Uniqube Housing System

Prepared for:

Canada Mortgage and Housing Corporation
Project Implementation Division
682 Montreal Road
Ottawa, Ontario
K1A 0P7

Prepared by:

Uniqube Inc. (Ben Kutner)

September 9, 1990

This project was carried out with the assistance of a grant from Canada Mortgage and Housing Corporation under the terms of the Housing Technology Incentives Program (HTIP). The views expressed are those of the author and do not represent the official views of the Corporation.

IMPLEMENTATION OF THE

UNIQUBE HOUSING SYSTEM

HOUSING TECHNOLOGY INCENTIVES PROGRAM

UNIQUBE INC.

CMHC FILE 6521-22/88/Uniqube Inc.

September 9, 1990

This project was carried out with the assistance of a grant from Canada Mortgage and Housing Corporation under the terms of the Housing Technology Incentives Program. The views expressed are those of the author and do not represent the official views of the corporation.

TABLE OF CONTENTS

ABSTRACT

Implementation of the Uniqube Housing System was prepared by Uniqube Inc. through funding made available through the Housing Technologies Incentives program, and was completed in 1990.

This report examines the issues surrounding the construction of an innovative form of housing. In the process of developing a prototype module, alternative construction methods were proposed, prior to the adaptation of a specific method. Computer modeling and testing was undertaken to verify the structural capacity of the module.

The feasibility of constructing Uniqube housing, through the application of existing products, applied in an alternative context was demonstrated.

EXECUTIVE SUMMARY

This study examined building systems as applied to the implementation of an innovative building form. The material includes an evaluation of the alternative systems proposed, and the results of implementation of one of the systems in the construction of a prototype module.

The major findings and recommendations are as follows:

(a) **Construction Systems as Applied to the Uniqube project configuration.** A number of available construction systems can be used to build Uniqube-form housing.

(b) **Appropriate Type of Building System.** It was determined that the most appropriate building systems were those which placed a minimum reliance upon specialized, high-technology building products and systems, and required labour with limited specialization.

(c) **Feasibility.** It was determined that the Uniqube system could be built within the constraints of the construction system utilized.

BACKGROUND STATEMENT

Project Concept

The Uniqube concept is a building system of interconnected cubic modules, which can provide uniquely functional spatial enclosures in a variety of urban applications. As living spaces, these unconventional forms not only provide the essential physical features of the conventional house and apartment, (for example, 1,200 square feet of floor space, the basic internal separation of functions, storage,...) but also embody the essential qualities of urbanism as described by William Thursell, editor of the Globe and Mail, "complexity, propinquity, and density."

As a new building typology, these cubic forms on their tree-like base structures introduce a new spatial relationship between the house-form, the group plane, and neighbouring units and forms. The Uniqube ;system introduces a new means to utilize urban spaces while providing continued accessibility to the areas beneath this "Living Roof".

Need for this work

The work done with respect to this project explored the suitability of available construction technologies with regards to new building forms. This is a low-risk method of expanding the use of existing manufactured products and methods.

Who will benefit from the results

The results of this study have indicated that available methods can be utilized to for the basis of new building forms. The beneficiaries of this work are the manufacturers of such products, and designers who may be contemplating such applications.

PROJECT OBJECTIVES

The objective of this project was to fabricate and test a prototype module within the context of a real project in order to resolve design concepts, develop specifications, and optimize methods for manufacturing and installation of the Uniqube building system.

The cladding system will be designed to perform as either an exterior wall or roof.

The project will utilize available construction technology, process, and available products, within the context of a new building form.

SYSTEM AS CONSTRUCTED AND TESTED

History of the Cube System

The general configuration of housing as studied was pioneered by Piet Blom in the Netherlands, where two projects have been completed. In Rotterdam. Blom integrated the clustered cubic forms into a project providing low-cost housing and community facilities, above a school and commercial complex. This unique project doubles as a bridge spanning a six-lane arterial road and providing a pedestrian walkway and concourse. In another integrated project in Helmond, called "d'Speilhus" (the Playhouse), housing units are combined with a live theatre and creative arts centre, and community facilities.

These projects offered distinctive community environments, however the methods of construction employed were conventional. A poured-in-place concrete structure carried the floors of the cube. The cube surfaces were attached to the concrete structure; carrying their own loads alone. The cladding of the cubes was conventional shingles and wood.

The first models were built with the following components as separate systems:

- Floor system structure
- Cube structure
- Cube cladding

Uniqube recognized that efficiencies could be obtained through integrating some of these building elements.

Original System Proposal

The original program submission projected the utilization of a panelized system, using porcelain-on-steel cladding, over a structural steel frame. The cladding system was designed to be totally independent of the steel frame, in order to allow a variety of different exterior materials. Unfortunately the manufacturer of the porcelain cladding was unable to arrange for a subcontractor to undertake the installation of the cladding at the previously agreed budget. The installers estimated using conventional construction approaches with full scaffolding and extensive on-site labour for installation of each

component. Similarly, the structural fabricator, while agreeing to manufacture the structural frames at budget, would not agree to supply the cladding, nor the erection of the modules, since this function is usually performed by a subcontractor. Similarly, crane erectors consulted, were unwilling to provide estimates prior to the completion and testing of a prototype module. These difficulties created major issues with regards to cost, and further assessment was undertaken with regards to the appropriateness of the originally proposed system.

A second system utilizing 'Polysteel' insulating foam panels with embedded steel joists was also reviewed. This proprietary system is used to construct industrial and commercial buildings. The cube-form was evaluated by Polysteel who were prepared to undertake a prototype project, if and when a site became available. The issue with regards to the notion of prototype construction recurred a number of times. Manufacturers of building products are generally unwilling to invest in research and development which might develop their products, or to adapt their systems to specific design. Therefore the notion of prototype or mock-up tended to become a more conventional project, in which the issues of site, building permits, zoning, financing, and viability, rather than the technology, would dominate the project. There was no question that the Polysteel system was generally compatible with the design. and, because of problems encountered in developing the necessary construction system, was also abandoned.

The major problems encountered with obtaining suitable contractors and suppliers, lead to the development of an alternative construction system, based on a concept which was not limited to specific suppliers.

System as Constructed

Three months of work went into resolving the design and system issues and two alternative schemes were identified as being most practical from a fabrication and installation viewpoint.

These alternatives were:

(a) fabrication and erection of structural frame components followed by attachment of partially or fully panelized roof and wall cladding with conventional or near-conventional joint connections, flashing, and other construction details.

(b) prefabrication of three-sided corner modules (eight per cubic unit) incorporating a fully integrated structural frame within roof and wall cladding panels.

Scheme (b) was chosen as it offered substantial savings with respect to the on-site finishing of joints and surfaces by means of completing the installation of all cladding components and corner joints in-plant. The provision of a continuous membrane which would act as both rain screen and joint covering would eliminate all on-site requirements for flashings and other miscellaneous metal work. Consultations were undertaken prior to the preparation of working and shop drawings to clarify the details of the proposed module components and the construction methodology.

When the utilized system is compared with the original method, the following major differences can be discerned.

Original Proposal:

- high skill level required
- high level of material 'fit' required
- close tolerances required
- separate structure, insulative system, rain screen

Revised System:

- lower skill level required throughout assembly of system
- no scaffolding required
- minimal on-site assembly in main system
- less reliant on specific suppliers and contractors

Fibrecrete / ThermoSteel Product Technologies

The Uniqube system as built and tested utilized two existing products, in order to create the structural and environmental separations necessary to form the roof/ wall system required for the Uniqube concept.

Fibrecrete Panel Component

The Fibrecrete panel is designed using several standard building material technologies.

Starting with the exterior surface the Fibrecrete panel consists of the following elements:

- Fibrecrete exterior wall system, 20 mm thick, consisting of a preformed cementitious base coat with a steel mesh matrix, and a coloured finished coat. Various alternative finish coats are possible.

- ThermoSteel stud frame of formed galvanized trussed steel metal studs

- 12 mm airspace between the concrete facing and insulation material

- 152 mm friction fit fibreglass batt insulation

- drywall

ThermoSteel Structural Components

ThermoSteel structural steel framing was utilized as an integral part of the wall system tested. It is a one piece steel framing element formed into a truss-shape. It is easily assembled using screw guns and self-tapping screws. The elements are hot-dip galvanized.

Overall Design Evolution

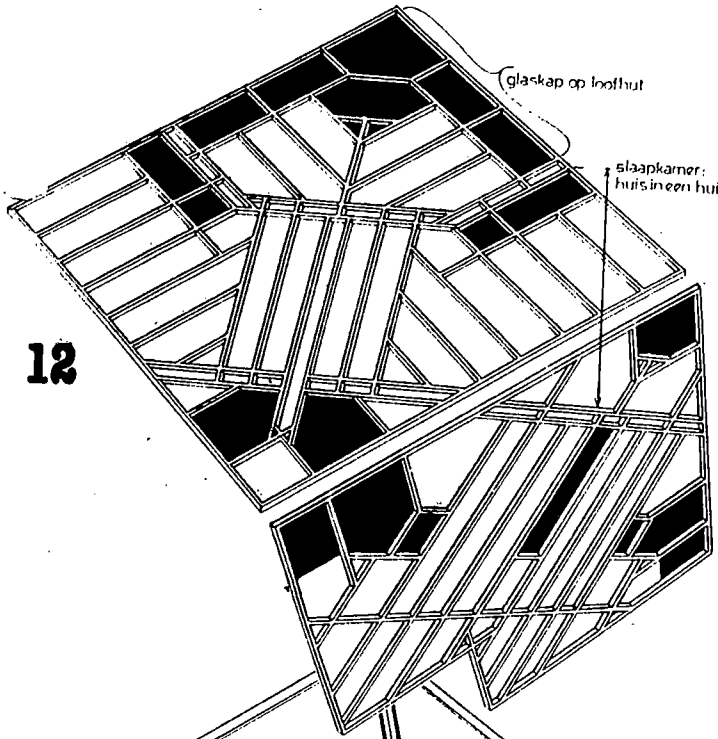
In conjunction with the changed construction method, the overall design concept evolved accordingly. The system made of Hollow Structural Sections encouraged an overall structure of interdependent cube elements. With the change to the ThermoSteel/Fibrecrete system, the concept changed to independent structures, each being totally self-supporting. As cubes will almost inevitably built in clusters, the interlocking will form very strong and stable buildings.

Drawings

Drawings are included, showing how the system was assembled. Computer aided design and three dimensional modelling was used in conjunction with design drawings and shop drawings.

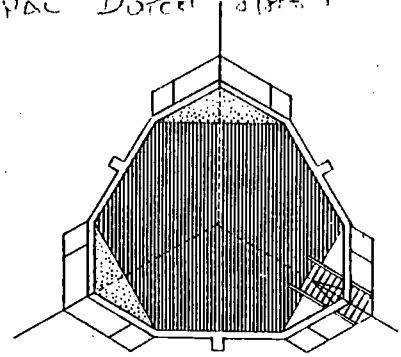
ORIGINAL DUTCH SYSTEM

12



loofhut 1020+

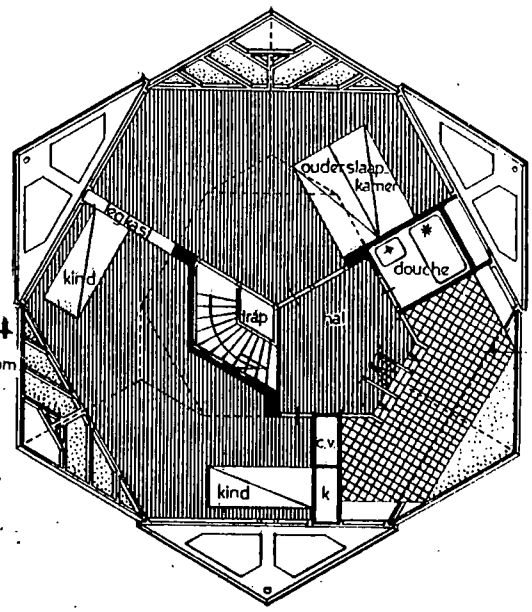
18m² bedoeld als tuin in huis/als slaapkamer te interpreteren voor hen die een open hemelhuis willen)

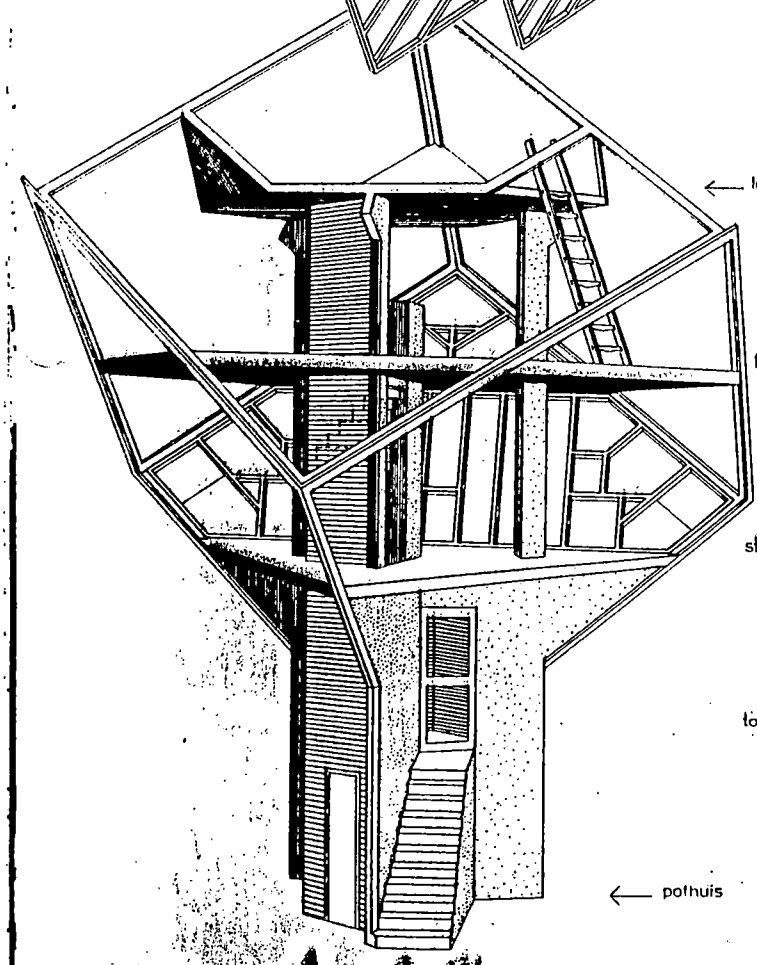


verhoogd vloertje naar loofhut waaronder berging

hemelhuis780+

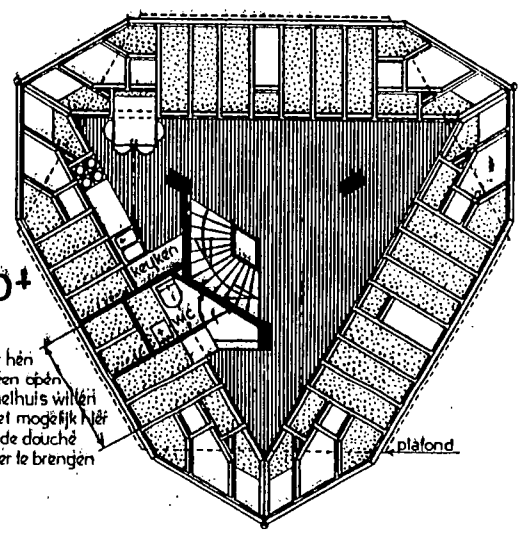
60m², de ruimte die geschikt is om onder te verdelen





