CANADA'S GREEN PLAN
LE PLAN VERT DU CANADA

C-2000 DESIGN OF PRINCE GEORGE NATIVE FRIENDSHIP CENTRE

PREPARED FOR:

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Northern Resource Systems	- Electrical Engineer
McElhanney Consulting Services Ltd.	- Civil Engineer
Jay Lazzarin	- Landscape Architect
Agra Earth & Environmental Ltd.	- Geotechnical Consultants
LEC Quantity Surveying Ltd.	- Cost Consultant
Tescor Pacific Energy Services Inc.	- Energy Engineer

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Introduction

The Prince George Native Friendship Centre has incorporated elements of the C-2000 Advanced Buildings Program to make it an energy efficient building while at the same time minimizing the adverse environmental impacts and improving the indoor environment.

The four storey, 12,400 s.f. building will be an attractive addition to the downtown core of Prince George reflecting native traditions and energy efficient techniques.

Energy Usage

A number of energy and environmental C-2000 requirements have been implemented into the design process and as a result the building will operate at around 30 % less than an ASHRAE/IES 90.1 building, the benchmark of good energy performance.

The primary strategy of the design team was to avoid the use of mechanical cooling in the building. Occupant comfort will be maintained at the same time as reducing annual energy consumption. Items such as a high performance low-e coating on the glazing, high performance window frames, and exterior shading have minimized cooling requirements and will ensure that the building is comfortable year round. Envelope insulation was optimized to ensure maximum efficiency without resulting in over design and increased costs.

A compartmentalized HVAC system using fan coil technology will maintain optimum supply temperatures with a minimum amount of reheat required. This has been complemented by a night flush of the building with cool outside air to offset heat gains collected during the day.

Energy efficient lighting fixtures have been used throughout the building including the use of T-8 fluorescent fixtures and electronic ballasts. Further energy savings will be provided by the use of photocell lighting controls for the perimeter areas of the building. In addition, the elevator capacity has been reduced from 3,500 to 3,000 lbs.

Environmental Considerations

Products, processes and materials were evaluated so that informed decisions could be made throughout the design process. The goal was to minimize the impact of the building on the environment and enhance the community as a whole.

Products containing recycled materials have been used wherever possible. A cementitious board containing recycled newsprint has been specified as the exterior cladding for the building. Indoor finishing materials such as gypsum board and acoustic ceiling tile will also be used. As an alternative to plastic laminates a product called *Environ* made from recycled material will be used as the top of the countertops.

Maintaining the Indoor Air Quality of the building has also been a focus. The reduction of materials with a tendency to off gas emissions has been used to ensure occupant comfort and wealth. Linoleum will be used instead of vinyl flooring. Low emission carpets will be used as well as carpeting systems that do not use adhesives. Low VOC and durable paint will be used throughout the interior of the building. All sealants have been specified to be low in VOC's.

Building components have been selected based on their durability and anticipated life span. Structurally the building is composed of structural and steel and concrete with an anticipated life of 100 years. The cementitious cladding is rated to last at least 50 years. The sloping metal roof has a similar life span and has the added benefit of being recyclable.

Status

Design of the building was completed in September, 1996 and tendered in the same month. At present the project is on hold pending additional funding.

Introduction

Le *Prince George Native Friendship Centre* va profiter de certains éléments du Programme des bâtiments commerciaux performants C-2000 pour favoriser l'efficacité énergétique de l'édifice qui l'abritra. Par la même occasion, il sera possible de réduire les effets environnementaux négatifs et d'améliorer le milieu intérieur.

L'édifice de quatre étages et de 12 400 pieds carrés constituera un ajout intéressant au centre de la ville de Prince George puisqu'il traduit bien les traditions autochtones et la mise en œuvre de techniques à haut rendement énergétique.

Consommation énergétique

On a mis en application plusieurs des exigences énergétiques et environnementales du Programme C-2000 au moment de la conception de l'édifice. En conséquence, celui-ci fonctionnera à un niveau environ 30 % moins élevé que la norme 90.1 de l'ASHRAE/IES pour les bâtiments, le point de référence d'un bon rendement énergétique.

La principale stratégie adoptée par l'équipe de conception consiste à éviter l'utilisation, à l'intérieur de l'édifice, d'un système mécanique de climatisation. Le confort des occupants sera assuré, tout en favorisant la réduction de la consommation énergétique annuelle. Certains éléments, comme un revêtement à faible émissivité et à haut rendement sur le vitrage, des cadres de fenêtre à haut rendement et l'ombrage extérieur, contribueront à limiter les besoins en climatisation, en plus de garantir le confort à l'intérieur de l'édifice tout au cours de l'année. On prendra un soin particulier à bien isoler l'enveloppe du bâtiment afin d'assurer un maximum d'efficacité énergétique sans pour autant en arriver à une conception démesurée et à des coûts prohibitifs.

Un système de CVC à cloisons, faisant appel à la technologie du ventilo-convecteur, permettra de maintenir un apport optimal de températures ne nécessitant qu'une quantité minimale de réchauffement. Pour compléter le tout, on laissera pénétrer à l'intérieur de l'édifice l'air frais de la nuit qui, ainsi, compensera l'apport de chaleur obtenu pendant le jour.

Des appareils d'éclairage à haut rendement énergétique seront installés partout dans l'édifice, notamment des appareils à fluorescents T-8 et des ballasts électroniques. On sera en mesure de faire d'autres économies d'énergie en ayant recours à des commandes d'éclairage à cellule photo-électrique tout autour du périmètre de l'édifice. D'autre part, la capacité des ascenseurs sera réduite de 3 500 livres à 3 000 livres.

Considérations environnementales

Les produits, les procédés et les matériaux utilisés ont fait l'objet d'une évaluation de manière à pouvoir prendre des décisions éclairées tout au long du processus de conception. L'objectif visé consiste à limiter les répercussions de l'édifice sur l'environnement et à favoriser la communauté dans son ensemble.

Chaque fois que cela est possible, on utilisera des produits contenant des matériaux recyclés. Ainsi, des panneaux en agglomérés faits de papier journal recyclé ont été choisis pour le bardage extérieur de l'édifice. Pour la finition intérieure, on s'est tourné vers des matériaux comme les panneaux de gypse et les carreaux acoustiques de plafond. Un produit fait de matériaux recyclés, l'*Environ*, servira de rechange au plastique stratifié pour le revêtement supérieur des comptoirs.

Le maintien de la qualité de l'air intérieur a également constitué une préoccupation. Afin d'assurer le confort et le bien-être des occupants, on limitera l'utilisation de matériaux ayant tendance à laisser échapper des gaz. Par exemple, le linoléum remplacera le vinyle comme revêtement de plancher. On y installera également des tapis à faible émissivité et sans colle. Partout à l'intérieur, on appliquera une peinture durable qui ne produit que peu de carbones organiques volatils. Tous les produits d'étanchéité devront également ne produire que peu de COV.

Les produits de construction ont été choisis en fonction de leur durabilité et de leur longévité prévue. Les structures du bâtiment seront faites d'acier et de béton, et devraient durer 100 ans. Le bardage en agglomérés devrait, selon les estimations, durer au moins 50 ans. Le toit métallique incliné présente la même durée de vie, en plus d'offrir l'avantage d'être recyclable.

Situation

On a achevé la conception de l'édifice en septembre 1996, et procédé aux appels d'offres dans la même période. Pour le moment, le projet est en suspens jusqu'à l'obtention de fonds supplémentaires.

1.1 Project Vision

The Prince George Native Friendship Centre (PGNFC) is a non-profit, non sectarian organisation dedicated to servicing the needs of Native People residing in the urban area and to improving the quality of life in the community as a whole. Fundamental to this is recognising the inherent worth of all people regardless of race, creed, or culture and to promote this view in the community at large.

The objectives of the Friendship Centre are:

- To promote the educational, cultural, social, and economic advancement of the Native Indian people in and about the Prince George region and to establish, maintain and operate facilities for the advancement and accommodation of the native Indian people.
- To assist Native Indian people newly arrived in Prince George to adapt to an urban lifestyle.
- To provide support to provincial and national Native people's organizations.

The vision of the project was best expressed by Elder Celena John Sai'Kaz when he stated:

Our Elders have taught us that we must
blend the technology of the present with
the wisdom and traditions of our past for the
benefit of mother earth and our future generations.

For this reason choices among products, processes and materials have been evaluated throughout the design process. The goal has been to make informed decisions that minimise the impact of the building on the environment and enhance the community, both for users and visitors.

1.2 Site Overview

The Prince George Native Friendship Centre development is located on the east side of George Street between First Avenue and Second Avenue in Prince George, B.C. The site is adjacent to the existing administration centre to the south and abuts to the existing education centre to the east.

The building encompasses a total of three floors plus a useable roof top terrace. The building footprint measures approximately 24 meters in length by 16 meters in width at the street frontage. Total gross building area is approximately 1152 m^2(12,400 sq. ft.) on three levels. The space between the existing building and proposed development will include a planted native garden (indigenous species/ethno-botanical) and a hard paved gathering space.

Level One

The first level is made up of administrative offices of the Native Friendship Centre. It includes an entry vestibule and a Galleria (including several display cases), open stairs with a feature "living wall" fountain. The lobby and reception area are open to upper levels. This floor houses the management operations of the centre, the accounting and the support staff.

Level Two

This floor accommodates drug and alcohol treatment programmes, the Healthiest Babies programme and support spaces including a staff lunch area. At present this is an open plan but will be adaptable depending on the individual needs of the tenants.

Level Three

This floor is a dedicated Day Care Centre and includes a space for a Multi-Purpose Room connected directly to the stairwell and elevator core.

Roof Terrace

This space accommodates a covered and open outdoor play area. Also included is a mechanical room, washrooms and dedicated storage room for the children's' toys.

1.3 Project Team Members

The project is jointly funded by the Prince George Native Friendship Centre and the British Columbia Ministry of Health. CANMET Natural Resources Canada and BC Hydro sponsored the research necessary for this project. The project team assembled consisted of nine members:

Bunting Coady Architects - Architect/Project Manager
Scouten and Associates Engineering Ltd. - Structural Engineer
Quadra Pacific Consultants Ltd. - Mechanical Engineer
Northern Resource Systems - Electrical Engineer
McElhanney Consulting Services Ltd. - Civil Engineer
Jay Lazzarin - Landscape Architect
Agra Earth & Environmental Ltd. - Geotechnical Consultants
LEC Quantity Surveying Ltd. - Cost Consultant
Tescor Pacific Energy Services Inc. - Energy Engineer

2.1 Introduction

The following sections detail the building systems that are being used or proposed for the Prince George Native Friendship Centre from the various design stages of the project. The functional and aesthetic intent of the design, the nature of the materials and systems selected, and the selection criteria are outlined below.

Generally, systems and materials were chosen based on the following selection criteria system shown in order of decreasing priority:

1. Aesthetics, functionality and durability
2. Occupant comfort
3. Energy efficiency
4. Environmentally sustainable benefits

2.2 Orientation and Configuration

Typically, orientation and configuration play a significant part in energy efficiency strategies. In this particular site there are limitations. The site is small and the size is further reduced by the clients garden/courtyard requirement. There are also existing buildings on the neighbouring sites.

