing systems	Horizontal Vertical	• Conc. slab • Conc. col. & shear walls	• Conc. slab • Conc. col. & shear walls	• Some larger spans. • Some new vert. structure.	• No change to slab + columns.
Skin	Exterior Cladding	In situ Prefab	• Precast conc. panels	• Precast conc. panels (incomplete)	• No change	• Tower cladding completed
	Fenestration	Windows - fixed/operable Curtain wall	• 2x glazing	• 2x glazing (incomplete)	• No major change	• Operable aluminum frame.
	Insulation	Interior Exterior Composite		• Incomplete	• Largely unchanged	• Rigid & batt
Circulation	Vertical Circulation	Elevators - # multiple use - # dedicated use Escalators Stairs	• No • 5 total	• 4 total • No • 2	• 6 total • No • 6 total	• 5 total (2 new) • 2
HVAC	Mechanical systems	Heating Ventilation Cooling		• Incomplete	• Increased air handling capacity required for hotel.	
Plumbing		Sanitary Water supply Stormwater		• Incomplete	• W/C in suites no change in location, some stacks and fixtures re-used.	
Power	Electrical systems	Transformation Distribution Emergency		• Incomplete	• Same transformer. • Some changes to distribution.	
	Other					
Lighting		Lighting - public areas - private areas		• N/A	• Fluorescents plus others.	• Pot lights, incandescent fixtures, etc.
Safety	Fire Safety	Ratings Stairs Alarm and Evacuation			• To Code (1985)	• Sprinklered
Interior	Partitioning	In situ Demountable		• Fixed	• Fixed GWB	• Fixed GWB
	Ceiling Systems	In situ Demountable	•	• Incomplete	• Acoustic tile on T-Bar and fixed GBW and spraytex	• Fixed ceiling system (stucco finish on plaster board and "spraytex" on u/s slab.
	Floor systems	Elevated	• Top of slab	• Finish on slab		• Finish on slab
Sound	Sound control	Floors Walls Special				• Acoustic batt

ARCHITECTURE/PLANNING DESIGN INFORMATION

PROJECT: **DELTA HOTEL**
ADDRESS: **Montreal, P.Q.**
CRESON DEVELOPMENTS/DELTA HOTELS
YOUNG + WRIGHT (ARCHITECTURAL)
JAB INC. ((MECHANICAL AND ELECTRICAL)

			Previous (1980s)		Current (1986)	
			Podium	Tower	Podium	Tower
	Use	Single Multiple	• Residential condominiums		• Hospitality suites (418 rooms)	
	Use & occupancy		• Residential		• Hotel	
	Gross Floor Area	Major Use Minor Use	• 30,658.13 s.m. res.		• 30,658.13 s.m. hotel	
	Site Ratio		• 6 approx.		• No change	
	Coverage		• 100%		• 100%	
	No. of Storeys	Above grade Below grade	• 1½ • 4½	• 23	• No change	• No change (new mech. p/h)
	Floor Plate Configuration	Shape Atrium Other features	• Large rectangle	• Rectangle (saw toothed) • No	• Large rectangle	• Rectangle (saw toothed) • No • Smaller units for hotel.
	Structural Grid Dimensions	Column spacing Shear walls	• 6.10 x 9.14 m • Several	• 20'x17' and 20'x10'	• Same grid (some changes to accommodate hotel use)	• 6.10 x 5.18 m and 6.10 x 3.05 m
	Floor Plate Depth	Exterior wall to core Length Width	• 106.99 m • 33.83 m	• 32' max. • 210' • 75'	• No change	• No change.
Service	Service Core Type	Single Split	• Split	• Single	• Split	• Single
	Core Location	Centre Side Off-Centre Multiple Core to floor ratio	• Multiple	• Side-centre	• Multiple	• Side-centre (enlarged)
	Fire Safety	Active -sprinklers Passive -shutters/dampers Smoke extractor Fire walls Rated assemblies	• Sprinkler to Code (1985)		• Sprinklers to Code (1985)	
	Typical Floor to Floor Height	Basement Floors Lower Floors Upper Floors	• 3 @ approx. 2.74 m • 4.57 m, 3.35 m • Dining level 4.57 m	• 3.35 m (plaza) • 2.74 m (20→21) 3.05 m(22, 23, 24)	• Same	• Same
	Aspect	Single Double Multiple	• Double	• Multiple	• Double	• Multiple
	Fenestration	Glazing to wall ratio Glazing to floor ratio Head height Sill height		• 30%	• Varies • Varies	• 30% • 2.08 m typ for suites • 2.30 m typ for suites
	Vertical Circulation	Elevators Stairs	• 6 • 5 (plus minor stairs)	• 4 in tower	• 8 total • 6 total	• 5 tower • 2
	Parking	Surface Basement Above grade Separate Structure Remote	• 3 levels	• None	• No change	