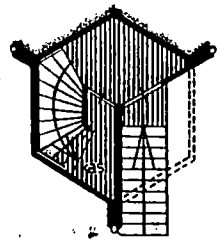
straathuis 520+

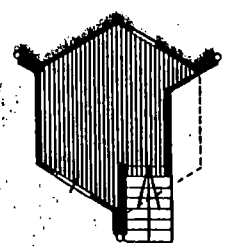
24m² algemene woonruimte



vóór hen die een open hemelhuis willen is het mogelijk hier ook de douche onder te brengen

220+ toegang



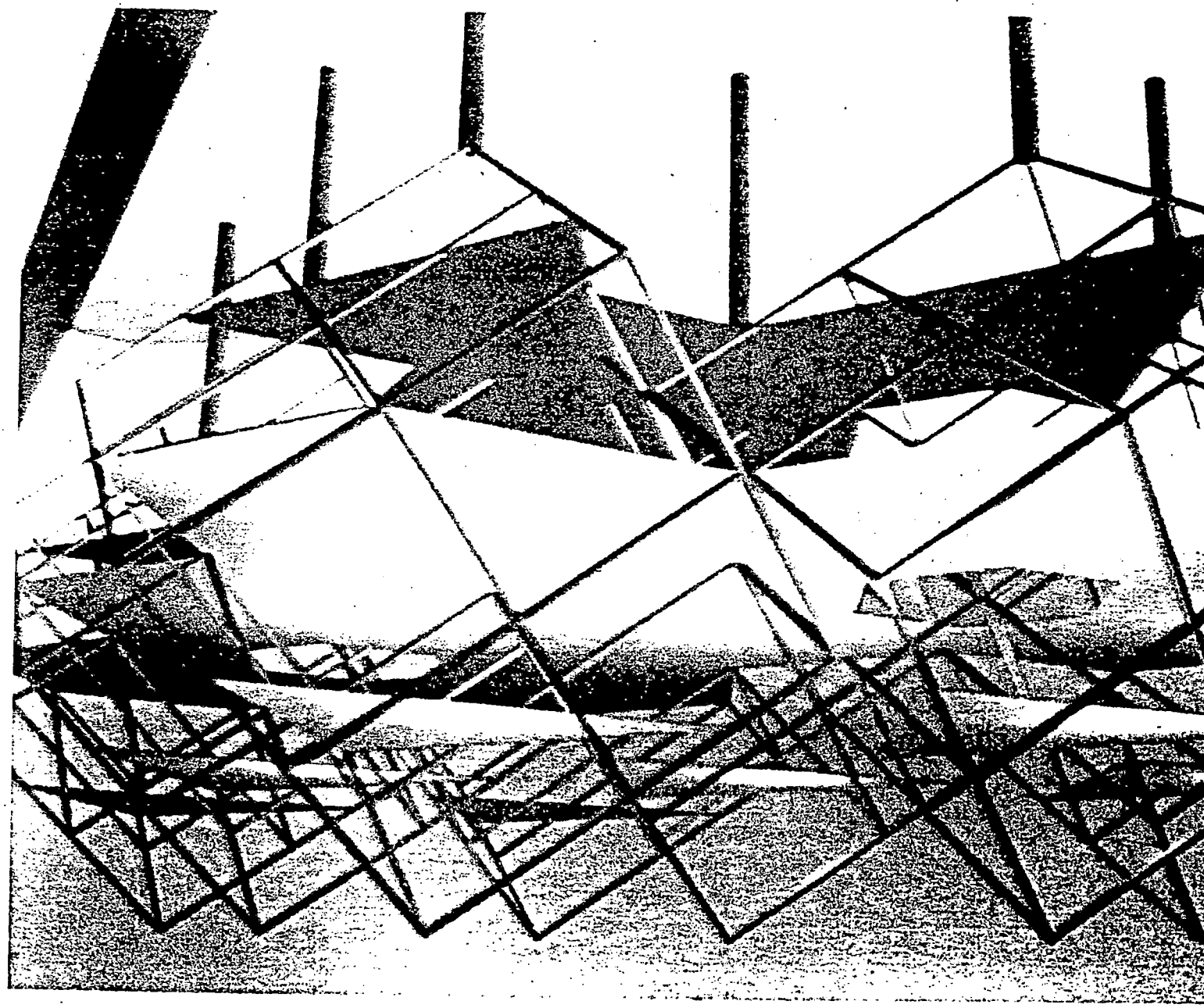


vervolg verbeteringen:

- dubbele beglazing dakramen
- balkloze betonvloeren
- meer glas in loofhut en dit beter te openen en te reinigen
- verbeteren van de bereikbaarheid van het plafje tussen de woningen
- andere uitvoering en opstelling radiatoren
- verlaging vensterbanken straathuis
- elimineren van schoonheidsfouten in- en exterieur

commentaar toekomstige bewoners

peil pothuis

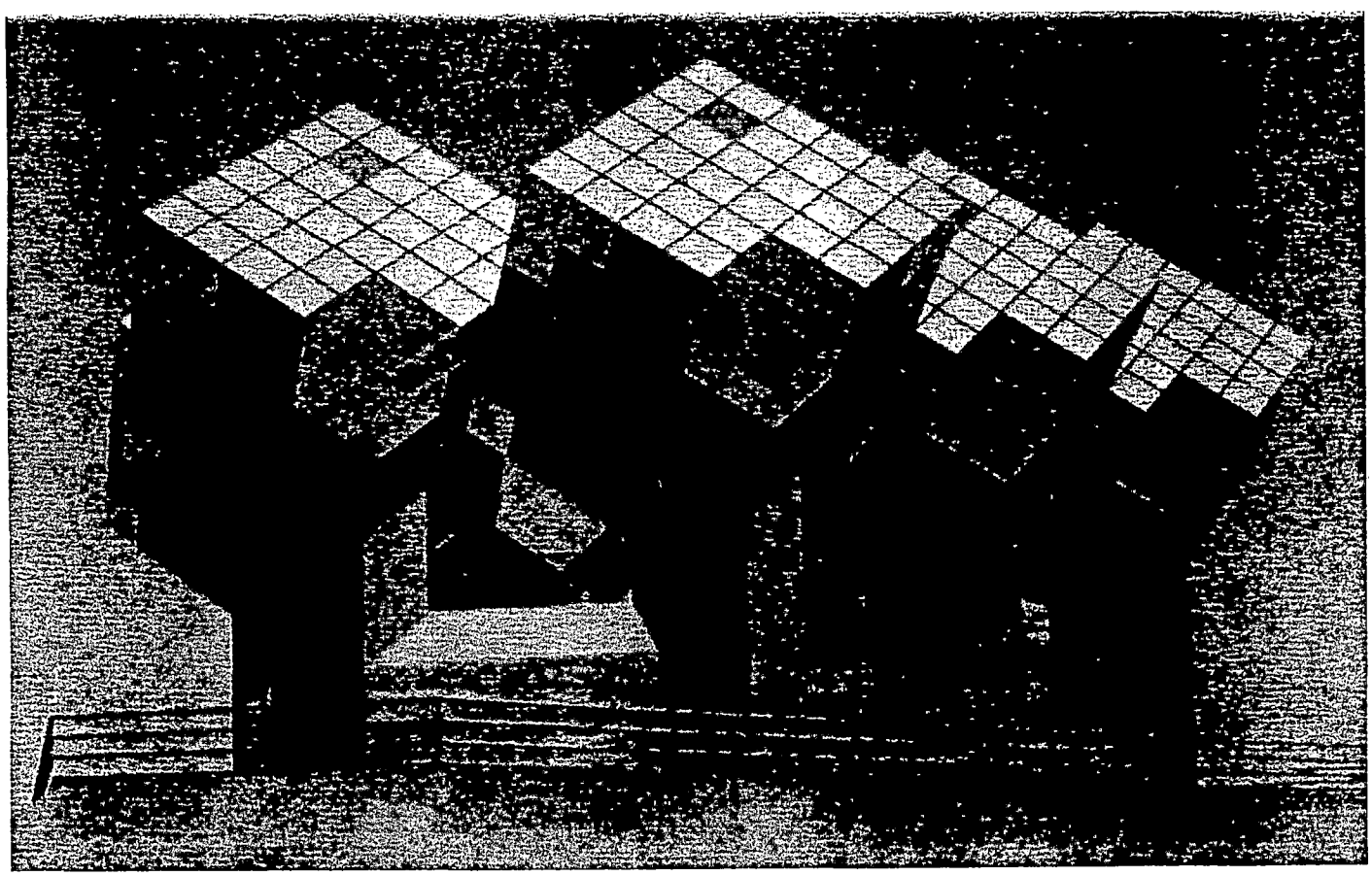


The Living Roof*

UNIQUBE* is an integrated design approach to the creation of multi-purpose space for light-industrial, commercial, residential and cultural building applications.

The Uniqube design concept produces a unique building envelope with articulated spatial volumes which may be self-contained or contiguous, and modulated according to purpose.

The Uniqube system introduces a methodology which brings together design, construction and new concepts of space utilization into a new environmental design archetype — "The Living Roof".



*Registered trade names

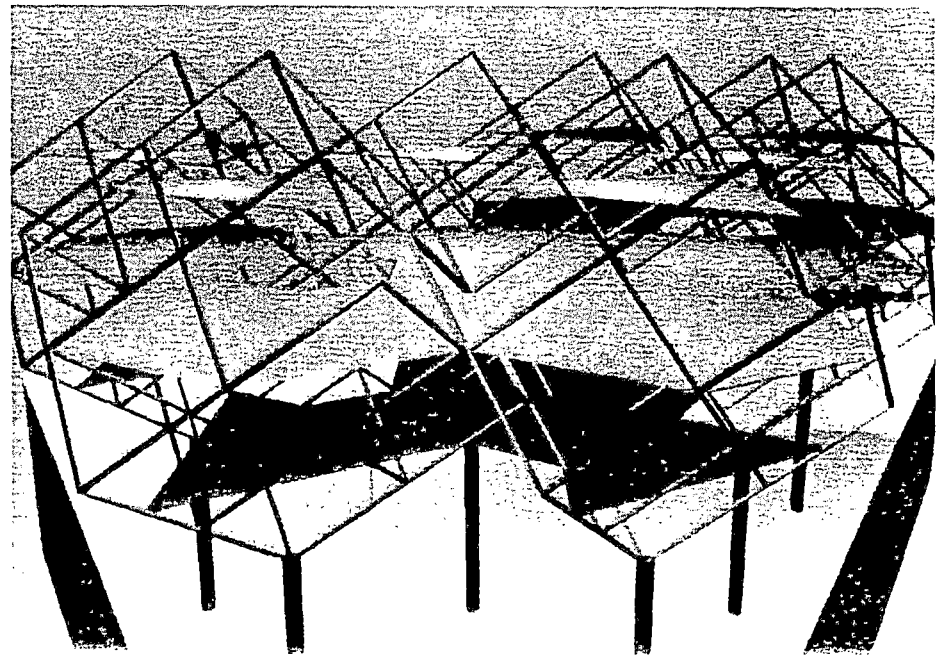
THE DESIGN

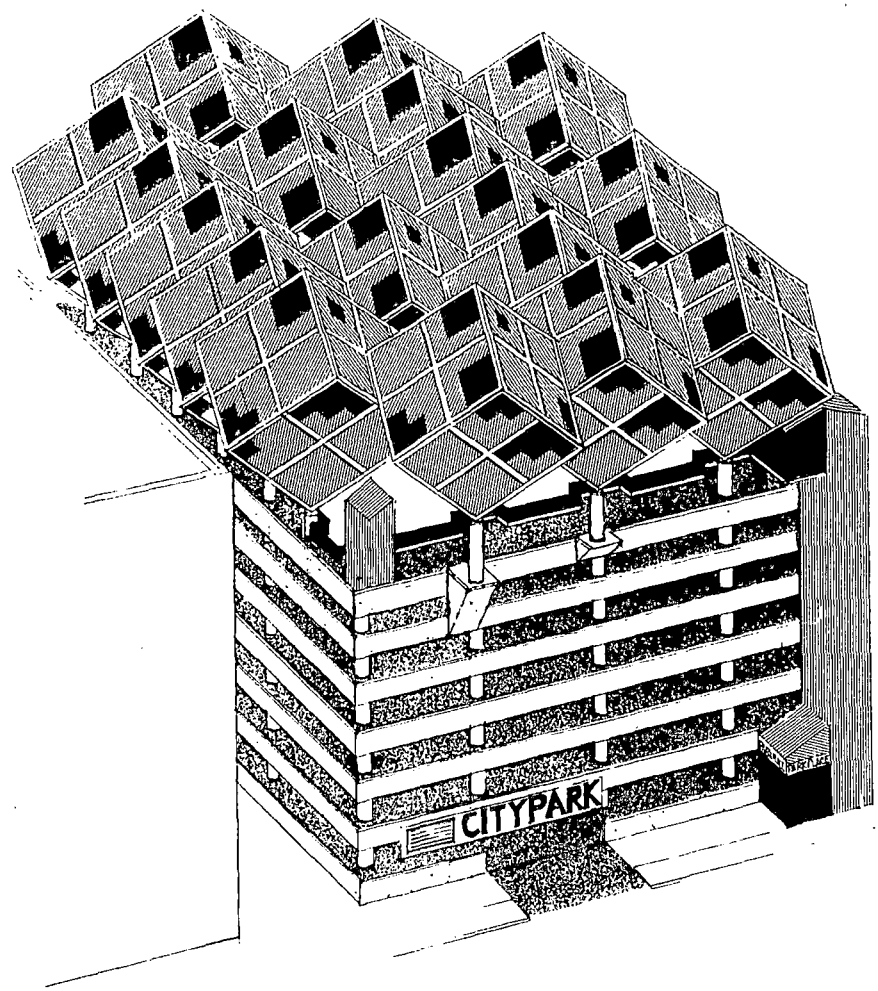
As an industrially-produced building system, Uniqube embodies a singular integration of structural and architectural design. Roof, wall and floor components have been unified to provide structural support and enclosure, making extensive use of prefinished and structural steel products.

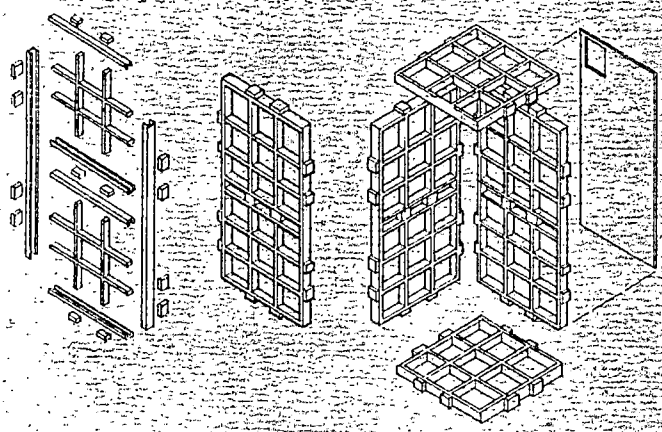
Evolving from the design ideology and works of Dutch architect Piet Blom, the Uniqube system developed in Canada is a proprietary design application of modular, self-contained cubic units to form space-frame roof structures.

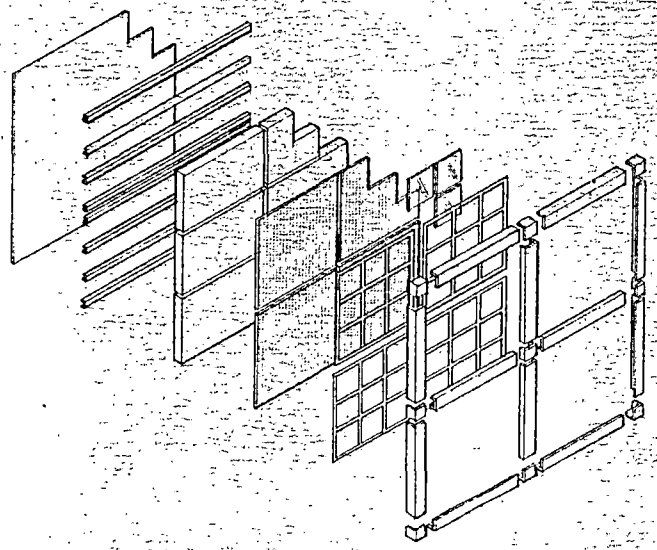
Both structure and cladding systems are integrated and may be erected as fully or partially prefabricated subassemblies, depending upon the application.