In spite of the limitations, the design team attempted to optimize the site conditions in regard to energy efficiency. The building will be a rectangular shaped building located in the north section of the site. The facades most prone to heat loss, the North and East, contain no windows thereby minimizing the amount of heat loss. A deliberate effort was made to have the longer elevation and entrance oriented to the South rather than the West, with adequate control of the high incident solar angles through sun shading and overhangs, thereby reducing heat build up within the building. If the longer face was oriented to the West, heat build-ups would be higher in the summer as the low west sun penetrates the building through the late afternoon. The spaces behind the west face are limited to a large vented galleria to reduce summertime overheating and improve occupant comfort.

The windows for this building are restricted to the south and west exposures to take advantage of daylighting opportunities. These windows also provide for solar heat gains during the winter months. The south face contains most of the office and daycare spaces and takes full advantage of daylighting. The facade is set back on itself to provide self shading in the summer during high incident sun angles. The south facade is also the optimum face for passive solar heating due to the sun's limited azimuth range in the wintertime.

2.3 Site And Landscaping

Parking Area

Parking for the Native Friendship Centre's is temporarily located across the street by special agreement with the City of Prince George. The parking areas will be made up of crushed gravel and concrete curbs. If possible, recycled crushed concrete will be used. A one meter landscaped strip will separate the parking lot from the street. The plants will have low water requirements .

If the temporary parking lot is developed with buildings in the future, the City has agreed to consider reduced requirements and on-street angle parking as a component of a coordinated street upgrade and local area development.

Disabled Access

The building is designed to be accessible to the disabled. The slopes have been kept to below the 1/20 limit for accessible walkways and no handrail is required. All spaces are designed to be easily accessible and exceed disabled access requirements.

Landscaped and Planted Areas

The site landscaping is an integral feature of the project. Approximately half of the site has been reserved as a ground level garden while the perimeter of daycare playground on the rooftop terrace will include container plants. According to the Landscape Architect, plant selection has been based on the following criteria:

1. Adaptability to site specific soil and sunlight conditions.
2. Ability to shape public/private spaces.
3. Environmental concerns including low maintenance, strong disease resistance, water conservation, habitat/food for birds, soil replenishment.
4. Importance to native culture including medicinal, food, drink flavouring, and paint.

Roof top terrace containers will contain low water indigenous plants including Red Twig Dogwood, and Creeping Junipers. The ground level courtyard includes a wide array of trees, shrubs and ground cover. The species selected are hardy, indigenous and relatively low water plants. The majority of the plants are of a perennial mix thereby reducing seasonal replacement. All areas will be watered with soaker hoses. It has been recommended that these be made of recycled material.

Shade Trees

Eliminating the need for mechanical cooling was a major focus of the energy strategy. While not necessary to maintain comfort levels in the building, trees play an important part in the energy reduction strategy of the Native Friendship Centre. The first two floors of the west and south elevations contain a large portion of glazing. Through the use of strategically placed deciduous trees the areas will remain cool in the summer and bright in the winter. Deciduous trees provide the benefit of leafy canopies that shade the building in the summer and lose their leaves to allow for solar gains in the winter. Also, the leafy canopy provides effective glare reduction in the summer months.

The west elevation bordering George Street requires the most shading because the first two floors are almost entirely composed of storefront glazing. In Prince George, street side landscaping is provided by the city. The City has agreed to provide suitable street trees for the boulevard planting on George Street from the following species list:

1. Fraxinus Patmore - Patmore Ash
2. Sorbus Aucuparia Rosedale - Rosedale Mountain Ash
3. Tilia Cordata - Littleleaf Linden
4. Ulmus Pumilia - Siberian Elm

Ideally, the west elevation trees have a full canopy to protect against low sun angles. Trees with a high overhead canopy like Trembling Aspen, White Spruce, and Chokecherry will prevent high incident solar gain to the first floor of the south elevation.

Paving

The site features a circular stone paved walkway made of locally available materials. Stone is one of the oldest building materials. The stone selected is granite that is readily available in the region and will not need to be quarried.

The walkway provides access to the courtyard patio and the building entrance. This creates directional order for pedestrians as well as serving an aesthetic function. The stone pavers also allow rain water to return to the ground water.

Site Furniture

The site furniture includes planters for the daycare terrace and seating benches in the courtyard. The benches will be locally produced from wood and reflect the native character of the building. Planters are a precast lightweight concrete product, Donolight or similar, made from cement mixed with recycled fibreglass and polystyrene.

2.4 Building Structure

Structural System

The original intent was to construct the building in wood. Structurally, the building would have been served by recycled beams salvaged from a local building owned by the Prince George Native Friendship Centre. The exterior studs would have been made up of engineered wood products to provide wider on center spacing, resulting in less wood and less thermal bridging. Wood has a very low embodied energy rating compared to steel and concrete.

The decision to place a large daycare in the building mandated a non-combustible assembly. As a result, the structural system for the Native Friendship Centre is a combination of structural steel (columns, beams and joists) and concrete block. Steel framing will be used. While the embodied energy of this product is high it produces very little waste and the waste generated is easily recyclable. Further, steel framing does not off gas so its impact on the indoor air quality is negligible. Finally, the steel and concrete are very durable with an anticipated life span of up to 100 years.

Vertical Structure

The vertical structure is composed of a variety of systems. The east wall is fire rated with perlite filled concrete blocks. The concrete is a highly durable material. The addition of perlite provides additional thermal mass and increases the overall thermal efficiency. The north wall is composed of structural steel studs.

An effort has been made to keep the columns within the envelope and minimize penetrations to maintain the integrity of the envelope. Initially, consideration was given to supporting the south overhang of the third floor by exterior poles but this was rejected due to the potential of thermal bridging across the building envelope. As a result, all support structure is internal to the building. The poles remain but are an architectural feature used to support the shading devices for the windows on the southern elevation.

Horizontal Structure

The floor system will be a 38mm steel deck with a 100mm concrete topping. This will be supported by wide flange structural steel framing on HSS columns to support the open web steel joists. This is an extremely durable system with longevity rated at over 100 years. The floor system will provide good acoustic sound separation and forms a finished surface for final floor finishes. It is a complete and simple system that is appropriate, functional and durable.

Building Cladding & Finishes

The exterior finish of the building will be varied.

The east firewall will be composed of split faced concrete block. While it requires substantial energy during its production, concrete block is a highly durable material made of relatively inert materials. It is also locally produced, ensuring that the transportation distance is small. The thermal mass of the concrete reduces energy peaks thereby reducing energy loads. Further, the addition of perlite to the core of the block makes this more thermally efficient than empty cores.

The north wall, also with a 2 hour fire rating, will be a rainscreen exterior insulation and finishing system (EIFS). Both Sto and Dryvit have developed a rainscreen system that accomplishes three of the most important rainscreen characteristics: an exterior face that acts like a rainscreen, a pressure equalized cavity, and a waterproof air barrier system. This system assumes that water infiltration into an exterior cladding is inevitable but by providing a means for moisture to egress the potential for envelope failure is significantly reduced. Additionally, this system reduces the effects of thermal bridging by providing a layer of insulation to the exterior of the steel studs.

The stairwell located in the North-West corner of the building will be clad with a stone veneer . This is a widely available and indigenous material installed by local stone masons with a minimum of quarrying necessary. Like concrete, it has a relatively low R-value but its thermal mass reduces peak energy loads. The joints of this assembly will require periodic resealing. However, the stone is large and flat and set in a thick mortar to reduce the number of joints and potential for failure.

The remainder of the walls will be finished with a horizontal cementitious board called Hardiplank®. The basic composition of this material is Portland cement, ground sand, cellulose fibre and other additives including recycled newspaper. This gives it the durability of fiber cement and the appearance of wood. It is resistant to damage caused by extended exposure to moisture, humidity, snow and insect infestation. It has a minimum life of 50 years with little anticipated maintenance.

The curved painted metal roof provides cover for the daycare playground on the roof top terrace and shading to some of the third floor windows. While the embodied energy of this product is high, its benefits do much to minimize its environmental burden. As well as being architecturally pleasing and functional, it is long lasting and durable. It is expected that the life of this product is over 50 years requiring minimal maintenance. Additional environmental benefits include recyclability and non-toxic material content.

2.5 Building Envelope

Roof

The roof at the playground deck of the Native Friendship Centre is an SBS (styrene-butadiene-styrene) modified bituminous roofing bonded onto a rigid insulation substrate. The minimum effective insulation value is R-25. This is a common and durable roofing system.

The roof assembly consists of a steel deck with rigid insulation bonded to the decking. The insulation will be installed in two layers with shiplap joints and rated at R-10. The rigid insulation fulfills two purposes: it slopes so that water is directed to the roof drain and is a thermal break to the steel roof joists and decking. The remainder of the insulation will be batt fibreglass suspended from the underside of the roof decking.

The SBS modified bitumen will be formulated so that its properties meet the extremes of the Prince George climate. It must have a low temperature flexibility, high fatigue resistance, a high softening point and wide temperature use. In general, the proper modification of bitumen will result in a far superior product than those of normal bitumen. The membrane is applied by torching directly to the rigid insulation with reinforcement at the perimeter parapet. The membrane is extended vertically up the parapet wall and over the flashing blocking for a continuous seal. The wall air seal sheet will be extended up to at least the level of the roof membrane. Concrete pavers will be installed over the full area of the playground to provide full coverage and protection and to ensure that the roof is ballasted.

The insulation is pentane expanded polystyrene and will be installed in two layers to eliminate gaps and the associated heat loss. Unlike the extruded polystyrenes and the polyisocyanurates, the expanded polystyrene is expanded with a hydrocarbon (pentane), not a CFC or an HCFC. The top layer of insulation will be attached with hot asphalt to eliminate thermal bridging associated with mechanical fasteners.

The roof parapet will be insulated under the roof membrane to prevent any heat loss through the concrete section and to ensure the continuous thermal performance of the envelope.

A roofing material similar to the fibre-cement exterior siding was considered for this project. While it has the same properties as the siding the product could not be used due to the curve of the roof canopy. The roofing material comes in the form of a shingle but is not flexible enough to accommodate the sloping skeleton frame.

Walls

While the exterior cladding and exterior wall structures of the Native Friendship Centre will vary the interior components of the walls are similar throughout out the building. The selected exterior wall system is composed of gypsum board, 6 mil vapour barrier, steel studs, plywood sheathing, peel and stick membrane, horizontal spacer bar on clips with 1-1/2" of rigid insulation. The insulation is a fiberglass type batt insulation rated at R-20.

The addition of continuous rigid insulation between the exterior cladding and the steel studs compensates for the potential heat losses due to thermal bridging caused by the steel studs. The addition of rigid insulation (R-7.5) gives the exterior walls an overall effective insulation value of R-17 for the concrete block, R-23 for the cedar siding, and R-21 for the EIFS.

An interesting new product was considered for this project to mitigate the heat losses associated with steel studs. The "*Studsnuggler*" is currently being developed by Oak Ridge National Lab. The product is a fitted foam profile used to insulate around metal wall studs. The addition of the foam allows the steel stud to have the same thermal conductance as a wooden 2X6. This product could not be used for this project because it is under patent consideration at the present time and hence is not available in the market place. However, the progress of this product will be monitored and considered for future projects, where deemed suitable.