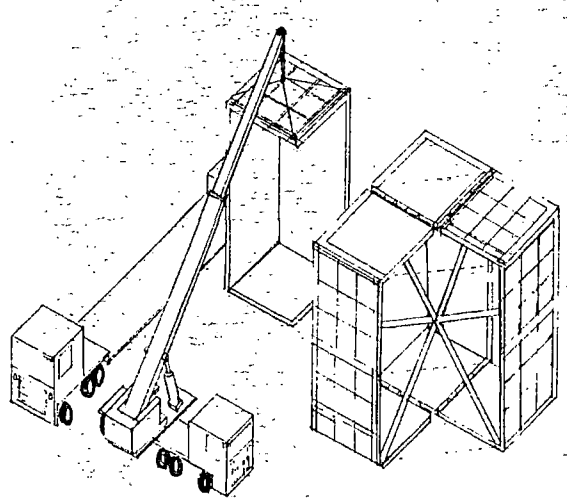
The interconnected units may perform like a megastructure with a variety of unique ground interface conditions possible (i.e. each unit may be supported by a pedestal or column base, or the entire configuration may be supported or suspended as a horizontal-span structure).











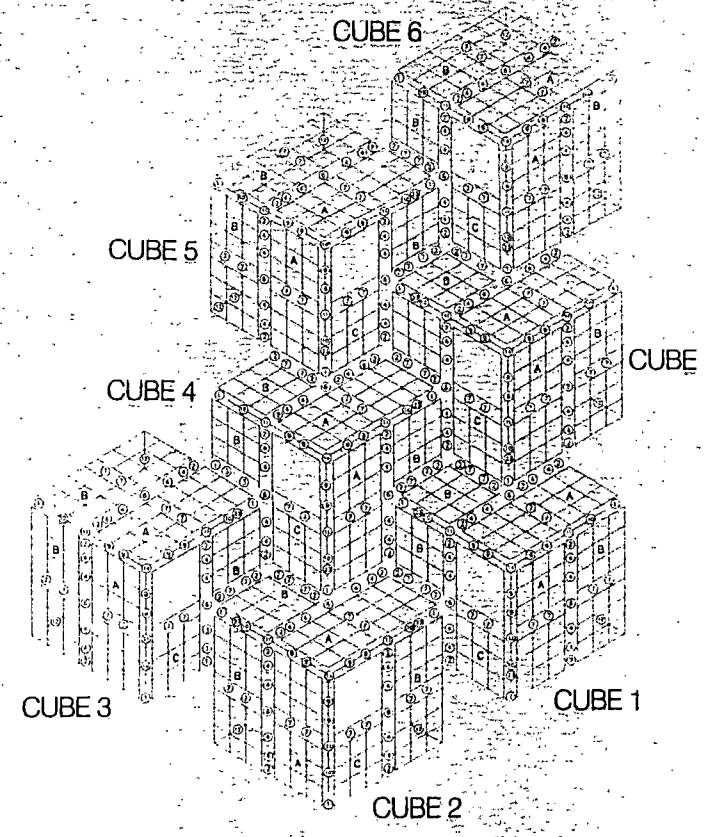
THE STRUCTURE

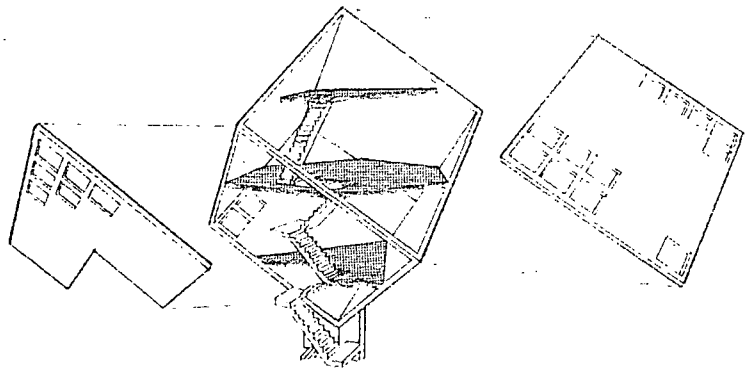
Uniqube uses a welded steel structural frame which carries all the superimposed loads and floors — each modular cubic unit comprising plate elements framed with HSS. Such extensive use of steel components is a significant improvement in construction technology and systems applications.

Cladding of the cubes is a proprietary prefinished steel system designed on rain screen principles and incorporating 76 mm of phenolic foam insulation, air and vapour barriers. Gutters are formed integrally with the sheet metal at cube edges. Roll formed and pre-coated steel windows and louvre assemblies are closely integrated with the cladding.

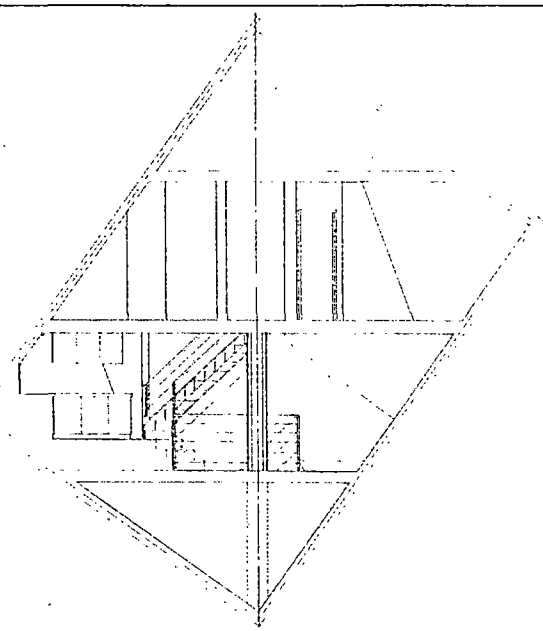
The design allows a wide range of different cladding systems to be used, such as Stelcolour Metallic or Elite pre-finished steels, depending on the context and desired finish.

Heating and cooling of each cube may be accomplished with a heat pump located below the lowest floor. Small diameter ducts distributed through the interior partitions carry high velocity air to aircraft-like diffuser nozzles.

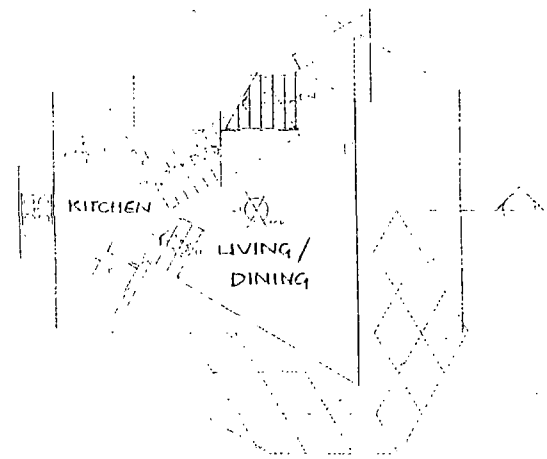




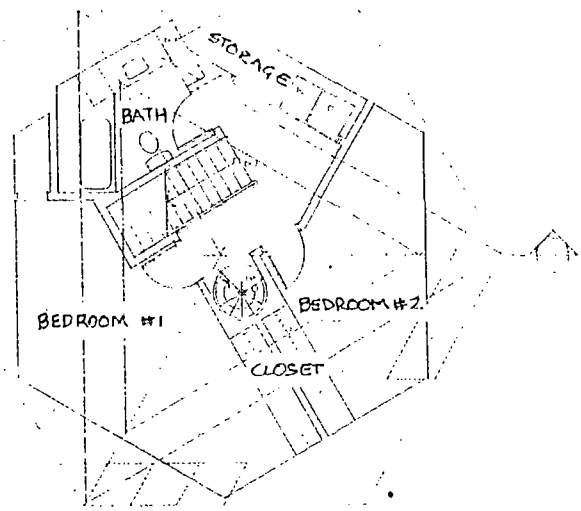
Each cube of 7.3 m in length per edge has been rotated at 45° to sit on a column at a single point, stability coming from the rigid interconnection of adjacent cubes. The system allows great flexibility in the location of interior walls and floors. Three planes may intersect the cube, providing approximately 111 m² of floor area. The cube's tilt results in full and efficient access of 368 m³ of interior volume. The spaces defined by the angled roof and wall planes create uniquely satisfying and functional space.



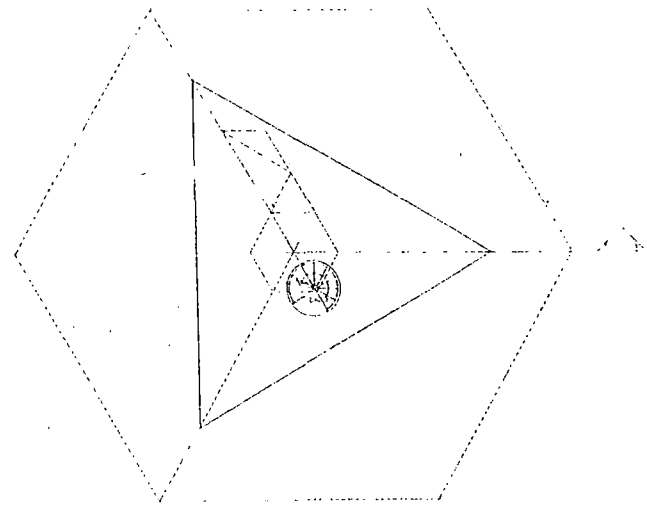
SECTION 1:50



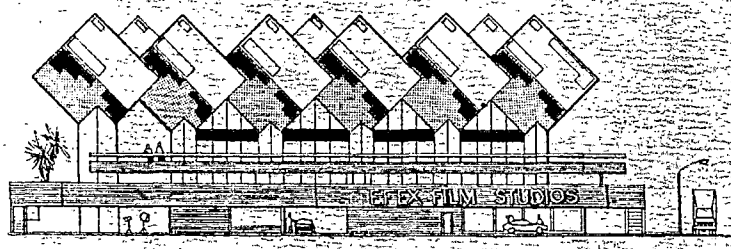
TRIANGLE LEVEL 1:50

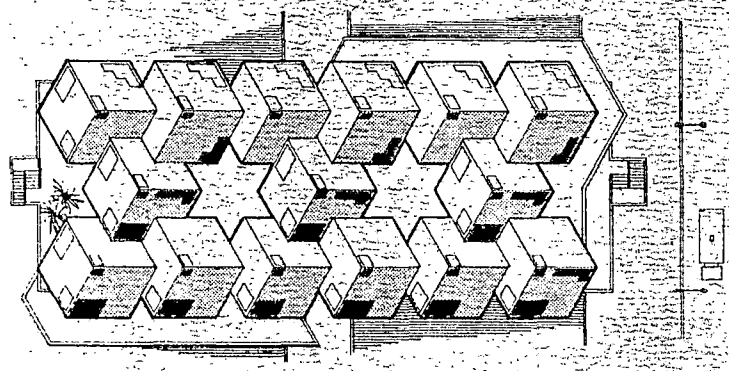


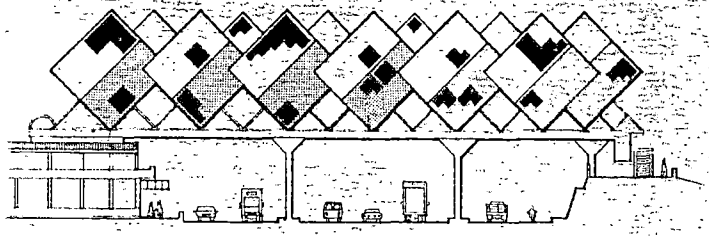
HEXAGON LEVEL 1:50

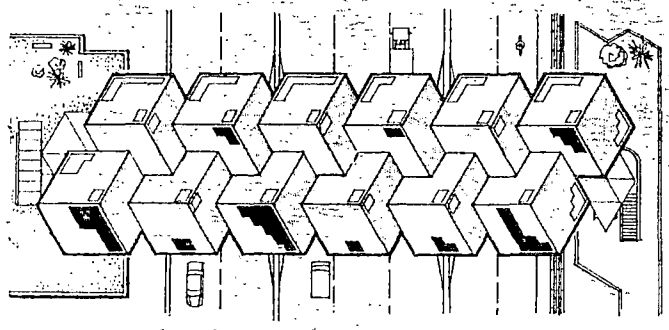


LOFT LEVEL 1:50









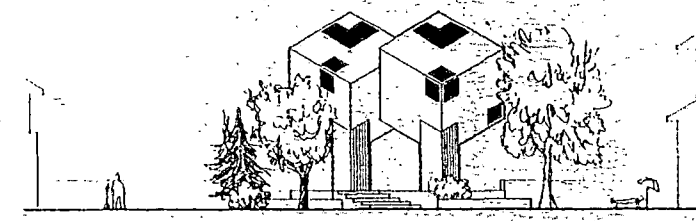
THE APPLICATION

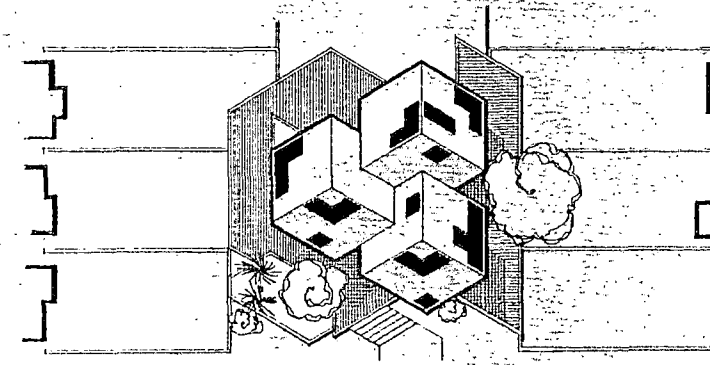
By using the system as a "living roof" structure, medium to high unit densities are achievable depending on the clustering configurations (i.e. close-packed or open). By visibly articulating the individual units within the structure, a human scale aesthetic is maintained within the entire project form.

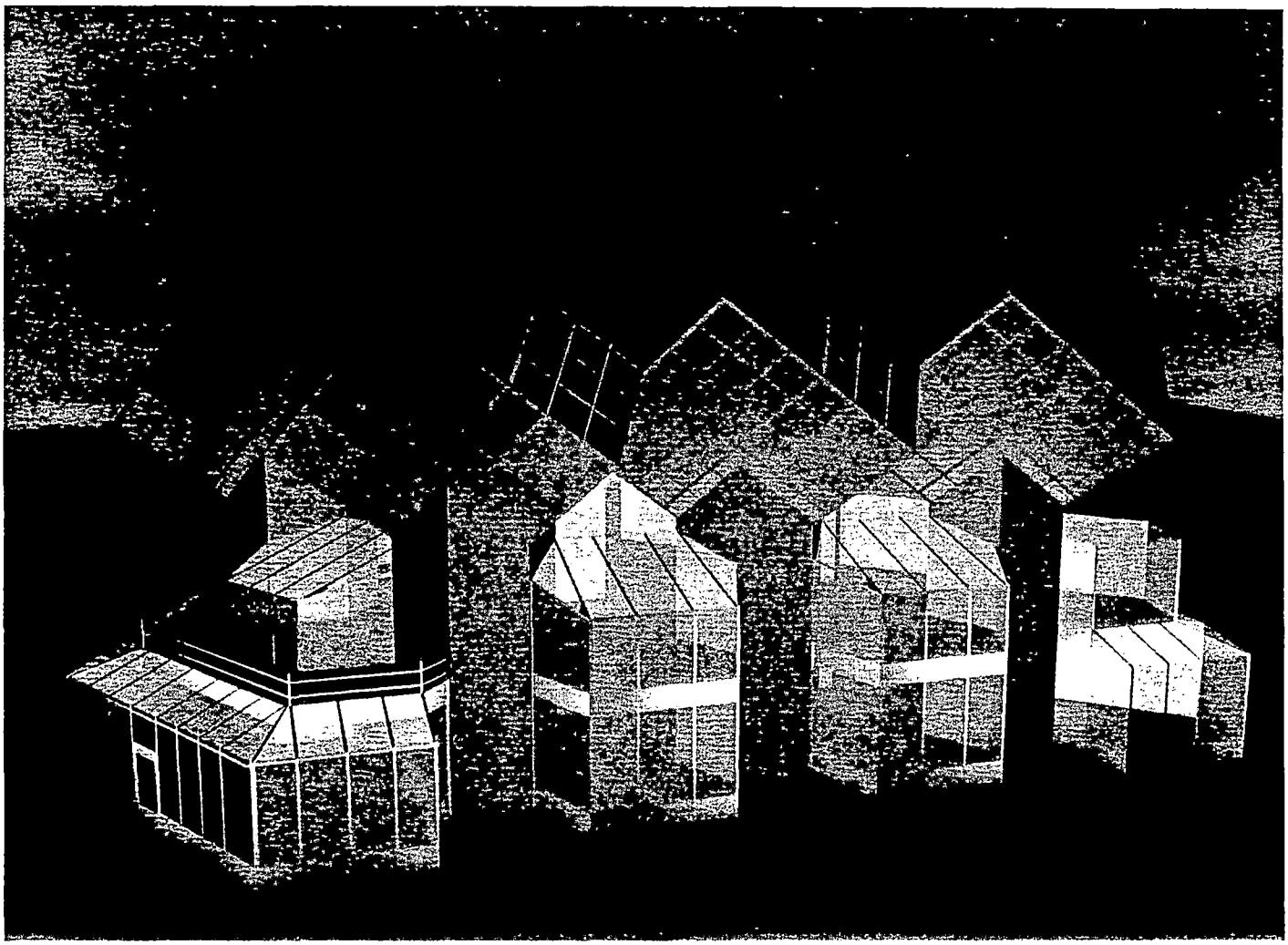
The concept may be used as a "roof" above buildings such as warehouses or parking garages. Using the roof level of the structure below as a deck for open space and circulation, this application can provide additional useable floor area for studio, office or residential uses in loft-like configurations.

The Uniqube system can be used over or between buildings in order to preserve existing site conditions or intensify the use of property. Accordingly, the system is ideal for urban areas where public circulation at or above ground level must be preserved or introduced, such as in harbour or market areas, or to create pedestrian bridges over roads.

Ground-based clusters may also be produced, where each unit is supported "tree-like" by a pedestal base which contains individual vertical access directly from grade level. These configurations are ideal for sensitively-scaled residential infill in deep backyards, along road and rail easements or for marine facilities.







The first North American demonstration of the Uniqube system is currently in process with the integrated efforts and collaboration of a group comprising designers, architects, engineers, building products manufacturers and an innovative developer. The project will showcase the Uniqube system used in a multi-purpose building incorporating residential, commercial and light industrial use in a prime urban context.

With its bridging, spanning and space-forming capabilities, the Uniqube system can be used by architects, engineers, system builders and developers in a variety of practical and economic project applications.

THE CONTRIBUTORS

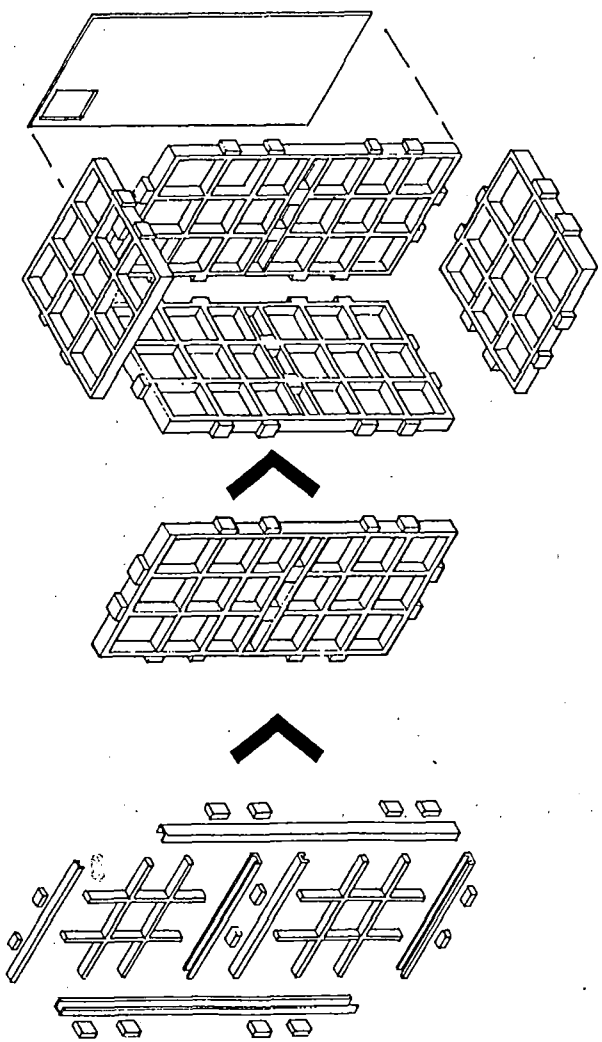
Arcop Architects Inc is an architectural practice undertaking a wide range of projects across Canada and in the U.S. Toronto-based, the firm also has offices in Vancouver and Florida.

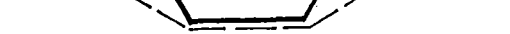
Current work includes high quality condominiums, mixed-use commercial and hotel developments and several large theatre projects.

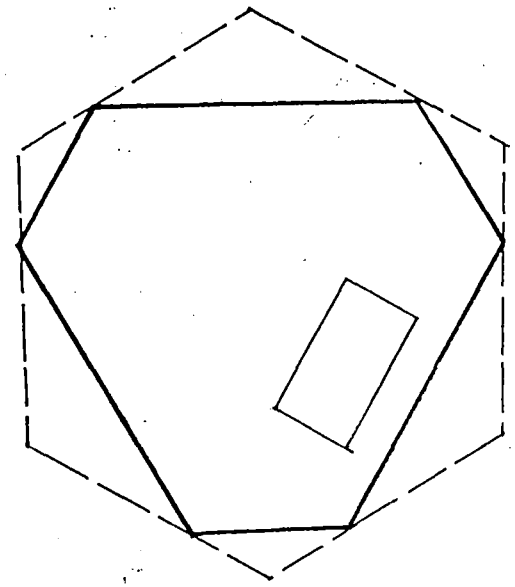
The firm is also actively involved in urban design and planning, including revitalization and waterfront projects. At present it is working on the master plan for a complete new community in central Florida.

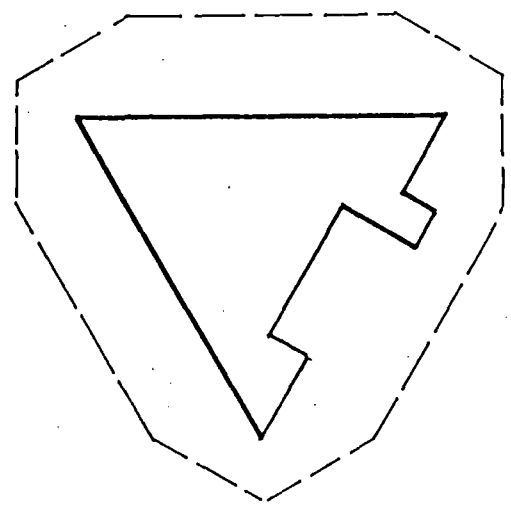
Peter Sheffield & Associates, has, since its foundation in 1970, been involved in over 500 construction projects varying in complexity and size from single-family residences up to and including some of the largest hospitals in Canada and the Toronto Sky Dome. Some of their projects were undertaken in extreme climate conditions, from the frigid arctic cold to the torrid heat of the Saudi Arabian desert.

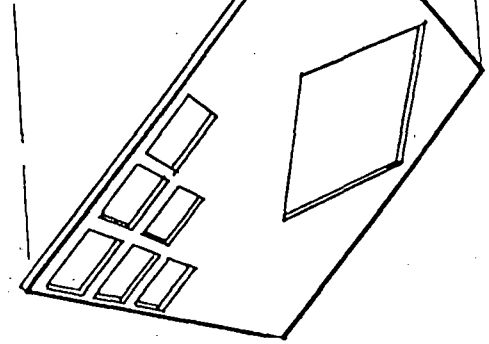
Multitechture Inc: Design management
Uniqube Inc: System design
Metropol Design and Kentridge Levitt Architects Limited: Design consultants