Soffit

The soffit is an integral part of the envelope system and will be insulated with fibreglass batt insulation. All pot lights will be thermally insulated and firestopped. The finish material is an insulating stucco on wire mesh on building paper on exterior grade concrete board. The supporting steel frame structure will be separated from the concrete face panels by a plastic spacer bar to prevent thermal bridging. The insulation and soffit areas will be separated from the return air plenum by the interior drywall sheathing running above the ceiling to the underside of the structure above.

Foundation

The floor is a slab on grade with cast in place concrete 'frost walls' and spread footings. Due to the severe winters, the foundation wall is 5' deep to ensure a minimum frost depth. 4' perimeter rigid insulation (R-11) will be placed under the floor to reduce heat loss. The footings will be damp proofed with a membrane to prevent heat loss through the ground.

Sealants

The sealants in the building will be composed caulking for windows and doors, joint and patch compounds for concrete and drywall work, mortar and grout for tile work, and adhesives for the attachment of flooring, wallboards and wallpaper. The reduction of a large amount of the potential for volatile organic compound (VOC) off gassing in the building will be achieved by the aggressive reduction of inappropriate sealant materials.

The interior *caulking* for the setting of the windows and doors will be a low toxicity caulking formulated with synthetic resins, that contain little or no hazardous solvents or fungicides. The exterior caulking is latex based as these products are smaller health risk than the acrylic caulking compounds.

Non-toxic *joint and patching compounds* have been specified. These are gypsum combined with mica, talc, limestone and clay products containing no vinyl or toxic additives. The need for joint patching has been reduced as much as possible by the architectural detailing. The interior drywall finishing work will be well ventilated to prevent dust build-up and exposure to workers minimized through the use of dust masks. All installations will include a thorough clean-up after drywall finishing work has been completed and prior to tenant fit-out work.

The *mortar and grout mixes* are cement based non-toxic substances. Acrylic resins, colors, fungicides and epoxies that increase toxicity will be avoided. The grout will be sealed to prevent staining and bacteria growth.

Products that require *adhesives* will be minimized and/or eliminated due to their tendency to off gas. For example, a high grade low VOC paint has been substituted for the more traditional vinyl wallpaper. Linoleum and/or cork will be used instead of sheet vinyl flooring and adhered with low toxicity wet adhesives or factory applied adhesive backing that is heat welded rather than solvent welded in place. Whenever possible products like wallboard and sheathing will be mechanically fastened. Adhesives for the carpeting will be solvent free, low odour and low in VOC content.

Exterior Envelope Shading

An important element of the cooling strategy is the use of exterior shading devices. With no mechanical cooling, it is vital that all controllable forms of heat gain be minimized. The sun is a major source of heat gain for many buildings contribute to contributing to the overall cooling loads as well as occupant discomfort due increased space temperatures, direct beam radiation striking the skin, and re-radiation from surfaces warmed by sunlight.

The necessity for exterior shading in the Native Friendship Centre was verified through computer modeling. Without exterior shading, computer simulation indicated that spaces in the building would experience uncomfortably high space temperatures for an excessive number of occupied hours during the year. A variety of design solutions to exterior shading were explored for the south facade. The result is two different systems: a metal slatted overhang cantilevered from the building face to shade the windows for the second and third floors; and, a series of metal slats supported by poles some distance from the face of the building to serve the first floor.

Refer to Section 4.0 for a more detailed examination of this analysis.

Internal Shading Devices

Internal shading devices have been recommended for privacy and glare control. The fixed external shading devices like those discussed above are not effective in controlling glare due to low solar angles. Highly shaded glazing will not used as it reduces the solar heat gain benefits in the winter and the daylighting benefits provided throughout the year.

Light coloured horizontal venetian blinds have been recommended. This deviuce blocks direct beams, diffuses direct and indirect daylight, redirects light onto other room surfaces and does not significantly interfere with the view.

An alternate technology, an open weaveroller shade, was considered but it does not have the daylighting attributes that a venetian possesses. Instead, this product is best used for glare control. It should be noted that for the open weave roller a dark colour is best for good glare control with the minimum affect on the view. On the other hand, a light colour should be selected if heat gain control is more of a concern although it iis more difficult to see through.

2.6 Windows, Doors and Openings

Windows & Doors

The doors and windows for the Native Friendship Centre will be high performance for the entire building. The primary benefit of an advanced framing system is the significant improvement in occupant comfort by reducing radiant body heat loss. This is especially true for those occupants seated next to framing elements of the window who would be chilled by the cold frame.

The typical window is a double pane clear glazing with one low-e coating in thermally broken aluminum frames. The shading coefficient for the glazing is 0.44 and the light transmittance is .70 with a U value at centre of glass (COG) 0.29. Operable window sections are in all window elements.

Frame Types

Two types of window frames were considered for the Native Friendship Centre: fibreglass and aluminum. Each system has its own inherent benefits and problems. Although aluminum is durable and recyclable and requires little or no finishing or maintenance it is high in embodied energy. For example, it is estimated that 25% of the world's hydroelectric generating capacity is dedicated towards aluminum production. Conversely, fibreglass is lower in embodied energy and better insulating than aluminum. Nevertheless, due to quality control issues there is no recycled content in fibreglass frames.

After careful consideration the aluminum Kawneer 5500 window frame series was selected for the Native Friendship Centre. The primary reason for its selection was related to energy performance and cost. Previous projects have shown that although the fibreglass frames are better insulating the difference is marginal in terms of reduced energy costs. The option of fibreglass frames was carried in the tender but was not cost competitive and are almost 23% more than the Kawneer 5500 series.

The Iso Web 5500 Kawneer series, with an aluminum frame matching Visionwall, will provide improved condensation resistance and thermal resistance capabilities. The flashing on the window sill will sit on a membrane fastened into the glazing system. The spandrels located on the west wall will have an insulated pan.

2.7 Non-Structural Architectural Systems

Ceilings

The ceiling in Native Friendship Centre forms the underside of the return air plenum. For this reason the composition of the suspended acoustic tile ceiling is important. The space above the ceiling will have sprayed fireproofing to the underside of the steel deck. This is not ideal, but is required as a result of the code upgrade to the building to suit a daycare use. Inert spun mineral fibre will be specified instead of fibreglass batt for all areas requiring fire stopping in shaft areas.

The ceiling tile for the open plan and office areas was chosen to reduce the potential for particulate in the spaces. *Armstrong Industries* produces a series of acoustic mineral fibre ceiling panels that are low in particulate count. The panels are back coated to ensure dimensional stability when installed. The coatings are water based. The only non-sealed surface is the edges of the panel. Armstrong ceilings also contain renewable and natural materials including starch, perlite and clay. The manufacturer also claims that the ceiling panels contain at least 18 percent and as much as 88 percent recycled material. The Armstrong ceiling panel system also has an excellent sound absorption factor and will assist in reducing noise levels.

The collection of dust on the upper side of the ceiling in the return air plenum could be a minor problem and will be minimized by controlling construction sequencing to ensure that the ceiling tiles are installed after drywall sanding.

Floors

The floor system for the Native Friendship Centre is a simple concrete topping on a steel deck. The finish varies depending on the location. The lobby is polished concrete inlaid with local stone. This creates a natural appearance and is easily maintained. The building has small areas of painted concrete floor. All paints will be to the Ecologo Canadian standard.

The kitchen and washroom areas will be served by sheet flooring. Vinyl will not be used due to its tendency to offgass and the nature of the adhesive material required to affix it. Instead, the resilient floor finishes like linoleum or cork were considered.

Linoleum is made from natural ingredients that are based on renewable resources. The basic ingredient is linseed oil derived from the flax plant. While it is high in embodied energy linoleum is durable and very low in VOC emissions. It will be used primarily in the washrooms, kitchens and lunchroom.

Cork is a natural product that is harvested from oak trees in a sustainable manner. It has a proven record as an effective flooring system that is durable, provides acoustical and thermal insulation, is resistant to moisture damage and decay, and is easily maintained. It is imported from the Mediterranean making it energy intensive and expensive to ship to Prince George. Cork is also suffering from overharvesting. For these reasons, the decision was made not to use cork as a finish.

The office area will be finished with carpet. There is an indoor air quality issue regarding carpets due to the off gassing of VOC's contained in the adhesives and backing and cushioning materials. The carpet manufacturing industry has responded to the VOC concern with the establishment of a program to test the indoor air quality of carpets. The program, developed by the Carpet and Rug Institute (CRI), ensures that the carpet type bearing the label has been tested, meets the criteria of the CRI IAQ Carpet Testing Program, and minimizes the impact on indoor air quality. A "low emission" carpet installation is one which:

- Eliminates synthetic latex bonding materials
- Eliminates topical stain resistance materials
- Eliminates flame retardants
- Eliminates foamed rubber or plastic backing pads
- Has pile which resists soiling and allows easy air movement for cleaning.

In general, the performance of a carpet depends on the durability of the product and on its tightloop construction and resistance to creating loose particulate that contaminate the air. Carpet manufacturers have found that "weaving" the fiber wastes less fiber and is more durable. A number of carpet manufacturers have developed a nylon fiber carpet that is recyclable and durable for ten years. Whatever carpet product is used, its VOC emissions can be reduced by asking the mill to 'bake' the carpet order to remove the chemicals remaining from the manufacturing process. The simplest way to test a product sample is to sniff it for emissions. Carpets spun from recycled drink box plastics are popular but not durable enough for a commercial installation. Latex or woven backings will be avoided due to their ability to harbor dust.

The adhesives used in carpet are also a major VOC concern. For this reason the use of alternate carpet systems is being considered in the office areas of the Native Friendship Centre. Interface Flooring Systems has a modular carpet system that is durable, recyclable and does not require adhesives. All Interface products are coated with Intersept ®, a patented antimicrobial agent which inhibits microbial growth that can be a major contributor to sick building syndrome and building related illnesses. *Peerless Carpets* has developed a Tac Fast system that uses Velcro strips and does not require adhesives and under cushion. *Heuga* has developed an environmentally sound backing system called *System Six* that reduces adhesion requirements and enables removal and recycling through their own carpet recycling program. If the interior finishing budget becomes an issue, then at the very least low VOC content and low odour carpet adhesives will be used.

Walls

A typical wall will be constructed as part of a non-combustible building type requiring steel studs and gypsum board. Gypsum is very safe from a toxic standpoint but is an environmental concern when it finds its way into landfills. Nevertheless, gypsum is 100% recyclable and local manufacturers use up to 26% recycled material in their products depending on availability. The board is screwed into place to avoid the use of adhesives. Installation procedures will minimize the health risks to installers through the use of masks and ventilation to reduce fine dust contamination.

The interior walls will be painted and include some architectural wood working. Vinyl wall coverings will not be used due to environmental concerns. Vinyl tends to off gas VOC's and can increase the contamination of the air and the need for more fresh air supply. Further, vinyl is made from petroleum, using a polymerization process, that can create serious risk of chemical exposure for workers and produces hazardous waste. Zolatone will be used in those locations that require a wall paper type finish. It is highly durable, low in VOC emissions and gives the appearance of a wall covering

The majority of the walls will be finished with durable interior paints that meet the Ecologo standard. In Canada, the paint industry has responded positively to the Ecologo program and modified their products to conform to its strict environmental guidelines.

The woods specified for use as decorative finish products in architectural work will be 'farmed' rather than forested and harvested wood products, and preferably locally produced. Finishes will be natural oils and waxes to avoid VOCs.

Miscellaneous

The use of plastic laminates will be avoided as much as possible. The production of plastic laminates is a highly polluting process. Government regulating authorities are doing much to streamline and reduce the impact of the production process. However, as laminates are durable and the best product for certain uses, put in context with alternate surfacing materials, decorative laminates are acceptable if used appropriately. Alternatives will always be considered first and evaluated on its appropriateness.

A stained medium density fibreboard is being considered as the interior finish for the elevator cab and the washroom partitions. The type of board specified is Medite II, a formaldehyde free wood product that is appropriate for such a confined area. The stains will be to the Ecologo standard. The adhesives will be of a non-toxic, non-solvent variety. Although not a traditional use of Medite it has been used with success in other projects for the same purpose. Furthermore, the finish also complements the architectural appearance of the building.

An alternate product is *Environ* ® from Phenix Biocomposites. This is a product that has the appearance of granite but works like wood and refers to itself as a new generation of hardwood. Made from recycled and sustainable, renewable resources it does not contain hazardous or toxic substance including formaldehyde. It is an excellent alternative to plastic laminates and is highly durable and appropriate for use within a heavily trafficked elevator. The problem with this product is the limited number of finishes availabe and those available were too dark for use in the elevator cab interior. This product is being considered for use in the countertops in those areas that are not exposed to water and the potential of water damage.

2.8 Plumbing and Sanitation Systems

Plumbing Materials and Standards

All plumbing systems will be installed in accordance with the 1992 edition of the BC Plumbing Code. All domestic water piping above grade will be Type L hard copper with cast brass or wrought copper fittings. Joints will be made using flux and lead free solder. All sanitary and storm drainage piping below grade will be ABS/PVC, as approved by the BC Plumbing Code, with solvent welded joints. All sanitary and storm sewer drainage piping above grade will be Class 4000 cast iron pipe to CAN 3-B70-M 86, with cast iron and mechanical joints. Insulation will be provided on all rain water leader piping systems to prevent condensation on cold water piping.

Sanitary vent piping above grade will be DWV copper with wrought copper fittings and 95/5 solder joints.

Washroom fixtures, floor drains and other sanitary fixtures will be connected to the building gravity sewer system. The drain waste and vent piping will be provided with cleanouts extended up from floor level in suitable locations for servicing. The main drain piping will not be sized for future additions.

Plumbing Fixtures and Trim

All plumbing fixtures will be institutional grade fixtures and colours. Fixtures and trim will be low water consuming. Water closets will be vitreous china, floor mounted flush tank type in most washrooms. Stainless steel sinks will be used in the kitchen.

Disabled access facilities will be provided as per Section 3.7 of the B.C. Building Code.

Sensor Controls

Due to the relatively small occupancy anticipated for this building, no sensor controls for the plumbing fixtures will be used.

Domestic Water

Domestic water will be heated and stored at 60°C to kill any Legionella bacteria present in the water and distributed at 45°C to allow for shower use and to prevent the re growth of Legionella. Delivery temperature will be maintained in the distribution system by self regulating heat tracing.

Rain Water

Rain water collection was not considered for this project. Previous experience has demonstrated that the annual costs savings associated with a project of this size do not offset the high initial set up costs. Instead it was felt that it was more practical to reduce water use by using drip irrigation and using plants that have low water requirements.

2.9 Vertical Transport

There is one elevator located in the building lobby serving all floors and the roof top playground. This will function as delivery and passenger lift. The elevator is hydraulic and downsized to 3,000 lbs. from 3,500 lbs. of the high efficiency variety to reduce energy consumption. The elevator is located beside the feature lobby staircase/interior fountain and it is hoped that the occupants will choose to walk rather than take the elevator.

2.10 Mechanical Systems

Secondary Systems

The heating and ventilation system in the Native Friendship Centre will provide unmixed, unvitiated outside air directly to a two-pipe fancoil unit and ceiling diffuser system in each individual HVAC zone using a roof-mounted ventilation air handler with indirect gas fired pre-heat. IN such a system the outside air is mixed with local return air in the fan coil and provided directly to the space. The ventilation air handler and associated ductwork is capable of variable air volumes and each individual HVAC zone is fitted with a variable ventilation air valve to enable the system to provide 60% economizer capability. This allows each HVAC zone to vary the mixture of 'cool' ventilation air and 'warm' return air to condition the space. This positive ventilation delivery directly to the zone and the constant volume air flow characteristics of the fan coil will result in an estimated net ventilation effectiveness of 0.90. This system configuration has the added benefit of allowing for increased ventilation air well in excess of ASHRAE Standard 62-1989, when conditions permit. A single multiple speed exhaust fan located on the roof top will maintain correct building pressurization by controlling in sequence with the variable speed drive ventilation supply fan. Separate exhaust fans will serve the washrooms. Minimum ventilation air volumes will meet ASHRAE Standard 62-1989 and gross fan coil air supply will provide a minimum zone air circulation rate of 6 air changes per hour.

Primary Systems

The primary heating system consists of a 720 MBH hot water boiler supporting a closed hydronic heating system providing hot water to reheat coils in the fan coil units and baseboard heaters in ancillary spaces. There is no mechanical cooling in the building.

2.11 Power Systems

Transformers/Supply

The Native Friendship Centre building will be supplied with a three phase, 120/208 Volt, 600 Amp service supplied from an underground BC Hydro service. Sub distribution will be to a 42 circuit panel board per floor, and to major mechanical loads, as required.

Standby Power

As it is not a code requirement, there were no provisions made for standby power.

Main Metering

A master B.C. Hydro meter is located on the outdoor unit substation. The advantage is that the meter can be read without access to the building.

Sub Metering

A complete sub-metering system is provided to indicate usage for common areas and individual tenant areas. The metering within the tenant areas includes lighting, power, and HVAC. The metering system specified is approved by the Industry Canada Legal Metrology Branch for utility sub-metering. This system utilizes the existing conductors as a "Power Line Carrier" to monitor energy consumption.

Vertical Risers

Power and telecommunications within the building will be through conduit and wire from the main electrical room to each sub-electrical room. These feeds will be located within the slab or just under the decking (depending on size) to the distribution points. As this building is only 3 floors a vertical buss duct riser has been deemed to be impractical and not cost effective.

Horizontal Distribution

Similar to above, conduit and wire will be distributed within or under the slab.

Plugs/Outlets

Receptacles will be provided along the perimeter walls and to the permanent interior office walls. Demountable partition walls will have receptacles supplied from ceiling boxes mounted above the suspended ceiling to accommodate future renovations. Open office areas will be equipped with receptacles mounted above the suspended ceiling to accommodate service poles. Service poles and all workstations will be supplied with two duplex receptacles, one telephone outlet and one data outlet.

2.12 Lighting Systems

Ambient Lighting

The focus of the lighting strategy has been to make it as energy efficient as possible while maintaining the quality of lighting. The office areas will feature recessed 2' x 4' two lamp fluorescent fixtures complete with 4" deep cell parabolic lenses throughout. The ballasts will be energy saving electronic ballasts. The lamps will be 32W T8 with a colour temperature of 3500K and a colour rendition index of 80 or greater. Recessed pot lights will be incorporated in the gypsum board ceiling areas in the washrooms and lobby areas. The lamps will be energy efficient compact fluorescence. Architectural pendant lighting with 250W Metal Halide lamps will be featured in the reception lobby area.

Average light levels within the office areas will be 60 foot-candles. Lighting will be controlled by line voltage wall switches.

Photocell control of lighting will be used to shut off perimeter zone lighting when the ambient lighting levels in the zone reach a minimum of 60 footcandles from daylighting. All perimeter lighting zones will include photocell control.

Emergency lighting and Exit signs will be to BC Building Code requirements. As well, emergency lighting will be provided in the disabled washrooms. Exterior lighting will be low wattage high pressure sodium. These fixtures will be building mounted and photocell controlled.

2.13 Cabling and Building Automation Systems

Communication Wiring

New category 3 telephone and new category 5 data cabling will be provided for all office areas and open office work stations. All data locations will be provided with single data outlets.

Building Security

A multizoned building security system will be provided to secure the building and to allow access to selected spaces outside of regular building areas.

A fire alarm system will be provided throughout the building. It will be connected to the mechanical sprinkler serving the lobby area, the HVAC systems, and to a remote monitoring facility.

2.14 Office Equipment

Final office equipment requirements for the Native Friendship Centre have not been determined. However, equipment densities have been assumed to be .75 watts/ft^2 for the office areas and .25 watts/ ft^2 for the daycare.

2.15 Appliances

The lunchroom and coffee station on the second floor are anticipated to have appliances. The daycare on the third floor will have a kitchen and laundry room. These requirements have been factored into plug load and are a minimal consumer due to the nature of the tenants. For these areas, energy efficient appliances are being recommended.

3.1 Envelope & Air Barrier System Design

Construction

Due to architectural, safety, and thermal requirements the wall assemblies are varied. The daycare located on the third floor requires that the building be non-combustible and as a result all exterior walls are steel framed. There are three main exterior wall assemblies used in the construction of the Native Friendship Centre. The south wall is a firewall assembly with a stucco finish. The east wall is also a fire wall using perlite filled concrete blocks. The remainder of the walls are finished with cementitous siding.

Although the finishes are different the interior of the wall assembly is basically the same. From the inside to outside the construction is:

Gypsum Wallboard
Polyethylene Vapour Barrier
Fiberglass Batt Insulation
2 x 6 Steel Studs
Exterior Gypsum Board
Rigid Insulation

The first floor of the south elevation and the first two floors of the west wall are comprised of a curtainwall window system with high performance glazing system.

Air Barrier and Air Leakage

Many building performance problems can be traced to air leakage through the building envelope. These problems range from high heating costs and poor temperature control to rain penetration and moisture accumulation within the wall assembly. The principle function of the air barrier is to prevent the infiltration of outdoor air into the building and the exfiltration of indoor air to the outside.

The air barrier used in the Native Friendship Centre varies depending on the wall assembly. For example, the air barrier for the stucco wall assembly is the rigid insulation and the double layer of exterior gypsum board. According to tests performed by the CMHC (Report No.5055.1 Test #6) this assembly is rated at 0.003 l/s * m^2. The air barrier for the east wall is the concrete block. The air barrier for the cedar siding is Tyvek with taped joints. Both these are anticipated to have a leakage rate of .1 l/s* m^2. A secondary air barrier for all these walls is the polyethylene vapour barrier located on the warm side of the fibreglass insulation.

The continuity of the air barrier system has been assured through extensive detailing and instructions contained within the contract documents. This is particularly true around windows, parapets and penetrations. Site inspections will verify adherence to these instructions. Actual leakage rates may be verified by testing the envelope assembly after completion of the project and prior to occupancy.