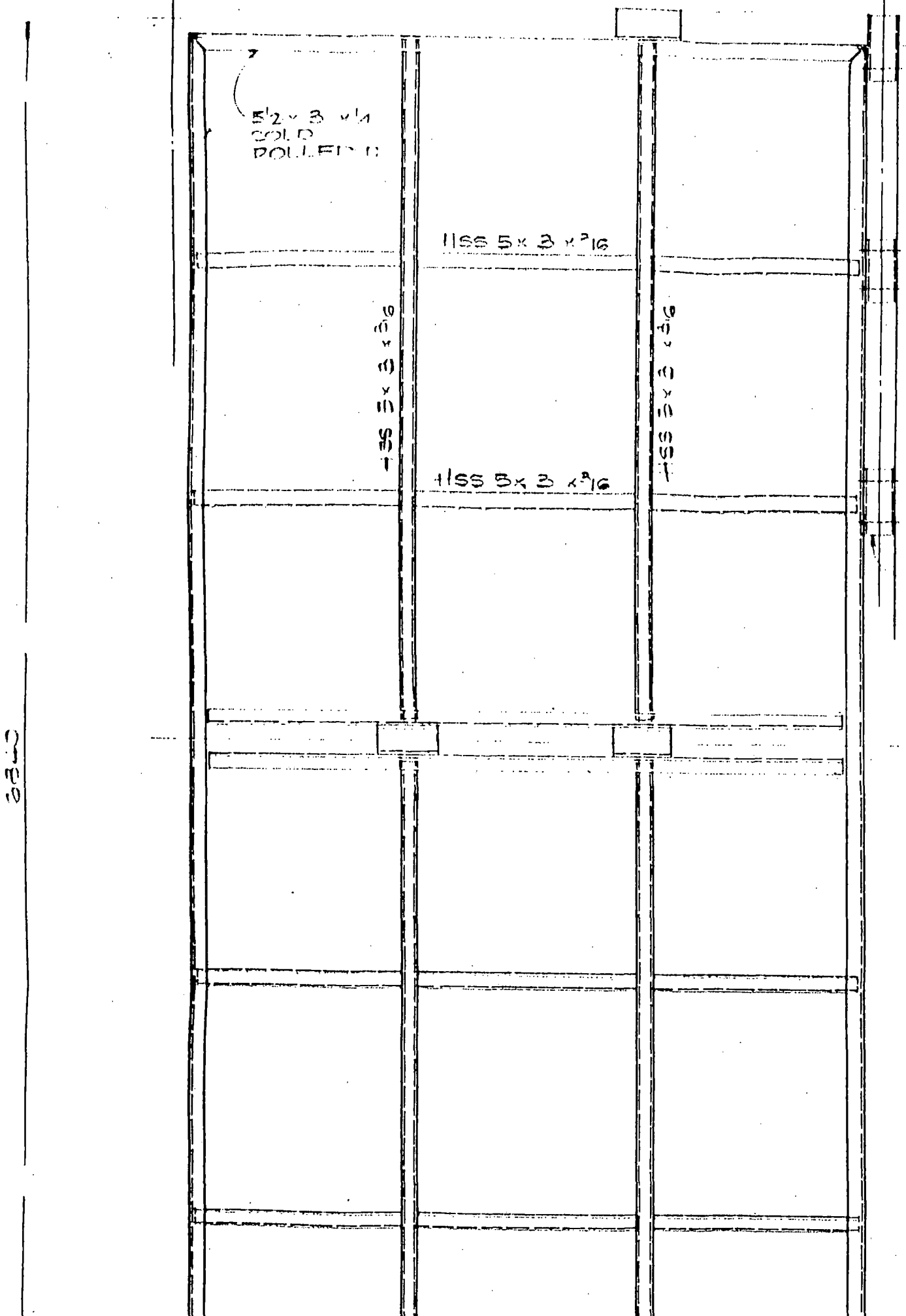




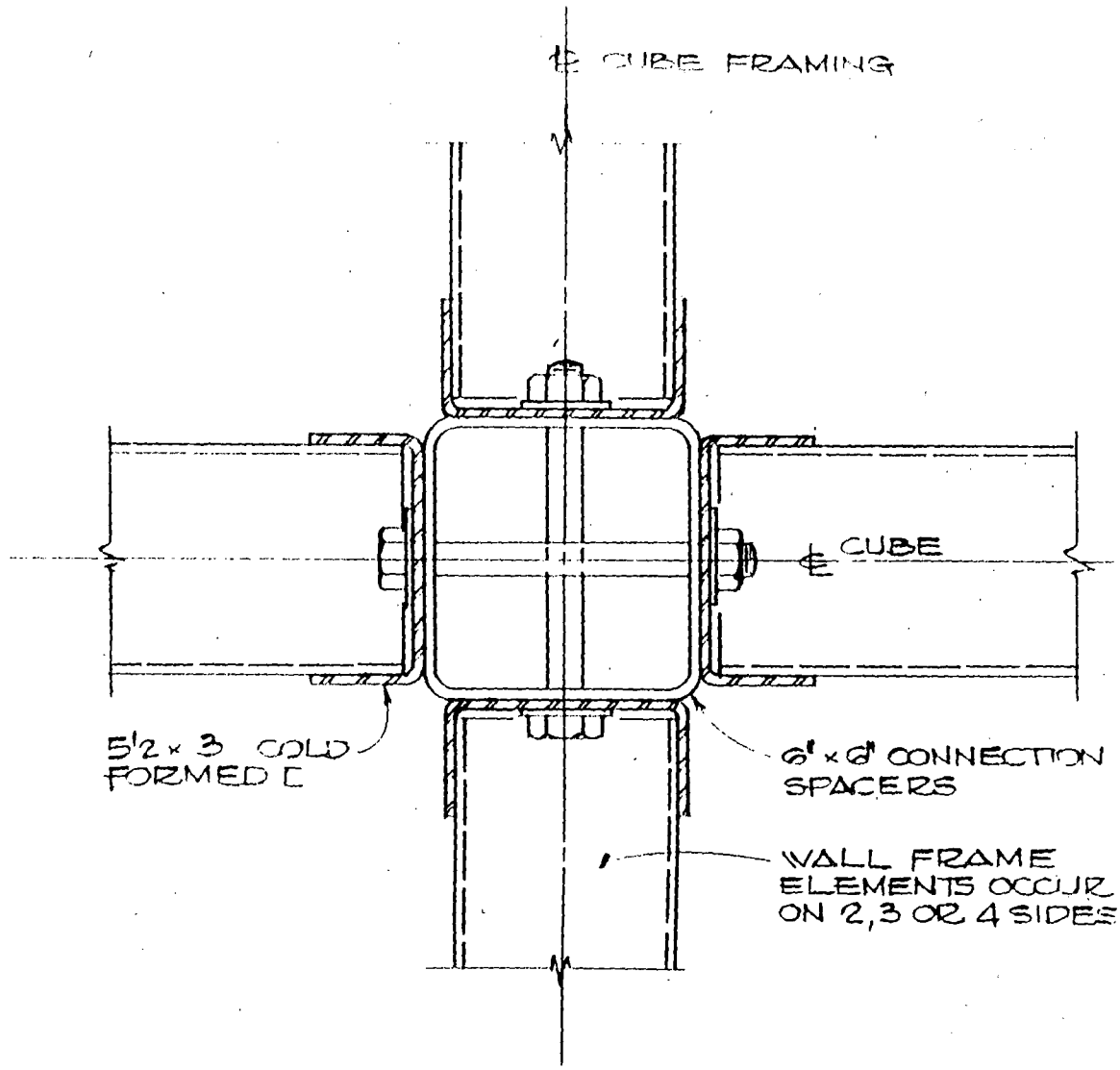




SYSTEM AS ORIGINALLY PROPOSED

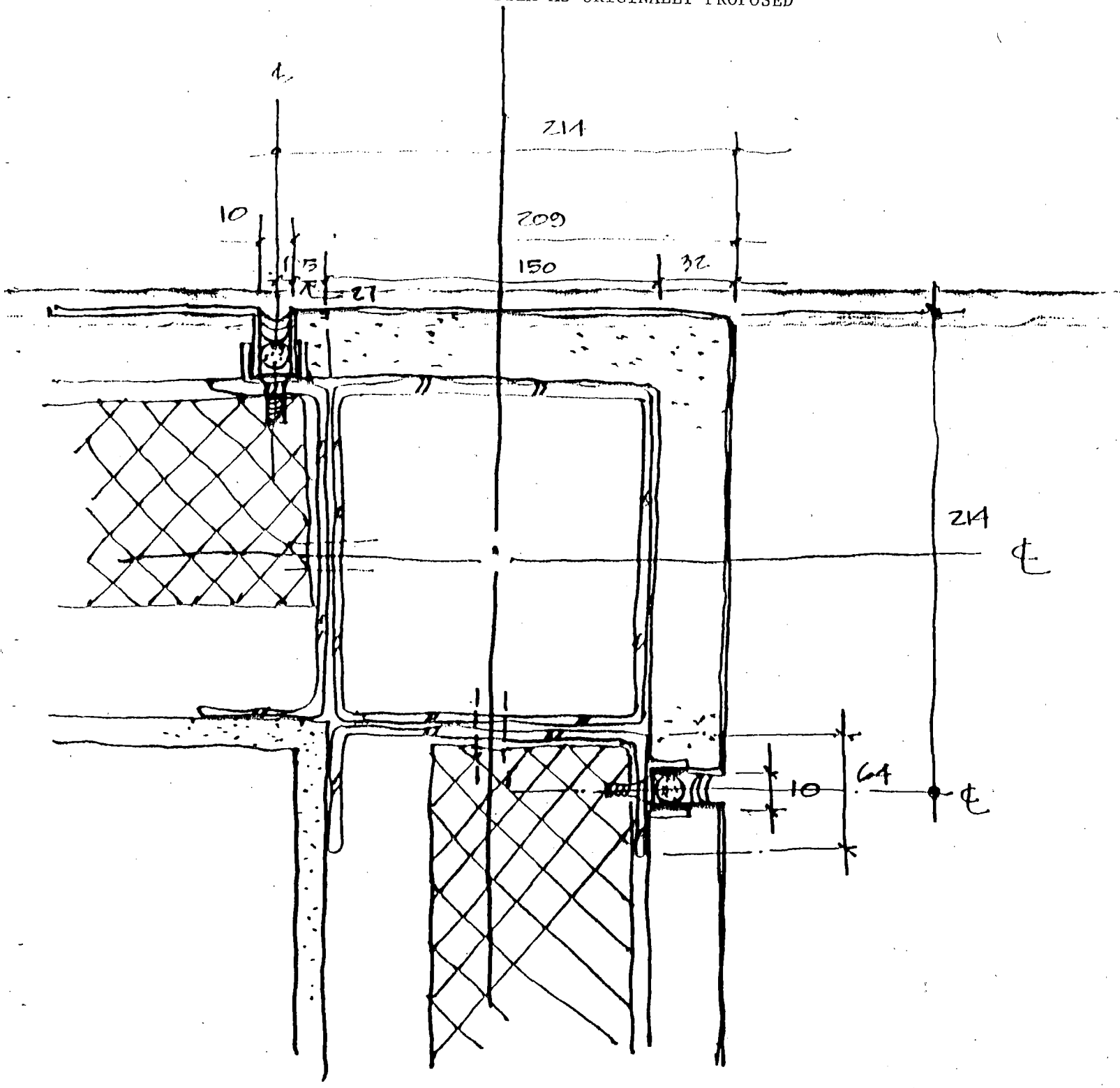


SYSTEM AS ORIGINALLY PROPOSED



TYPICAL WALL FRAME CONNECTION DETAIL

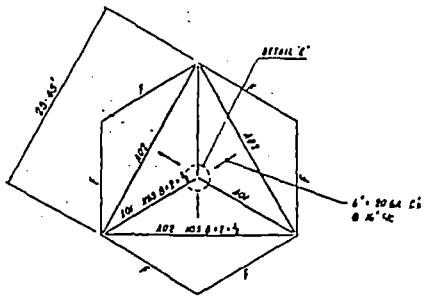
SYSTEM AS ORIGINALLY PROPOSED



DETAIL (A)

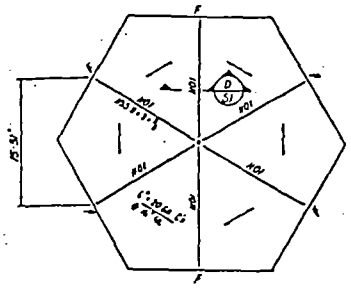
WALL CONSTRUCTION:

- 32 PORCELAIN PANEL W/ GYPSUM BRD BACKING.
- 64 x 150 ST [CHANNELS @ 1068.6 o.c.
- 100 RIGID INSULATION BETWEEN 6" ST STUDS @ 450 o.c.
- VAPOUR BARRIER.
- 16 GYPSUM BRD.



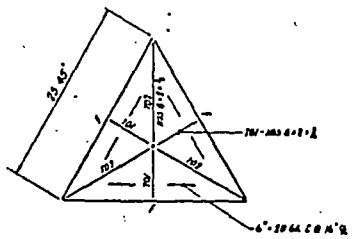
ATTIC LEVEL

1. LL = 40 P.S.F.
2. DECKING IS ½" I & G PLYWOOD



HEXAGONAL LEVEL

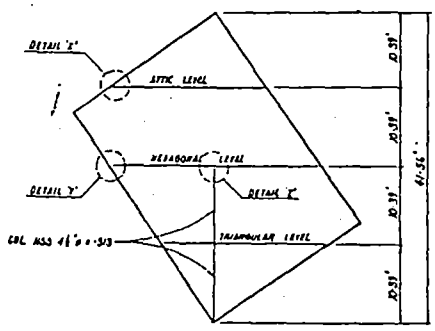
1. LL = 40 P.S.F.
2. F INDICATES WALL FRAME MEMBERS.
3. DECKING IS ½" I & G PLYWOOD



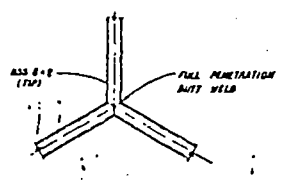
TRIANGULAR LEVEL

1. LL = 40 P.S.F.
2. F INDICATES WALL FRAME MEMBERS.
3. DECKING IS ½" I & G PLYWOOD

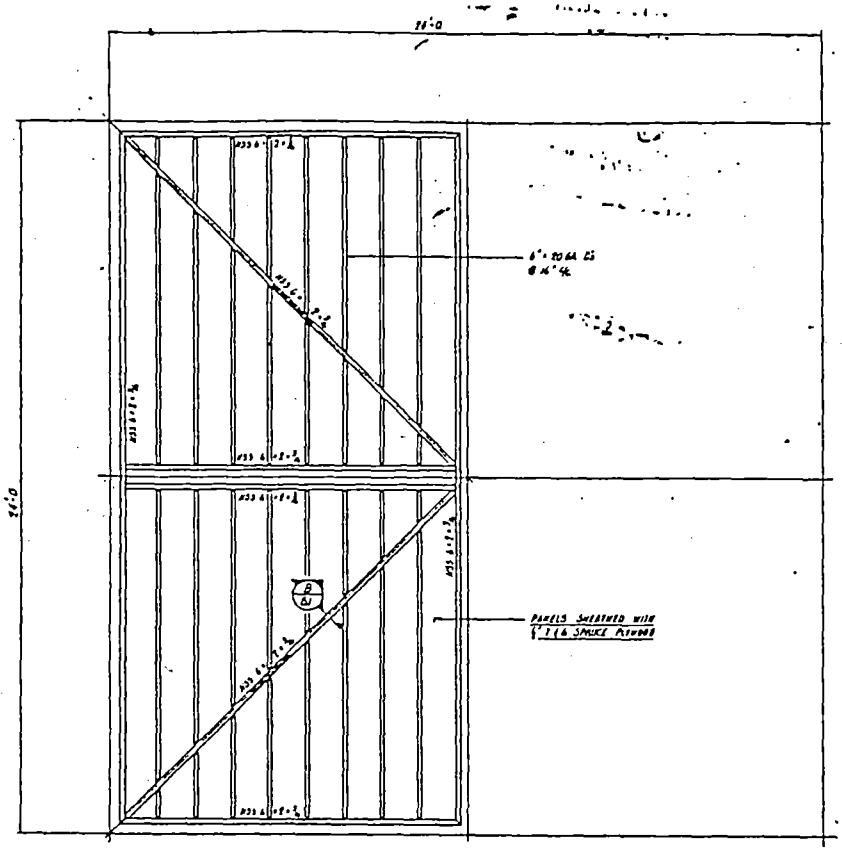
DIMENSIONS ARE TO ℄ OF INTERSECTION OF PANEL CENTER LINES



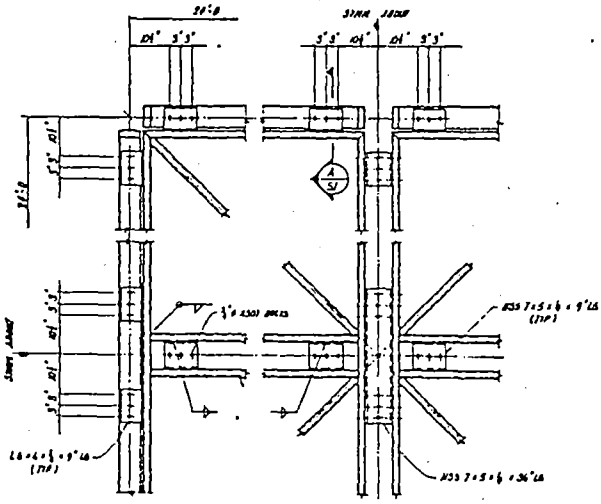
ELEVATION



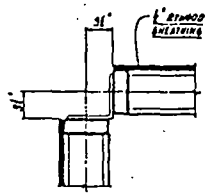
DETAIL 'E'
1½" = 1'-0"



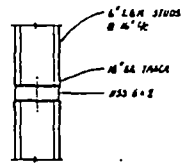
TYPICAL PANEL
½" = 1'-0"



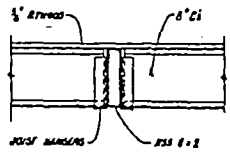
ENLARGED PANEL DETAIL
¾" = 1'-0"



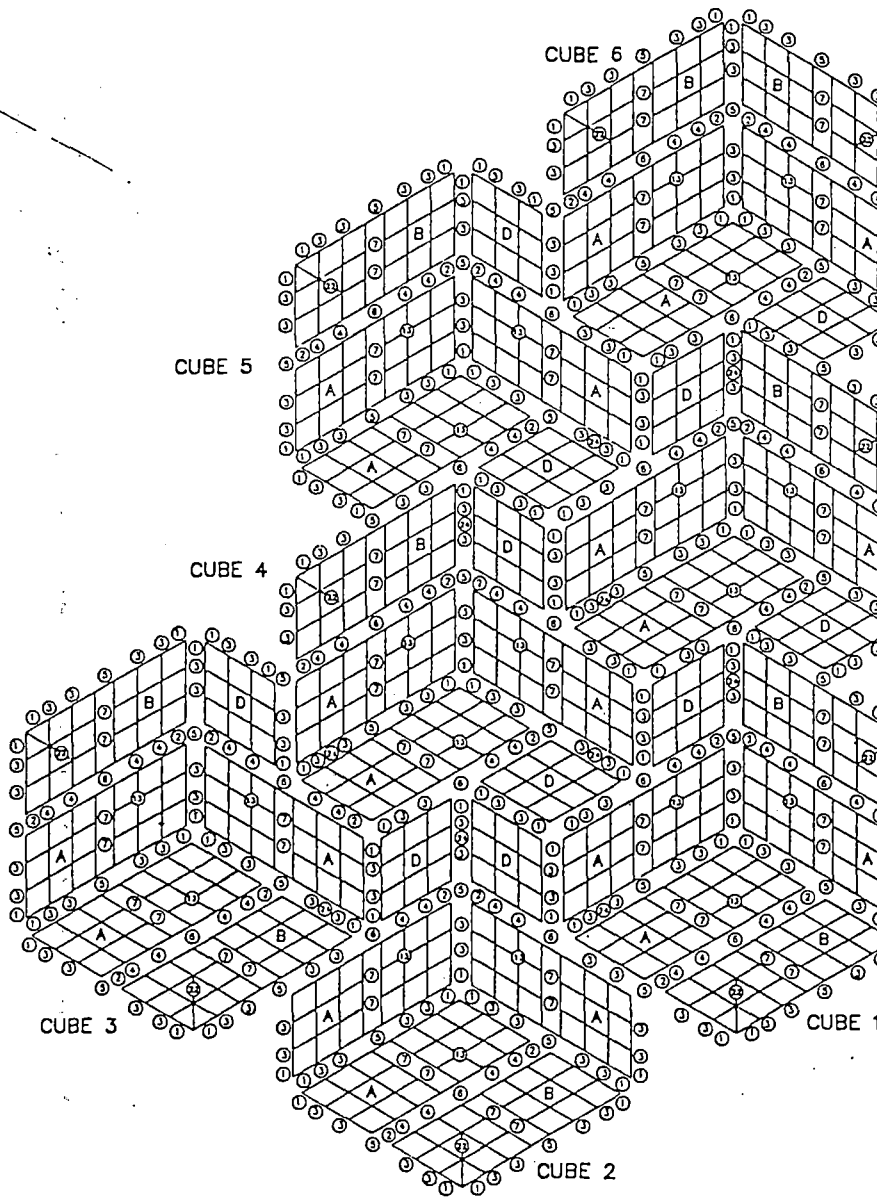
SECTION (A/S1)
1½" = 1'-0"

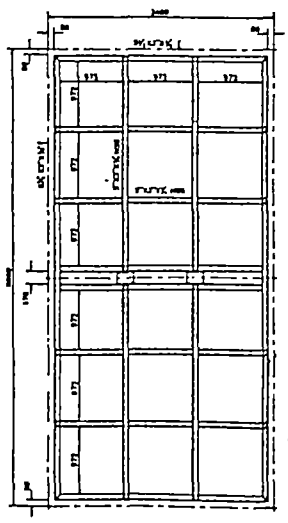


SECTION (B/S1)
1½" = 1'-0"