Thermal Bridging Control Strategies

The design strategy of the Native Friendship Centre was to achieve true R values by detailing walls to minimize the effects of thermal bridging. Thermal bridging can seriously interfere with the performance of the building envelope. Problems include:

- Loss of moisture control due to temperature gradient differentials resulting in condensation forming within the wall cavity.

- Reduced insulation values result in heat loss and increased energy consumption.

Through the use of a 38mm layer of rigid insulation thermal bridging is not anticipated to be a problem for the walls for this building.

Wall

For this report, analysis of the building assemblies was performed using *FRAME V.4* . This is a computer simulation program used to quantify the effective insulation values of wall assemblies taking into account the effects of thermal bridging created by the various building components.

Analysis of the effect of thermal bridging was performed on the concrete block, stucco, cedar siding and stone wall sections. As this is classified as a non-combustible building, steel studs have been used for the exterior wall. Steel, unlike wood, is a highly conductive building material and therefore creates a thermal bridge from the interior to the exterior. An illustrated example of this heat flow for the four wall systems is provided in the appendix. Note that the thermal flow within the wall assembly is almost exclusively through the steel studs.

To mitigate the effects of thermal bridging, a 38 mm layer of rigid insulation rated will be installed for all wall sections except the concrete block assembly. For this assembly, the block cavities will be filled with perlite. For all walls the extra layer of insulation acts as a thermal break and improves the overall insulative value of the wall.

According to the analysis performed by *FRAME* the following are the effective ratings for each wall system:

Wall Assembly	U-Value	RSI	R
Concrete Block	0.3440	2.91	16.5
Cedar Siding	0.2472	4.05	23.0
Stone Veneer	0.3557	2.81	16.0
Stucco Siding	0.2617	3.82	21.7

3.2 Moisture Control

A major contributor to the failure of the building envelope is the accumulation of moisture within the wall assembly due to vapour diffusion and water penetration. Excessive and long term accumulation of moisture can result in the following:

- weaken or impair the insulation and structural materials by altering their chemical composition.
- repeated freezing and thawing can weaken or disfigure such masonry materials as stone and brick resulting in efflorescence and spalling.

- staining will occur if the moisture flows to the warm inside surface and evaporates.
- insulation may expand or shrink excessively.
- wet insulation can lose its insulative qualities.
- moisture can contribute to the corrosion of electrical junction boxes, metal ties, steel stud assemblies.

Through the use of a vapour barrier, effective air barrier strategies and minimized envelope penetrations moisture is not anticipated to be a problem for the Native Friendship Centre.

Vapour Diffusion

Vapour diffusion is the process by which water vapour migrates through a material. The rate of vapour migration depends on the following factors:

- pressure differences between the inside of the building and the outside air;
- resistance of building materials;
- rate of air leakage.

With the advent of modern, airtight, highly insulated buildings, it has become increasingly important to consider vapour flow characteristics when designing exterior walls. In older buildings condensation is generally not a problem because they have high air exchange rates due to air leakage. As a result, water vapour traveled through the building envelope without ever reaching pressures that resulted in condensation. The primary mechanism in controlling condensation within the building envelope is through the use of a vapour barrier. A properly placed vapour barrier will retard the passage of moisture as it diffuses through the assembly of materials within a structure.

The vapour barrier in the Native Friendship Centre building is the 6 mil polyethylene located on the warm side of the fibreglass batt insulation. This is an industry standard and a proven means of preventing excessive vapour diffusion from entering the envelope. For the vapour barrier to be effective it must be continuous with all penetrations caulked and effectively tied into other construction elements like the windows, doors, ceiling and foundation. Attention to these concerns during installation and inspection will ensure that vapour diffusion is kept to a minimum.

Dew Point Analysis

As noted, the use of mechanical cooling will not apply to the Native Friendship Centre. At ambient conditions (25% Relative Humidity) the dew point is approximately 3°C. For all wall assemblies the dew point falls within the rigid insulation. An illustrated example of this is provided in Appendix B with the dew point highlighted for each wall assembly. In the case of this building no problems are anticipated. Since any condensation that may occur requires a condensing plane to be absorbed, the rigid insulation with a zero absorption capacity will stay dry. Further discussion is provided in the *EMPTIED* Analysis section.

EMPTIED Analysis

Calculations for condensation potential due to vapour diffusion were performed on the *EMPTIED* software program for all the wall assemblies. *EMPTIED* is a computer program that estimates the amount of moisture that is likely to accumulate in a specified building envelope due to vapour diffusion and air leakage. Refer to Appendix A for detailed results.

The data in Figure 9 is for the stucco wall assembly. As discussed, the anticipated leakage rate for the stucco wall assembly is 0.003 l /s* m^2(equivalent to .035 cm^2/m^2 @ n=0.7), with no pressure differential, at the Calgary ambient relative humidity levels*, and no moisture added upon heating of outside air. The worst month for the simulated year is December with a condensation rate of .0005 kg/m^2. The lower table indicates that condensation is solely due to air leakage. Vapour diffusion is non existent due to the use of a vapour barrier located on the warm side of the insulation. The upper table shows an evaporation rate of .0006 kg/m^2. For this worst case condition, the potential for evaporation exceeds the condensation and thus no moisture will accumulate.

A positive pressure of 75 Pa was added to the same wall section with the same leakage rate. Once again, the results show that all of the condensation is due to air leakage. Although the condensation rate has increased to 0.0045 kg/m^2 the evaporation rate is more than adequate at ensuring that the wall assembly remains dry.

The results for the cedar siding wall assembly are similar to the stucco section. For this particular section the worst potential month is March. During this month .0025 kg/ m^2 could accumulate within the wall assembly without any pressure added and 0.226kg/ m^2 with a positive pressure rate of 75 Pa. As with the stucco section, the evaporation rate of this wall assembly more than exceeds the condensation rate making the issue of moisture collection due to condensation a non-issue.

Similar results were achieved with the concrete block and stone assemblies. Individual results are available in the appendix for reference. In all cases the rate of evaporation exceeds the amount of condensation.

As noted, moisture collection within the wall assembly due to condensation is not a concern. Although no problems are foreseen for all wall assemblies the results do underline the importance of the following:

- controlling air leakage
- continuity of the vapour barrier
- balanced operation of the heating/cooling equipment
- control of humidity levels.

Moisture Penetration

Penetrations in the exterior cladding invite the potential for moisture to enter the wall cavity. The long term accumulation of this water can result in the deterioration of the insulation and the building materials. For this building, penetrations within the envelope have been kept to minimum. For example, preliminary designs had external supports entering the envelope. However, due to concerns with creating a thermal bridge and the potential for moisture ingress this was eliminated.

* *EMPTIED* does not include data for Prince George. Calgary was used as the default based on the recommendation of the program developer, Gus Handegord, because its climate is closest to that of Prince George.

4.1 Premises and Performance Targets

Energy efficient strategies selected for the Prince George Native Friendship Centre were those that met the design criteria, namely durability, occupant comfort, energy efficiency and environmentally sustainable benefits. Significant client concerns were the maintenance costs and technical ability required for maintenance of the proposed building systems. With this in mind, the Native Friendship Centre was developed using entirely mainstream and readily reproducible technologies applied in an effective and integrated manner.

The primary building strategy involved the non-use of mechanical cooling. In doing so maintenance and initial capital construction cost were avoided. In addition, the resulting building will cost 33% less to operate than the ASHRAE/IES 90.1 Reference Building, a significant improvement over the industry standard for energy efficiency.

The results of the ASHRAE/IES 90.1 are as follows:

Design Building	Electric Energy	87,445 kWh	7.3 kWh/ft^2	
	Natural Gas Energy	223,030 kWh	18.7 kWh/ft^2	
	Building Energy	310,475 kWh	26.0 kWh/ft^2	73% ASHRAE/IES
	Building Cost	$ 9,132.00	$ 0.77/ft^2	70% ASHRAE/IES
	Building Energy (SEAF = 3.0 Electric)	485,365 kWh		70% ASHRAE/IES
Reference Building	Electric Energy	134,810 kWh	11.3 kWh/ft^2	
	Natural Gas Energy	290,780 kWh	24.4 kWh/ft^2	
	Building Energy	425,590 kWh	35.7 kWh/ft^2	
	Building Cost	$ 13,541	$ 1.13 / ft^2	
	Building Energy (SEAF=3.0 Electric)	695,210 kWh		

4.2 Computer Simulation Methodology

All energy analyses were performed using DOE2.1e, an hourly energy simulation software package developed by Lawrence Berkeley Laboratory (LBL) and the United States Department of Energy. LBL Window 4.1 software was used for all window and frame analyses. DOE is widely acknowledged as the most comprehensive and analytically rigorous program of its type.

4.3 Design Evolution

On the basis of the primary design strategy to not use mechanical cooling in the building, the strategies utilized to select the building systems had two main goals: to reduce the annual energy consumption of the building; and, to maintain occupant comfort conditions without mechanical cooling. Both design targets required a whole building approach with a wide range of incremental strategies devised to reach the goals. A review of the process is divided into lighting and equipment, envelope, and HVAC strategies.

Lighting and Equipment Strategies

The benchmark for energy efficient lighting design is the ASHRAE/IES 90.1 standard and the design intent of this project was to exceed this standard without compromising the visual environment. A reduction in lighting energy consumption benefits both the target of lower building energy consumption and reduced building cooling requirements. The proposed lighting system includes two lamp T8 fluorescent fixtures, high efficiency electronic ballasts and discrete daylighting control in the perimeter areas at 60 footcandles. Daylighting controls were analyzed in all perimeter zones and model results indicated that energy savings using photocell control was approximately $450 per year. An estimated 10-12 photocell sensors are required at a total capital cost of approximately $2,000.

Elevator capacities were marginally reduced from a 3,500 lb to a 3,000 lb rating. This reduced the required elevator motor energy and overall energy consumption.

Envelope Strategies

Envelope strategies to reduce energy consumption and building cooling loads are commonly directed towards the glazing selection, external shading options and wall and roof constructions. A combination of these directions was used to optimize the building fabric of the Friendship Centre.

The proposed glazing is a double pane insulated unit composed of two panes of clear glazing with a low emissivity coating on one pane. The selected low-e coating is a high performance film providing a low shading coefficient with high transmittance. Clear glazing was selected to improve the daylighting opportunities and maximize the winter solar heat gain benefit. Analysis of a lower shading coefficient glazing (tinted glazing) resulted in little change to the building energy consumption and was rejected in favour of clear glazing for better daylighting.

A variety of glazing and frame improvement strategies were analyzed and rejected as not cost effective. These included triple glazing, high performance 'Vision-Wall' glazing and fibreglass frames.

Exterior shading strategies progressed through a series of design iterations. A few features of the window design and building orientation complicated the development of an optimally effective shading strategy. Specifically, these included:

- the southwest orientation of the "south" facade
- the long vertical dimension of many of the glazed areas
- a high proportion of glazing on the west facade.

These features are problematic for essentially the same reason: they result in lower altitude sun angles striking key glazing surfaces. The lower the angle the more difficult it is to block without obstructing view and daylight.

A simple graphic technique called a "shading mask" was used to analyze the shading performance of various design schemes. A shading mask is a diagram built on a horizontally-projected sun path diagram. It illustrates the percentage of window shaded for every moment of the year. A shading mask is typically prepared for each critical window. In this case, one per floor per shaded orientation was appropriate. The advantage of a shading mask is its ability to convey an entire year of information in a single picture. The graphic nature of the presentation also makes it fairly intuitive to read, given the density of information contained in the diagram. The disadvantage of the technique is the inexactness of the data. For example, shading performance is presented in ranges and 50-100% shade is shown as a single range. A companion tool has been developed to add detail to the shading mask technique. This is a spreadsheet that gives a full year of shading performance information, with exact percentages of shade for every hour, for the 21st day of each month of the year.

The purpose of a shading mask analysis is to compare one design to another, or to refine a design, in terms of how effective a given shading device is at providing shade. The process generally starts with a first guess at shading device design (based primarily on architectural goals) and/or a guess at shading performance goals (based on engineering experience. For example, an initial intuitively derived goal might be to provide at least 50% shade for summer afternoon hours). The shading mask technique is used to arrive at a design that appears to satisfy both the original architectural and energy goals. At this point, the shading scheme can be described in the full computer simulation model for feedback regarding its impact on building energy use. In general, analysis of the simulation results may indicate an adjustment in the original goals and an adjustment of the proposed design, that can again be achieved through trial and error using the shading masks as a "low-tech" design tool prior to the continuation of "high tech" computer simulation.

It is important to note that shading masks (and the companion spread sheet) do *not* provide energy performance effects of shading devices. This requires full computer energy simulation of the whole building.

In the case of the Friendship Centre the initial computer analysis confirmed the assumption that peak cooling conditions occur in the afternoon in June, July and August, with the building peak in July. Therefore a starting goal for the shading scheme of at least 75% of the glazed area shaded during these months was established. Working backwards with the shading mask tool, geometric guidelines regarding the required angular relationships between shading device elements and glazed surfaces were arrived at. The result is a system that utilizes horizontal elements, in the form of an overhang on the upper two floors and as suspended slats hanging away and parallel to the wall surface for the first floor.

Subsequent analysis of the proposed external shades integrated with the design building confirmed the shading mask analysis by reducing the number of overheating hours in the building. Refer to the shading masks and spreadsheet analysis of the final design, as of July 29, 1996 in Appendix D.

The ASHRAE/IES 90.1 Standard was utilized to set the benchmark for wall and roof construction. The standard for the Prince George climate is an effective roof construction R-value of 25 and an average effective wall construction R-value of 17.2. The building was modeled with increased insulation levels but the minimal energy savings did not justify the increased construction costs associated with the additional wall and roof insulation improvements.

HVAC Strategies

As the building system responsible for maintaining comfort conditions throughout the year and the single most significant factor in the building energy performance equation, the type of HVAC system selected is of paramount importance. The system response to building heating, cooling and ventilation loads is a prime concern when determining the energy efficiency of a building. In this regard central mixed air systems do not perform well. Central mixed air systems address multiple zone load variations by supplying cooler air to meet the worst zone cooling load, and then relying on reheat to control overcooling in other areas. This reheat can become excessive in buildings with a wide variation in loads.

A further concern with central mixed air systems is the ventilation requirements of the building. The variable ventilation requirements at the zone level are generally addressed by utilizing the ASHRAE 62-1989 Ventilation Standard that prescribe the total system ventilation levels for a multizone system. This calculation invariably prescribes a higher ventilation quantity to balance the maximum and minimum zone ventilation requirements.

One solution to these problems is to compartmentalize HVAC systems as much as possible, minimizing the number of zones served by any one system and delivering the optimum supply air temperature with a minimum of reheat necessary, and supplying the exact ventilation requirement. The fan coil system proposed for the Native Friendship Centre accomplishes this resulting in heating energy savings.

A further HVAC design concern is the deletion of mechanical cooling. There are a variety of strategies for cooling a building without mechanical cooling. The most common HVAC strategy is to supply a different mixture of outdoor and return air to lower the temperature of the supply air to the spaces. Mixing a higher quantity of 'cool' outdoor air and 'warm' return air results in a lower supply air temperature. This strategy is primarily effective during the spring and fall when ambient temperatures are in the 50 F to 65 F range, and is often referred to as economizer capability. The proposed HVAC system will include the capability for 60% outdoor air supply. Further increases in economizer capability were found to provide minimal comfort benefits in relation to the increased construction costs associated with the larger supply and return air ductwork and fans.

A further HVAC strategy proposed involves the utilization of a night flush of the building with 'cool' outside air during the night. Computer analysis of the building loads indicated that stored heat collected during the day in the thermal mass of the building was released at night leading to elevated space temperatures by early morning. Subsequent occupancy of the building and a further cycle of solar and internal heat gains often resulted in space temperatures exceeding design throughout the day. Utilizing the night flush to remove this heat gain considerably reduced the number of hours in which any HVAC zone exceeded design comfort conditions.

4.4 Conclusion

Through the use of computer simulation and shading masks the design team was able to design an energy efficient building without using high mainstream technologies. The avoidance of mechanical cooling, the installation of photocell sensors, the design of shading devices and optimized envelope construction will result in a building that has about a third less energy than a similar building without the adopted strategies. Refer to Appendix C for the DOE 2.1e results for more detail.

A.
Emptied Analysis
Figures 9-12

ʼEAR 1
Wall type = STUCCO5-.003LKG/0PA

	Plane 1 - kg/m}				Plane 2 - kg/m}			
MON	Conden	Evap	Drain	Absorb	Conden	Evap	Drain	Absorb
Sep	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Oct	0.0001	0.0460	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Nov	0.0002	0.0188	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Dec	0.0005	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jan	0.0004	0.0118	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Feb	0.0002	0.0094	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Mar	0.0003	0.0060	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Apr	0.0001	0.0332	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
May	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jun	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jul	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Aug	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Output for CALGARY, ALBERTA
interior temp = CALHO.DYR
interior dewpoint = CALHO.DYR
leakage area = 0.00210 cm}/m}

PLANE1 = STUCCO-20MM
PLANE2 =
Max absorb plane1 = 0.00
Max absorb plane2 =

CONDENSATION BREAKDOWN - AIR LEAKAGE - VAPOUR DIFFUSION
Condensation Breakdown applies to all years
Wall type = STUCCO5-.003LKG/0PA

	Plane 1 - kg/m}					Plane 2 - kg/m}				
MON	Air Lkge	Diffusion	Total	HAFZ	HBFZ	Air Lkge	Diffusion	Total	HAFZ	HBFZ
Sep	0.0000	0.0000	0.0000	715	5	0.0000	0.0000	0.0000	0	0
Oct	0.0001	0.0000	0.0001	536	208	0.0000	0.0000	0.0000	0	0
Nov	0.0002	0.0000	0.0002	298	422	0.0000	0.0000	0.0000	0	0
Dec	0.0005	0.0000	0.0005	96	648	0.0000	0.0000	0.0000	0	0
Jan	0.0004	0.0000	0.0004	209	535	0.0000	0.0000	0.0000	0	0
Feb	0.0002	0.0000	0.0002	232	440	0.0000	0.0000	0.0000	0	0
Mar	0.0003	0.0000	0.0003	250	494	0.0000	0.0000	0.0000	0	0
Apr	0.0001	0.0000	0.0001	491	229	0.0000	0.0000	0.0000	0	0
May	0.0000	0.0000	0.0000	727	17	0.0000	0.0000	0.0000	0	0
Jun	0.0000	0.0000	0.0000	720	0	0.0000	0.0000	0.0000	0	0
Jul	0.0000	0.0000	0.0000	744	0	0.0000	0.0000	0.0000	0	0
Aug	0.0000	0.0000	0.0000	744	0	0.0000	0.0000	0.0000	0	0

EMPTIED **Analysis on Stucco Wall Section with 0 Pressure Difference**

YEAR 1
Wall type = STUCCO5-.0021LKG/75PA

MON	Plane 1 - kg/m} Conden	Evap	Drain	Absorb	Plane 2 - kg/m} Conden	Evap	Drain	Absorb
Sep	0.0008	0.1174	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Oct	0.0018	0.0779	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Nov	0.0027	0.0397	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Dec	0.0045	0.0077	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jan	0.0041	0.0283	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Feb	0.0023	0.0242	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Mar	0.0026	0.0199	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Apr	0.0014	0.0585	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
May	0.0002	0.1205	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jun	0.0003	0.1594	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jul	0.0004	0.1964	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Aug	0.0007	0.1784	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Output for CALGARY, ALBERTA
interior temp = CALHO.DYR
interior dewpoint = CALHO.DYR
leakage area = 0.00210 cm}/m}

PLANE1 = STUCCO-20MM
PLANE2 =
Max absorb plane1 = 0.00
Max absorb plane2 =

CONDENSATION BREAKDOWN - AIR LEAKAGE - VAPOUR DIFFUSION
Condensation Breakdown applies to all years
Wall type = STUCCO5-.0021LKG/75PA

MON	Plane 1 - kg/m} Air Lkge	Diffusion	Total	HAFZ	HBFZ	Plane 2 - kg/m} Air Lkge	Diffusion	Total	HAFZ	HBFZ
Sep	0.0008	0.0000	0.0008	715	5	0.0000	0.0000	0.0000	0	0
Oct	0.0018	0.0000	0.0018	536	208	0.0000	0.0000	0.0000	0	0
Nov	0.0027	0.0000	0.0027	298	422	0.0000	0.0000	0.0000	0	0
Dec	0.0045	0.0000	0.0045	96	648	0.0000	0.0000	0.0000	0	0
Jan	0.0041	0.0000	0.0041	209	535	0.0000	0.0000	0.0000	0	0
Feb	0.0023	0.0000	0.0023	232	440	0.0000	0.0000	0.0000	0	0
Mar	0.0026	0.0000	0.0026	250	494	0.0000	0.0000	0.0000	0	0
Apr	0.0014	0.0000	0.0014	491	229	0.0000	0.0000	0.0000	0	0
May	0.0002	0.0000	0.0002	727	17	0.0000	0.0000	0.0000	0	0
Jun	0.0003	0.0000	0.0003	720	0	0.0000	0.0000	0.0000	0	0
Jul	0.0004	0.0000	0.0004	744	0	0.0000	0.0000	0.0000	0	0
Aug	0.0007	0.0000	0.0007	744	0	0.0000	0.0000	0.0000	0	0

EMPTIED **Analysis on Stucco Wall Section with +75 Pa Pressure**

EAR 1
all type = SIDING-.5LKG/OPA

	Plane 1 - kg/m}				Plane 2 - kg/m}			
ON	Conden	Evap	Drain	Absorb	Conden	Evap	Drain	Absorb
ep	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ct	0.0003	0.4824	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ov	0.0001	0.4439	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ec	0.0012	0.3397	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
an	0.0007	0.3888	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
eb	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ar	0.0025	0.4456	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
pr	0.0001	0.4797	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ay	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
un	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ul	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ug	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

utput for CALGARY, ALBERTA
nterior temp = CALHO.DYR
nterior dewpoint = CALHO.DYR
eakage area = 0.35000 cm}/m}

PLANE1 = RIGID EPS EXTRUDED 3
PLANE2 =
Max absorb plane1 = 0.00
Max absorb plane2 =