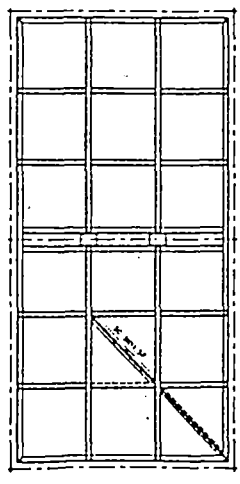


SECTION (D/S1)
TYP. FLOOR FRAMING DETAIL
1½" = 1'-0"

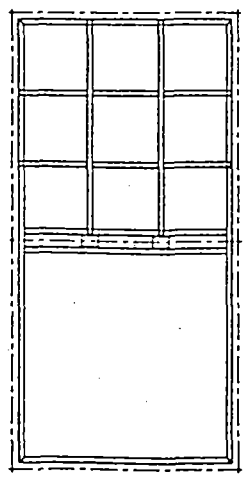




PANEL TYPE A



PANEL TYPE B



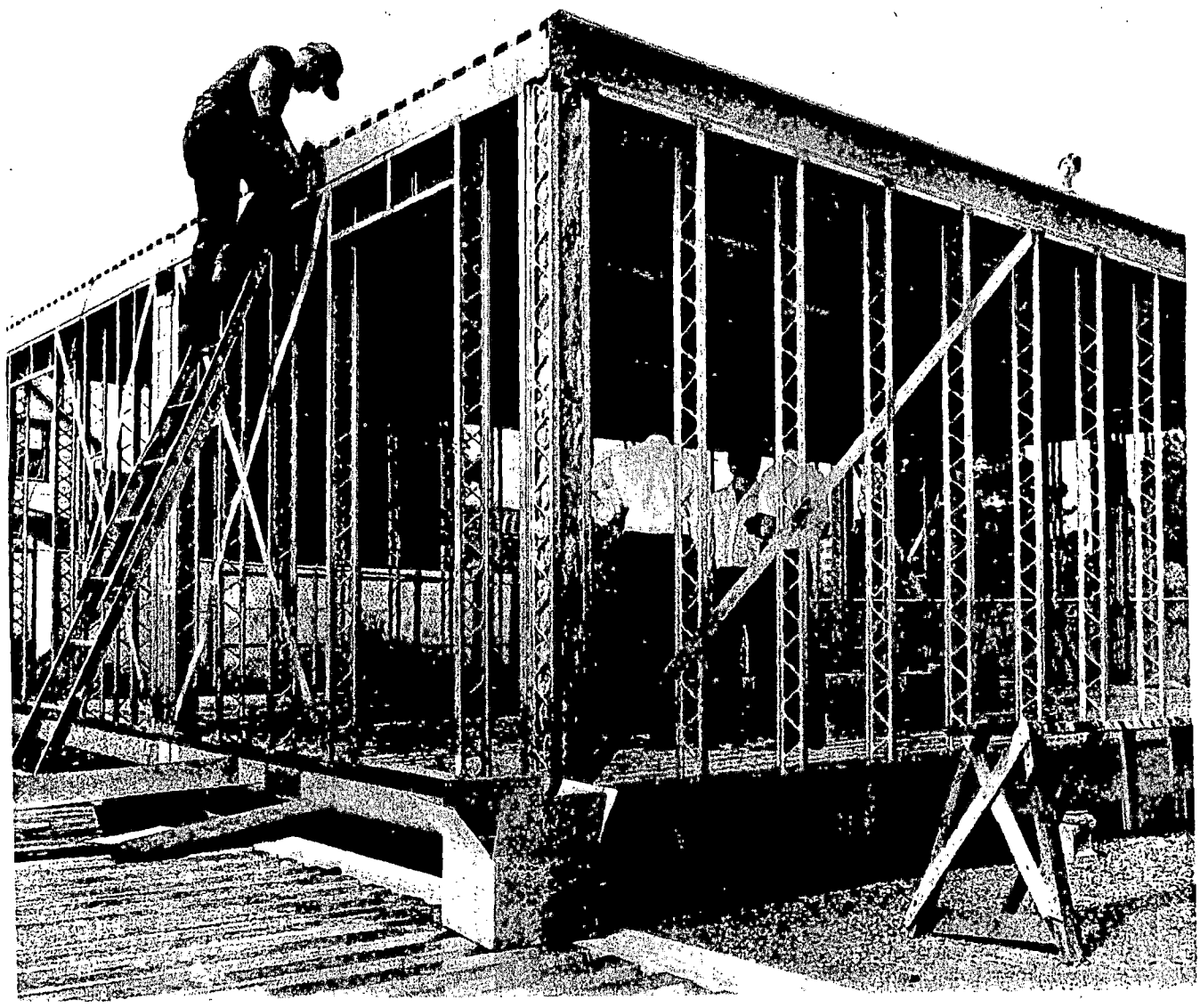
PANEL TYPE C

THERMO STEEL THERMOSTEEL BUILDING SYSTEMS

LIGHTWEIGHT, THERMALLY-EFFICIENT STEEL FRAMING SYSTEMS

For exterior and interior load-bearing walls, curtain walls, floors and roofs.

- More than 30% energy-savings
- Up to 40% weight savings
- 25% increase in load bearing



UNIQUE THERMOSTEEL "C" SECTIONS GIVE YOU DESIGN FLEXIBILITY WITH COST SAVINGS

Strong, lightweight Thermosteel® studs and joists are the ideal solution for a wide range of load-bearing applications — especially where energy-efficiency is important.

Energy Savings

Unique design increases the overall energy-efficiency on insulated steel stud exterior walls, over other non-combustible systems, resulting in energy-savings of 30% or more.* 'Ghosting' and condensation are no longer a factor.

Weight Savings

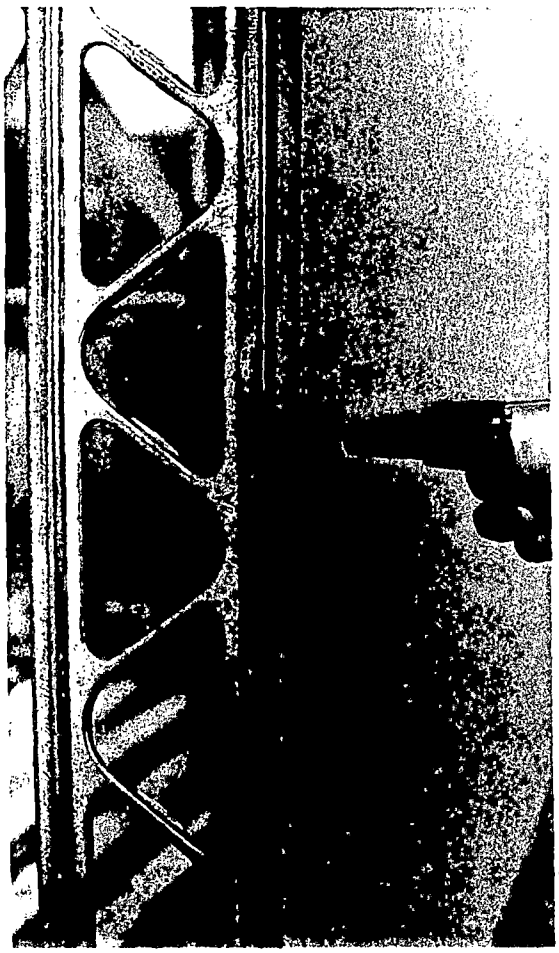
Thermosteel framing is a structurally sound framing system for buildings of up to six stories high.
Strength-to-weight ratio is Thermosteel sections is about 25% greater than conventional load-bearing studs.

Construction Savings

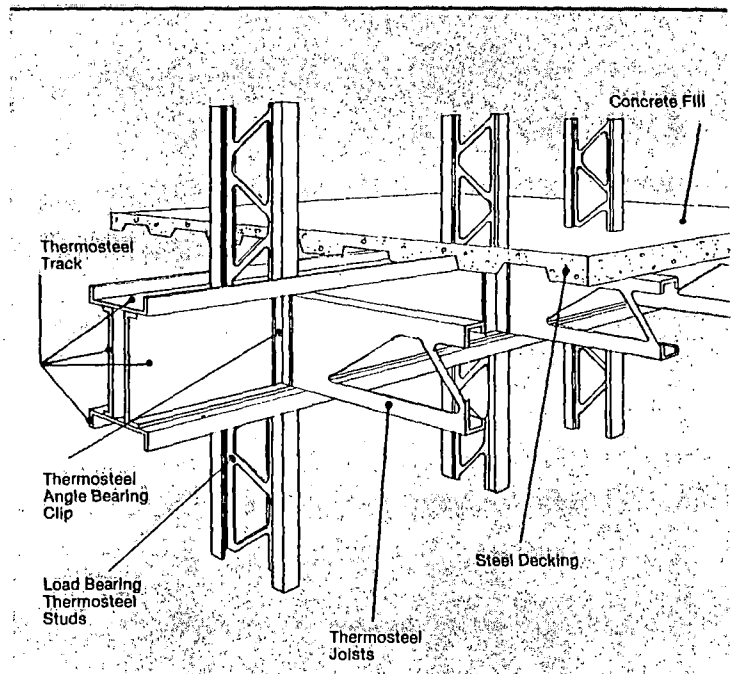
Cost-savings are realized through:

1. 'All-weather' construction.
2. Lighter material handling requirements.
3. Exterior insulation not required.
4. Reduction of total building load.

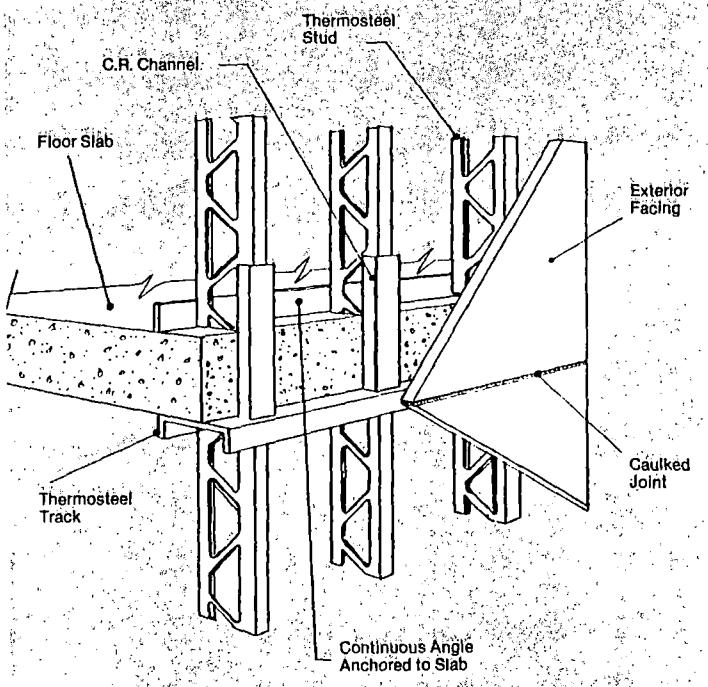
*Test results available upon request.



Standard Steel Joist and Stud Applications

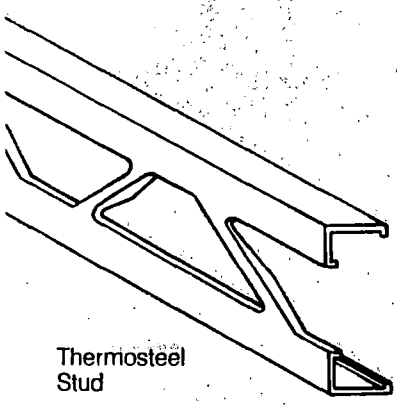


1. Load Bearing Interior Wall

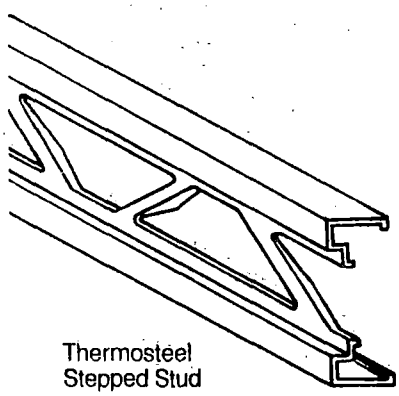


2. Framing for Panels By-Passing Slab

THERMOSTEEL PRODUCT INFORMATION



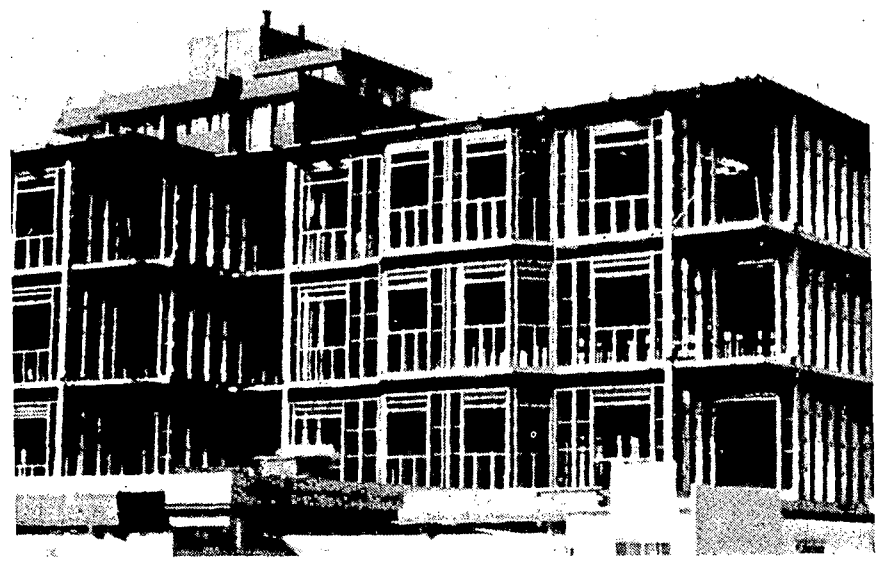
Thermosteel Stud



Thermosteel Stepped Stud

PRODUCT	USES
Thermosteel Joists and Channels	Framing for floors, roofs, balconies and other key areas.
Thermosteel Studs and "C" Sections	Interior and exterior bearing walls through to six stories high; curtain walls; spandrel walls; exterior infill systems. Complete with regular track.
Thermosteel Drywall Studs	Drywall partitions; furred walls and ceilings. Complete with track channel
Other standard and custom light framing system components	From heavy channel for flooring to drywall corner bead or suspended ceiling grid, there's a Thermosteel product for most building needs. Thermosteel products are produced from galvanized, primed steel, or other coated steels. A wide range of sizes and gages are available.

Patent pending, U.S.A., Canada and worldwide.