CONDENSATION BREAKDOWN - AIR LEAKAGE - VAPOUR DIFFUSION
Condensation Breakdown applies to all years
all type = SIDING-.5LKG/OPA

	Plane 1 - kg/m}					Plane 2 - kg/m}				
ON	Air Lkge	Diffusion	Total	HAFZ	HBFZ	Air Lkge	Diffusion	Total	HAFZ	HBFZ
ep	0.0000	0.0000	0.0000	720	0	0.0000	0.0000	0.0000	0	0
ct	0.0003	0.0000	0.0003	706	38	0.0000	0.0000	0.0000	0	0
ov	0.0001	0.0000	0.0001	509	211	0.0000	0.0000	0.0000	0	0
ec	0.0012	0.0000	0.0012	345	399	0.0000	0.0000	0.0000	0	0
Jan	0.0007	0.0000	0.0007	330	414	0.0000	0.0000	0.0000	0	0
eb	0.0000	0.0000	0.0000	452	220	0.0000	0.0000	0.0000	0	0
ar	0.0025	0.0000	0.0025	587	157	0.0000	0.0000	0.0000	0	0
pr	0.0001	0.0000	0.0001	692	28	0.0000	0.0000	0.0000	0	0
ay	0.0000	0.0000	0.0000	744	0	0.0000	0.0000	0.0000	0	0
Jun	0.0000	0.0000	0.0000	720	0	0.0000	0.0000	0.0000	0	0
Jul	0.0000	0.0000	0.0000	744	0	0.0000	0.0000	0.0000	0	0
ug	0.0000	0.0000	0.0000	744	0	0.0000	0.0000	0.0000	0	0

***EMPTIED* Analysis on Siding Wall Section with 0 Pressure Difference**

'EAR 1
Vall type = SIDING-.35LKG/75PA

MON	Plane 1 - kg/m} Conden	Evap	Drain	Absorb	Plane 2 - kg/m} Conden	Evap	Drain	Absorb
Sep	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Oct	0.0036	9.4593	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Nov	0.0011	7.2820	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Dec	0.0098	4.2762	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jan	0.0058	5.7272	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Feb	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Mar	0.0226	6.4064	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Apr	0.0013	8.4432	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
May	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jun	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jul	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Aug	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Output for CALGARY, ALBERTA
interior temp = CALHO.DYR
interior dewpoint = CALHO.DYR
leakage area = 0.35000 cm}/m}

PLANE1 = RIGID EPS EXTRUDED 3
PLANE2 =
Max absorb plane1 = 0.00
Max absorb plane2 =

CONDENSATION BREAKDOWN - AIR LEAKAGE - VAPOUR DIFFUSION
Condensation Breakdown applies to all years
Wall type = SIDING-.35LKG/75PA

MON	Plane 1 - kg/m} Air Lkge	Diffusion	Total	HAFZ	HBFZ	Plane 2 - kg/m} Air Lkge	Diffusion	Total	HAFZ	HBFZ
Sep	0.0000	0.0000	0.0000	720	0	0.0000	0.0000	0.0000	0	0
Oct	0.0036	0.0000	0.0036	706	38	0.0000	0.0000	0.0000	0	0
Nov	0.0011	0.0000	0.0011	509	211	0.0000	0.0000	0.0000	0	0
Dec	0.0098	0.0000	0.0098	345	399	0.0000	0.0000	0.0000	0	0
Jan	0.0058	0.0000	0.0058	330	414	0.0000	0.0000	0.0000	0	0
Feb	0.0000	0.0000	0.0000	452	220	0.0000	0.0000	0.0000	0	0
Mar	0.0226	0.0000	0.0226	587	157	0.0000	0.0000	0.0000	0	0
Apr	0.0013	0.0000	0.0013	692	28	0.0000	0.0000	0.0000	0	0
May	0.0000	0.0000	0.0000	744	0	0.0000	0.0000	0.0000	0	0
Jun	0.0000	0.0000	0.0000	720	0	0.0000	0.0000	0.0000	0	0
Jul	0.0000	0.0000	0.0000	744	0	0.0000	0.0000	0.0000	0	0
Aug	0.0000	0.0000	0.0000	744	0	0.0000	0.0000	0.0000	0	0

***EMPTIED* Analysis on Siding Wall Section with +75 Pa Pressure**

YEAR 1
Wall type = BLOCK4-.1LKG/0PA

MON	Plane 1 - kg/m} Conden	Evap	Drain	Absorb	Plane 2 - kg/m} Conden	Evap	Drain	Absorb
Sep	0.0001	0.1665	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Oct	0.0022	0.1290	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Nov	0.0027	0.0877	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Dec	0.0082	0.0430	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jan	0.0074	0.0694	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Feb	0.0023	0.0708	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Mar	0.0044	0.0739	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Apr	0.0011	0.1116	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
May	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jun	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jul	0.0001	0.2394	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Aug	0.0003	0.2225	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Output for CALGARY, ALBERTA
interior temp = CALHO.DYR
interior dewpoint = CALHO.DYR
leakage area = 0.07000 cm}/m}

PLANE1 = AIR SPACE VERTICAL 2
PLANE2 =
Max absorb plane1 = 0.00
Max absorb plane2 =

CONDENSATION BREAKDOWN - AIR LEAKAGE - VAPOUR DIFFUSION
Condensation Breakdown applies to all years
Wall type = BLOCK4-.1LKG/0PA

MON	Plane 1 - kg/m} Air Lkge	Diffusion	Total	HAFZ	HBFZ	Plane 2 - kg/m} Air Lkge	Diffusion	Total	HAFZ	HBFZ
Sep	0.0001	0.0000	0.0001	720	0	0.0000	0.0000	0.0000	0	0
Oct	0.0022	0.0000	0.0022	644	100	0.0000	0.0000	0.0000	0	0
Nov	0.0027	0.0000	0.0027	405	315	0.0000	0.0000	0.0000	0	0
Dec	0.0082	0.0000	0.0082	201	543	0.0000	0.0000	0.0000	0	0
Jan	0.0074	0.0000	0.0074	286	458	0.0000	0.0000	0.0000	0	0
Feb	0.0023	0.0000	0.0023	303	369	0.0000	0.0000	0.0000	0	0
Mar	0.0044	0.0000	0.0044	456	288	0.0000	0.0000	0.0000	0	0
Apr	0.0011	0.0000	0.0011	577	143	0.0000	0.0000	0.0000	0	0
May	0.0000	0.0000	0.0000	744	0	0.0000	0.0000	0.0000	0	0
Jun	0.0000	0.0000	0.0000	720	0	0.0000	0.0000	0.0000	0	0
Jul	0.0001	0.0000	0.0001	744	0	0.0000	0.0000	0.0000	0	0
Aug	0.0003	0.0000	0.0003	744	0	0.0000	0.0000	0.0000	0	0

EMPTIED **Analysis on Concrete Block Wall Section with 0 Pressure Difference**

YEAR 1
Wall type = BLOCK4-.1LKG/75PA

	Plane 1 - kg/m}				Plane 2 - kg/m}			
MON	Conden	Evap	Drain	Absorb	Conden	Evap	Drain	Absorb
Sep	0.0012	1.7019	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Oct	0.0254	1.4628	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Nov	0.0273	1.0023	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Dec	0.0763	0.4480	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jan	0.0656	0.7784	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Feb	0.0223	0.7677	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Mar	0.0427	0.7928	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Apr	0.0118	1.2241	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
May	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jun	0.0002	2.1590	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jul	0.0014	2.4783	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Aug	0.0053	2.2674	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Output for CALGARY, ALBERTA
interior temp = CALHO.DYR
interior dewpoint = CALHO.DYR
leakage area = 0.07000 cm}/m}

PLANE1 = AIR SPACE VERTICAL 2
PLANE2 =
Max absorb plane1 = 0.00
Max absorb plane2 =

CONDENSATION BREAKDOWN - AIR LEAKAGE - VAPOUR DIFFUSION
Condensation Breakdown applies to all years
Wall type = BLOCK4-.1LKG/75PA

	Plane 1 - kg/m}					Plane 2 - kg/m}				
MON	Air Lkge	Diffusion	Total	HAFZ	HBFZ	Air Lkge	Diffusion	Total	HAFZ	HBFZ
Sep	0.0012	0.0000	0.0012	720	0	0.0000	0.0000	0.0000	0	0
Oct	0.0254	0.0000	0.0254	644	100	0.0000	0.0000	0.0000	0	0
Nov	0.0273	0.0000	0.0273	405	315	0.0000	0.0000	0.0000	0	0
Dec	0.0763	0.0000	0.0763	201	543	0.0000	0.0000	0.0000	0	0
Jan	0.0656	0.0000	0.0656	286	458	0.0000	0.0000	0.0000	0	0
Feb	0.0223	0.0000	0.0223	303	369	0.0000	0.0000	0.0000	0	0
Mar	0.0427	0.0000	0.0427	456	288	0.0000	0.0000	0.0000	0	0
Apr	0.0118	0.0000	0.0118	577	143	0.0000	0.0000	0.0000	0	0
May	0.0000	0.0000	0.0000	744	0	0.0000	0.0000	0.0000	0	0
Jun	0.0002	0.0000	0.0002	720	0	0.0000	0.0000	0.0000	0	0
Jul	0.0014	0.0000	0.0014	744	0	0.0000	0.0000	0.0000	0	0
Aug	0.0053	0.0000	0.0053	744	0	0.0000	0.0000	0.0000	0	0

EMPTIED Analysis on Concrete Block Wall Section with +75 Pa Pressure

'EAR 1
/all type = STONE-.1LKG/OPA

ION	Plane 1 - kg/m} Conden	Evap	Drain	Absorb	Plane 2 - kg/m} Conden	Evap	Drain	Absorb
;ep	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
)ct	0.0003	0.0817	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Iov	0.0001	0.0831	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
)ec	0.0009	0.0655	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jan	0.0004	0.0710	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
'eb	0.0001	0.0808	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Iar	0.0009	0.0910	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
\pr	0.0001	0.0832	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Iay	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jun	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jul	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
\ug	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

)utput for CALGARY, ALBERTA
.nterior temp = CALHO.DYR
.nterior dewpoint = CALHO.DYR
.eakage area = 0.07000 cm}/m}

PLANE1 = RIGID EPS EXTRUDED 3
PLANE2 =
Max absorb plane1 = 0.00
Max absorb plane2 =

CONDENSATION BREAKDOWN - AIR LEAKAGE - VAPOUR DIFFUSION
Condensation Breakdown applies to all years
/all type = STONE-.1LKG/OPA