AWCI
Association of the Wall & Ceiling Industries—International

MEMBER
Metal Lath/Steel Framing Association

METAL BUILDING DEALERS ASSOCIATION

ULC

THERMO STEEL **THERMOSTEEL BUILDING SYSTEMS**

a division of Randob Enterprises Ltd.
12 Davidson Road, Brampton, Ontario
Canada L6W 1X3 (416) 454-3060

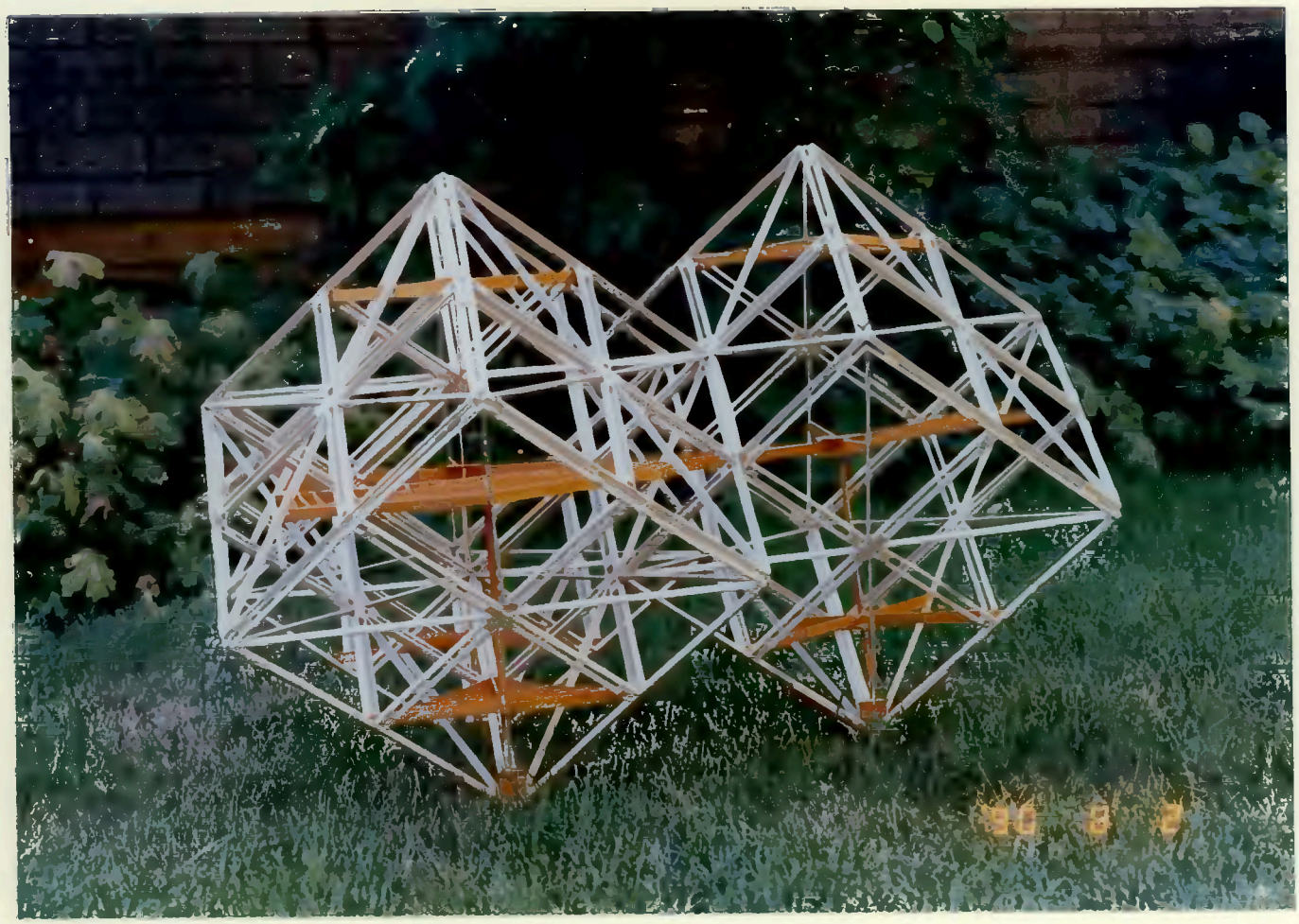
Associated Companies:

STORAL

ONTARIO ROLL FORMING

S.M. 2/84 — 5C Printed In Canada

STRUCTURAL MODEL



WORK CARRIED OUT

A quarter scale prototype structure was constructed using three 6 foot by 6 foot panels. The module itself was entirely constructed in one plant, with the ThermoSteel studs placed in vibrating flat-bed pans, which were used to create the panels.

The module was suspended from a crane for testing. It was found that to conduct stress testing of components, an entire cube would have to be built, since the final prototype design acts as an integrated structural system, with superimposed live and dead loads being transferred through the complete wall and floor system.

Accordingly computer modelling was used to verify the structural capacity of complete cubes.

Panel Construction

The panels were constructed using ThermoSteel studs at 16" on centre. The studs are 18 gauge G60 galvanized. A fabricated box-beam assembly, made of ThermoSteel studs was designed to give corner and edge support.

The three face elements of the model were constructed separately, then were assembled into the final prototype model.

Typical engineering details were formulated to confirm the effectiveness of utilizing the ThermoSteel stud with the proprietary exterior coating as a load-bearing/ wind-bearing panel assembly, in accordance with the engineering requirements specified by Mr.Peter Sheffield.

The panel weight, including the studs and the Fibrecrete coating gave a combined weight of 14 pounds per square foot. This yielded a weight for a 3,456 square foot cube of 42,784 pounds.

Jointing Methods for Exterior Surfaces

The construction of the prototype enabled the jointing details to be established to meet environmental and engineering requirements.

Three types of jointing details were developed:

(1) A cementitious finish on the edges of the adjoining steel members with a compatible jointing compound offering increased flectural stability.

(2) Metal to metal facing using a full-width compressible membrane, with the exterior edge caulked.

(3) Metal to metal facing using a neoprene backed rod and compatible jointing compound.

A combination of methods (2) and (3) was utilized.

Photographic Record

A photographic record of the process was undertaken. A selection of these photographs showing the overall module and details is included.

Testing of System

The design and construction process was iterative, with the system being designed as it related to available and suitable construction technologies and techniques.

The module was suspended from a crane for testing. It was found that to conduct stress testing of components, an entire cube would have to be built, since the final prototype design acts as an integrated structural system, with superimposed live and dead loads being transferred through the complete wall and floor system.

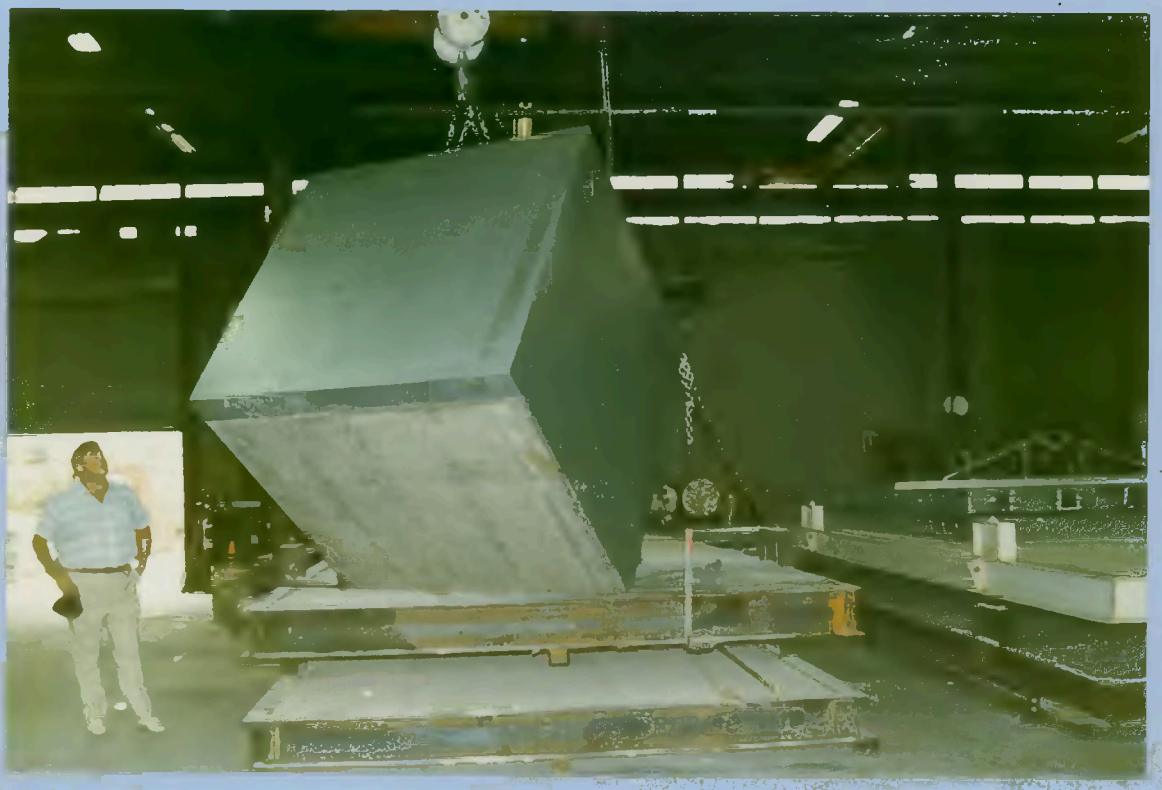
Accordingly computer modelling was used to verify the structural capacity of complete cubes.

Testing was done by means of extensive computer modelling, utilizing real-time simulation, on three dimensional software. to determine appropriate member sizes and connections. Exhibits include some of the material developed as part of the computer modelling process.

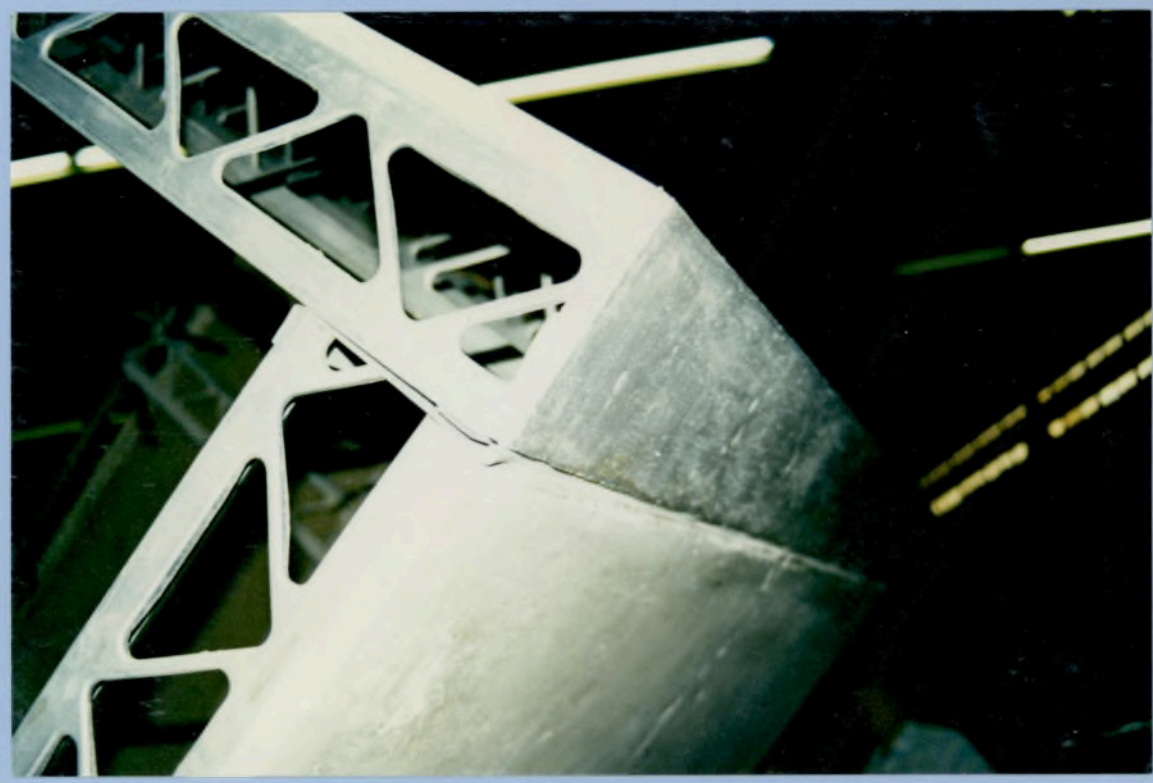
Drawings and Schematics

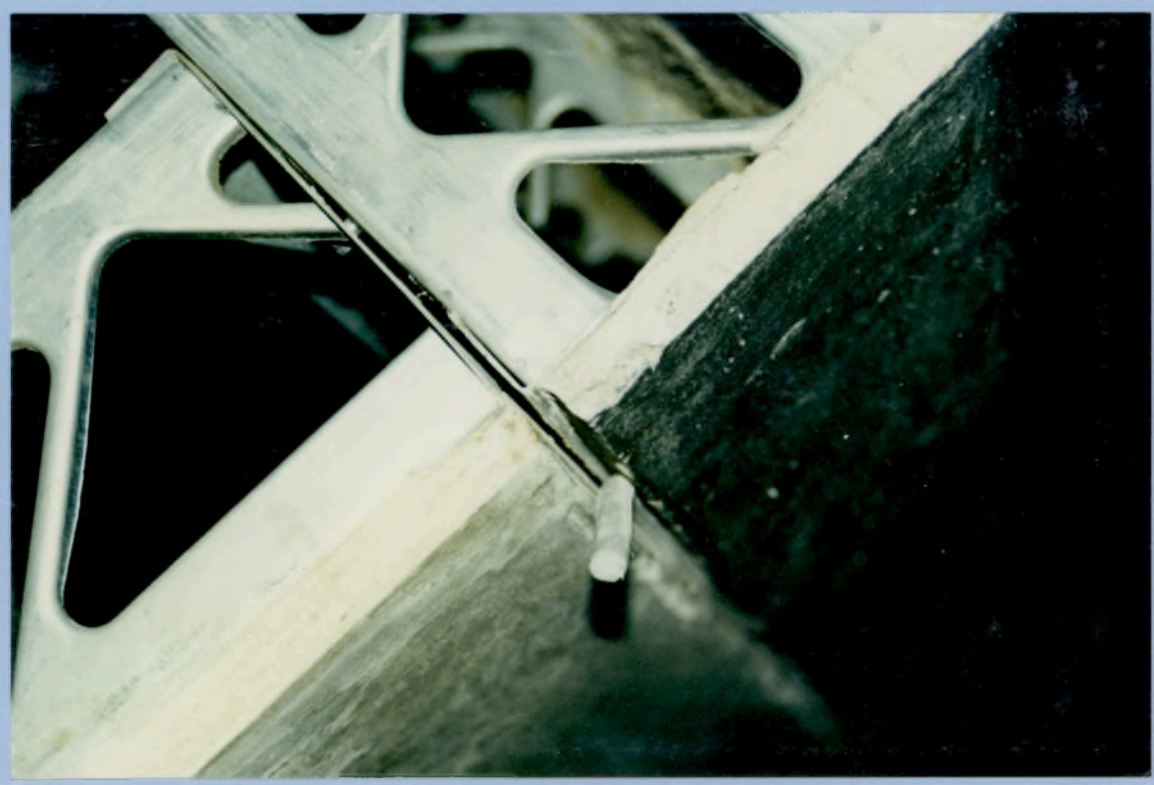
A selection of drawings used in the design and construction of the prototype module are included.

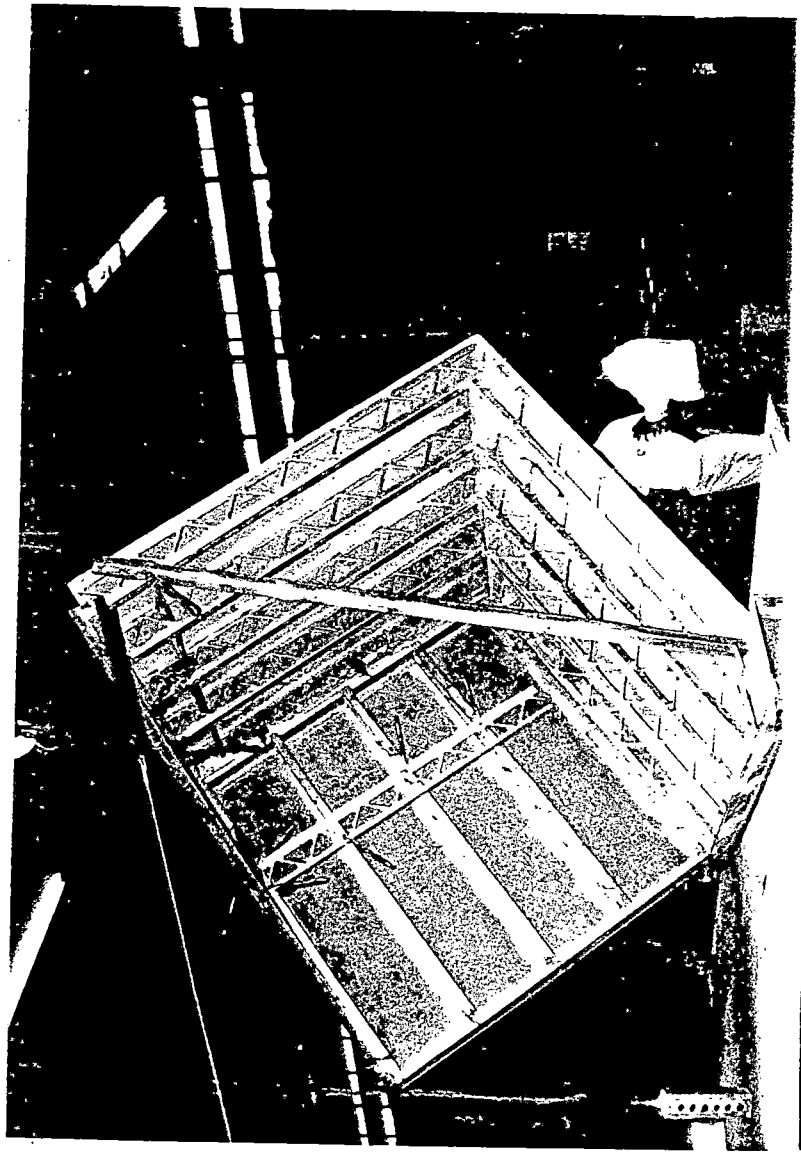
MODULE AS CONSTRUCTED

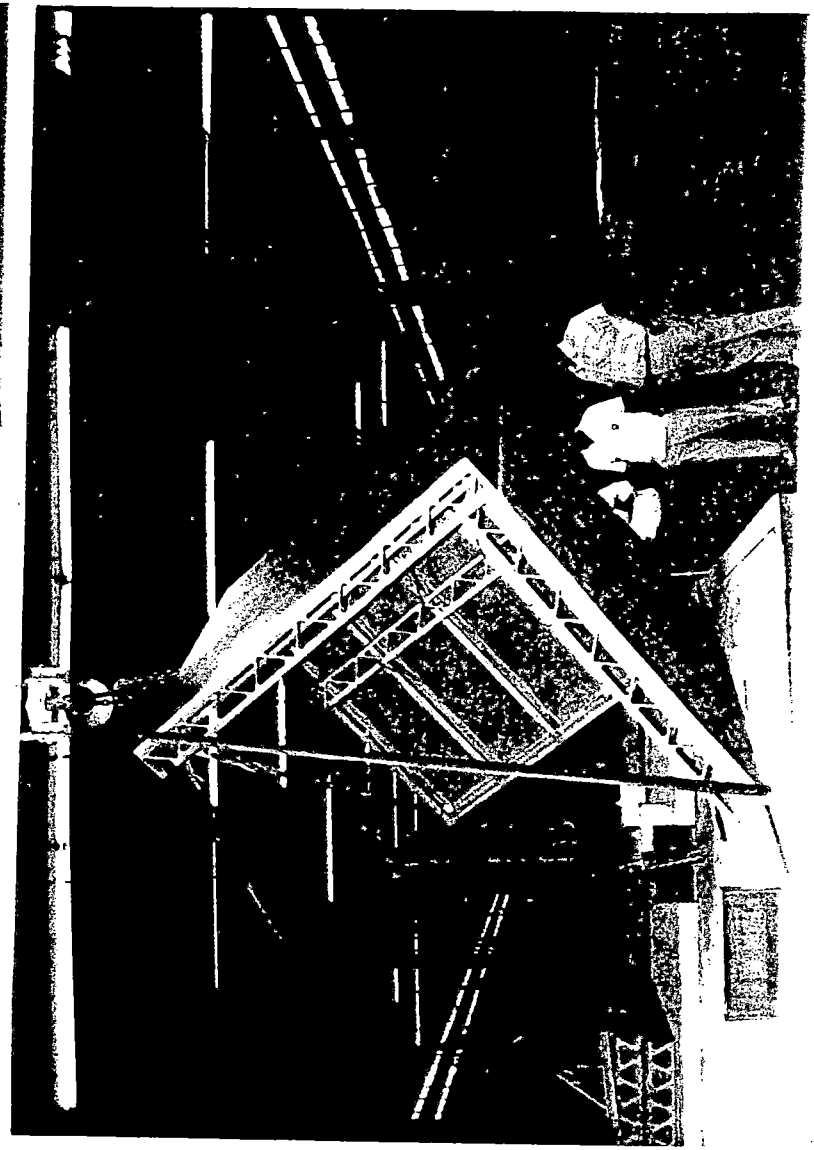


DETAILS OF MODULE AS CONSTRUCTED

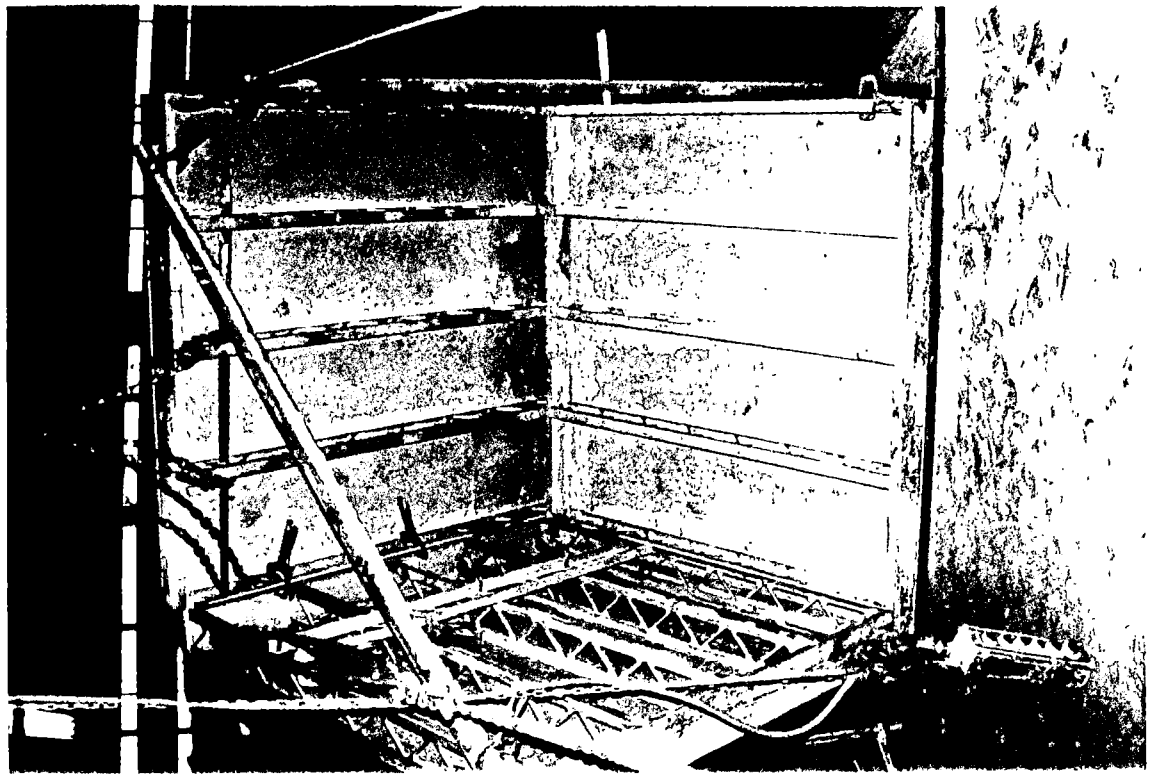


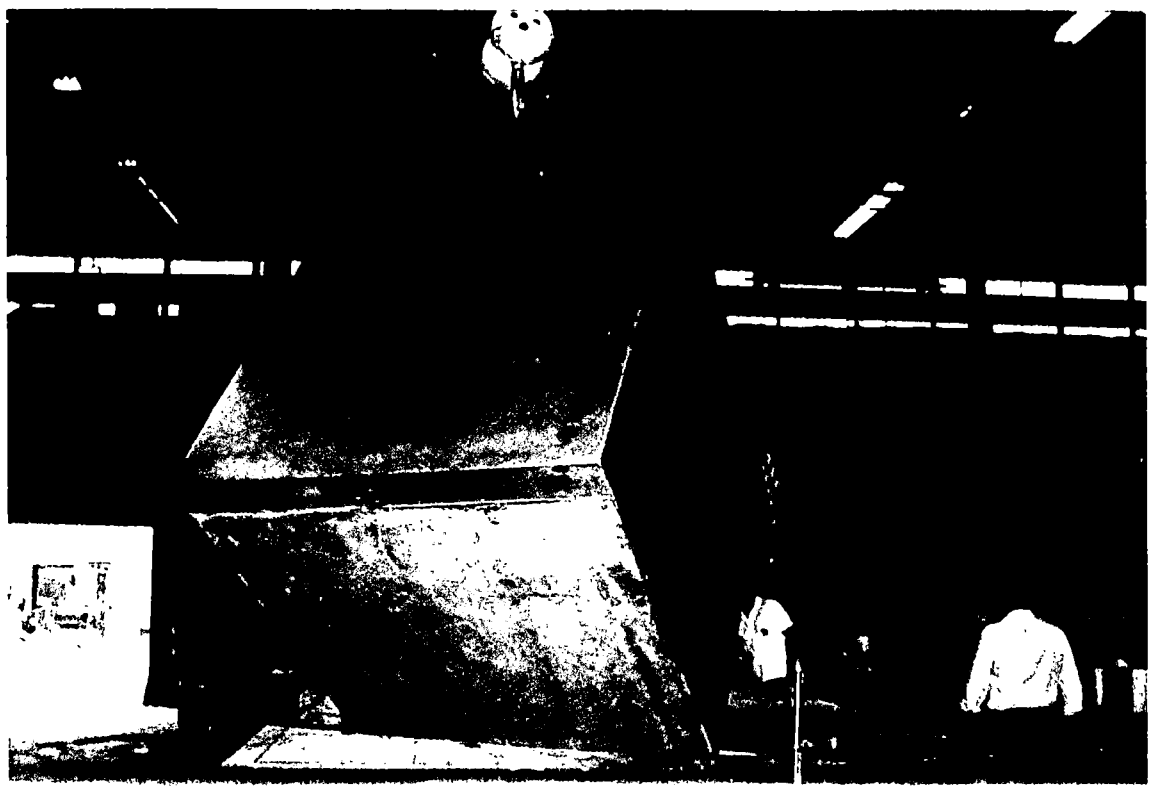






UNIQUBE PROTOTYPE MODULE
SEPTEMBER 1989. BRAMPTON





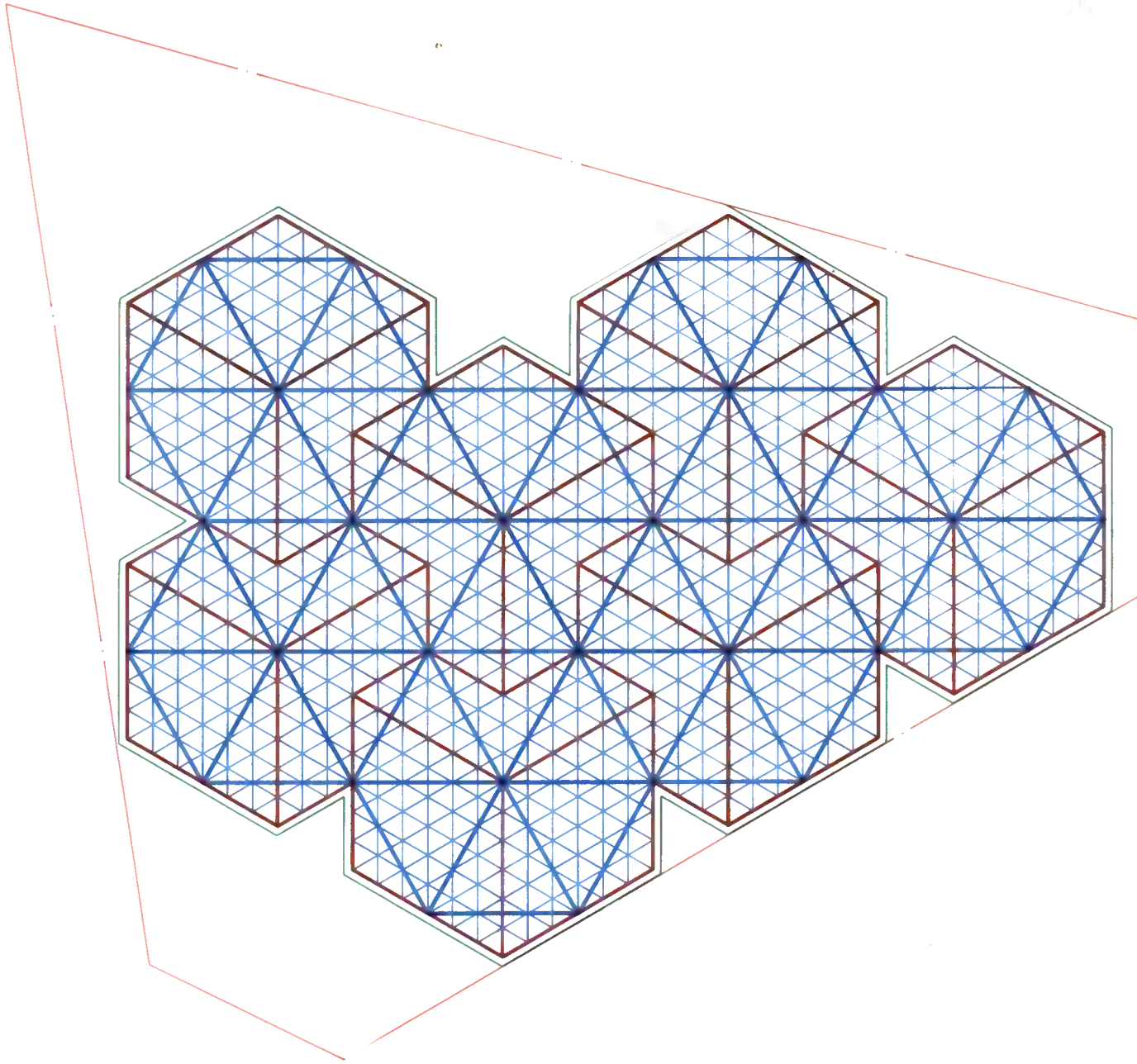
ASSESSMENT AND INTERPRETATION OF THE TEST RESULTS

Analysis

The system was analyzed and modeled by use of computer simulation, prior to construction, to determine the details of the design elements.

The project met the applicable structural design criteria, including wind, snow, roof, earthquake and live loads.

The requirements of the Ontario Building Code were met.



UNICUBE – 1 SUMACH STREET
STRUCTURAL ENGINEERS: PETER SHEFFIELD &

CONCLUSIONS

In the case of this study, the process of reaching the final construction method was perhaps the most instructive. The first project concepts involved the use of high-technology, high-fit methods, with skilled labour and specialized processes required. This is in keeping with one traditional concept of industrialized construction processes. For the development and construction of the prototype module, these concepts were frustrated due to the problems in budgeting, and the co-ordination involved in working with the originally proposed specialized processes.

The method ultimately used to build the prototype module, was, in contrast, a comparatively low-technology process, which can be undertaken by persons with a minimal level of skill. This means that the system is not dependent upon individual suppliers, a most suitable attribute, given the transience of many elements of the building industry.