ION	Plane 1 - kg/m} Air Lkge	Diffusion	Total	HAFZ	HBFZ	Plane 2 - kg/m} Air Lkge	Diffusion	Total	HAFZ	HBFZ
;ep	0.0000	0.0000	0.0000	720	0	0.0000	0.0000	0.0000	0	0
)ct	0.0003	0.0000	0.0003	706	38	0.0000	0.0000	0.0000	0	0
Iov	0.0001	0.0000	0.0001	509	211	0.0000	0.0000	0.0000	0	0
)ec	0.0009	0.0000	0.0009	345	399	0.0000	0.0000	0.0000	0	0
Ian	0.0004	0.0000	0.0004	330	414	0.0000	0.0000	0.0000	0	0
'eb	0.0001	0.0000	0.0001	452	220	0.0000	0.0000	0.0000	0	0
Iar	0.0009	0.0000	0.0009	587	157	0.0000	0.0000	0.0000	0	0
.pr	0.0001	0.0000	0.0001	692	28	0.0000	0.0000	0.0000	0	0
Iay	0.0000	0.0000	0.0000	744	0	0.0000	0.0000	0.0000	0	0
Iun	0.0000	0.0000	0.0000	720	0	0.0000	0.0000	0.0000	0	0
Iul	0.0000	0.0000	0.0000	744	0	0.0000	0.0000	0.0000	0	0
\ug	0.0000	0.0000	0.0000	744	0	0.0000	0.0000	0.0000	0	0

EMPTIED Analysis on Stone Veneer Wall Section with 0 Pressure Difference

:EAR 1
/all type = STONE-.1LKG/75PA

	Plane 1 - kg/m}				Plane 2 - kg/m}			
ION	Conden	Evap	Drain	Absorb	Conden	Evap	Drain	Absorb
;ep	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
)ct	0.0028	1.7885	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Iov	0.0013	1.3594	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
)ec	0.0074	0.7671	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jan	0.0037	1.0568	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
'eb	0.0009	1.1182	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
lar	0.0081	1.1883	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ipr	0.0008	1.5844	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
lay	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jun	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jul	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
iug	0.0001	2.3477	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

)utput for CALGARY, ALBERTA
:nterior temp = CALHO.DYR
:nterior dewpoint = CALHO.DYR
:eakage area = 0.07000 cm}/m}

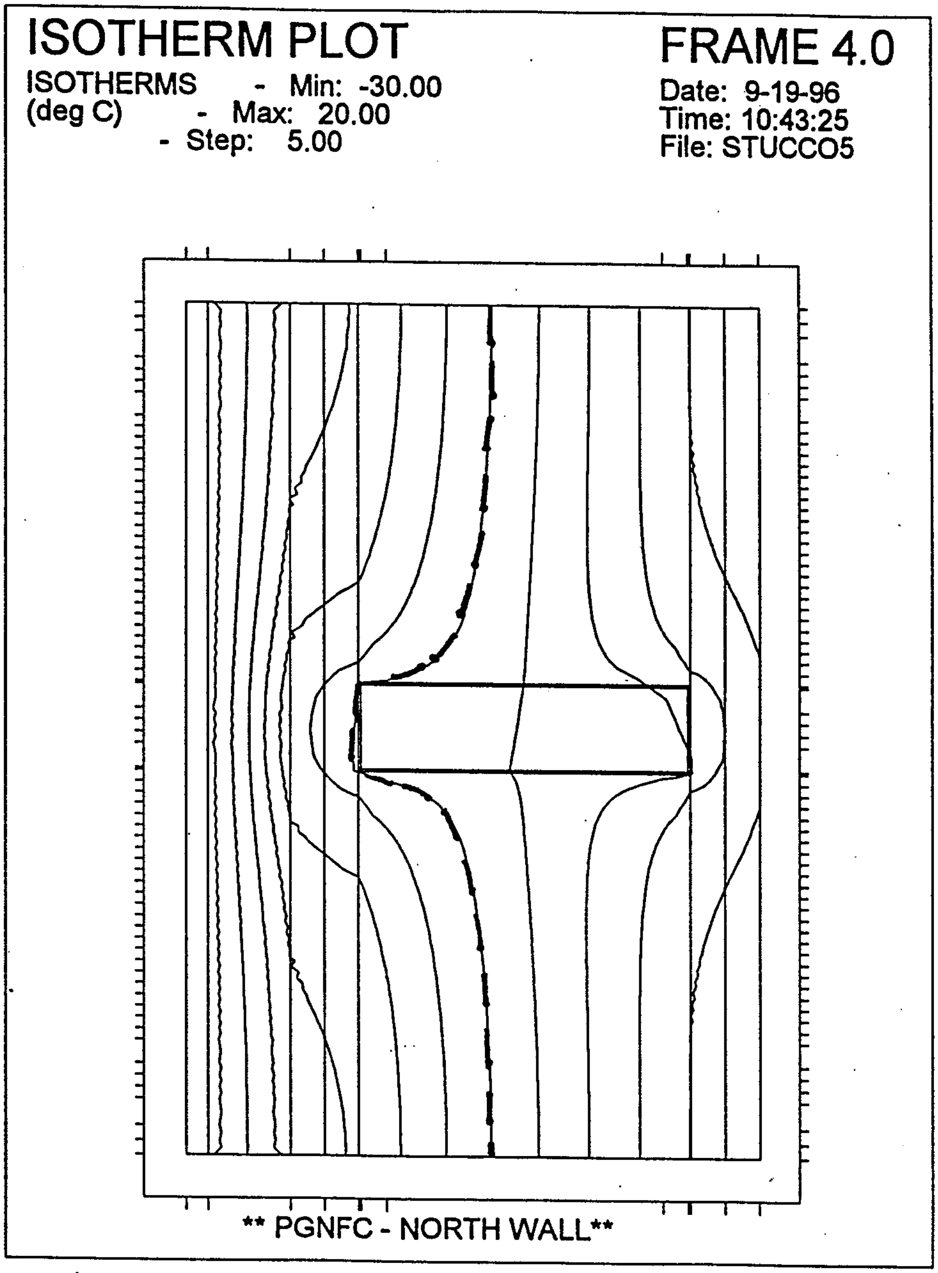
PLANE1 = RIGID EPS EXTRUDED 3
PLANE2 =
Max absorb plane1 = 0.00
Max absorb plane2 =

CONDENSATION BREAKDOWN - AIR LEAKAGE - VAPOUR DIFFUSION
Condensation Breakdown applies to all years
/all type = STONE-.1LKG/75PA

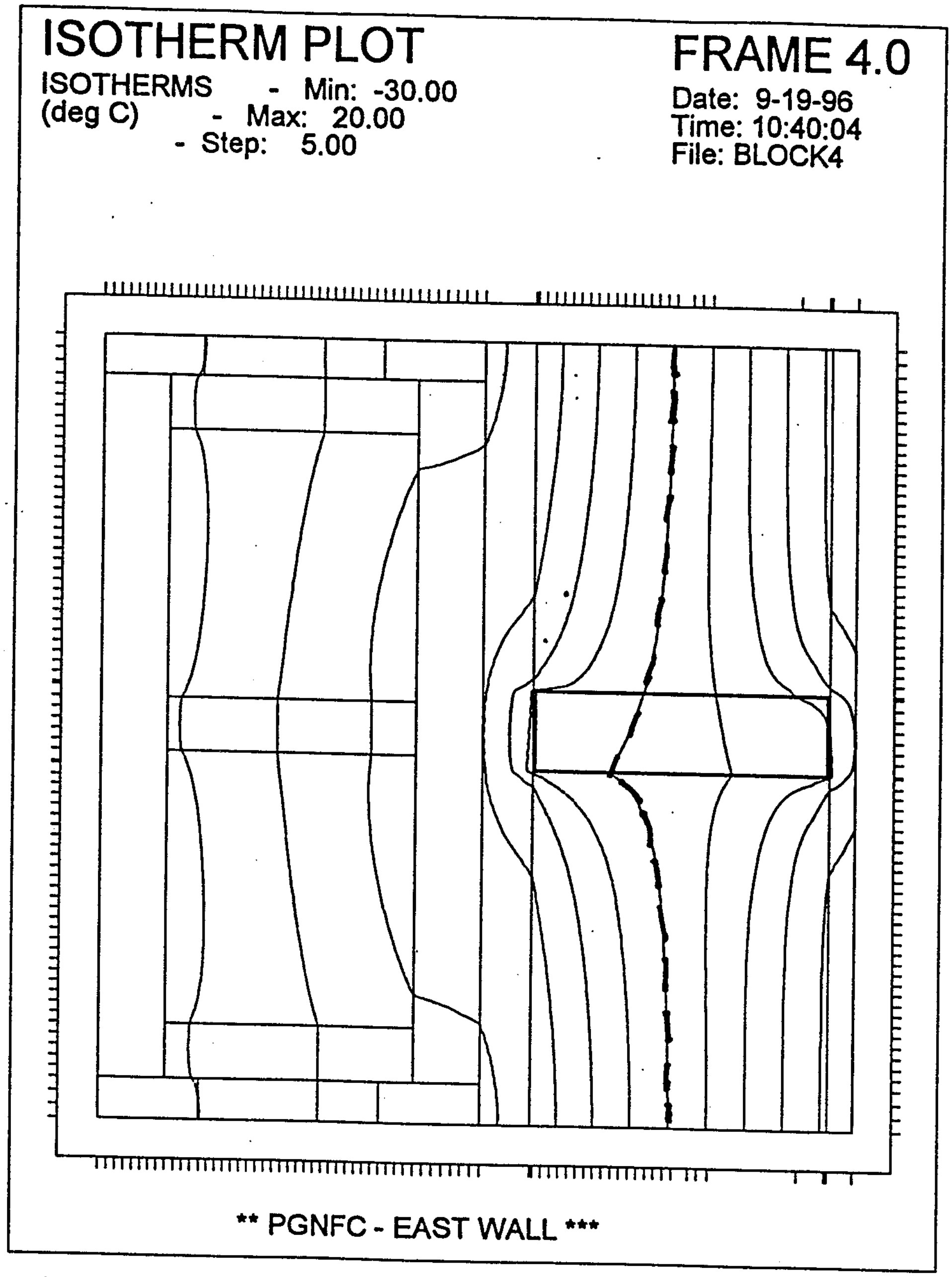
	Plane 1 - kg/m}					Plane 2 - kg/m}				
ION	Air Lkge	Diffusion	Total	HAFZ	HBFZ	Air Lkge	Diffusion	Total	HAFZ	HBFZ
;ep	0.0000	0.0000	0.0000	720	0	0.0000	0.0000	0.0000	0	0
)ct	0.0028	0.0000	0.0028	706	38	0.0000	0.0000	0.0000	0	0
Iov	0.0013	0.0000	0.0013	509	211	0.0000	0.0000	0.0000	0	0
)ec	0.0074	0.0000	0.0074	345	399	0.0000	0.0000	0.0000	0	0
Jan	0.0037	0.0000	0.0037	330	414	0.0000	0.0000	0.0000	0	0
'eb	0.0009	0.0000	0.0009	452	220	0.0000	0.0000	0.0000	0	0
lar	0.0081	0.0000	0.0081	587	157	0.0000	0.0000	0.0000	0	0
ipr	0.0008	0.0000	0.0008	692	28	0.0000	0.0000	0.0000	0	0
lay	0.0000	0.0000	0.0000	744	0	0.0000	0.0000	0.0000	0	0
Jun	0.0000	0.0000	0.0000	720	0	0.0000	0.0000	0.0000	0	0
Jul	0.0000	0.0000	0.0000	744	0	0.0000	0.0000	0.0000	0	0
iug	0.0001	0.0000	0.0001	744	0	0.0000	0.0000	0.0000	0	0

EMPTIED **Analysis on Stone Veneer Wall Section with +75 Pa Pressure**

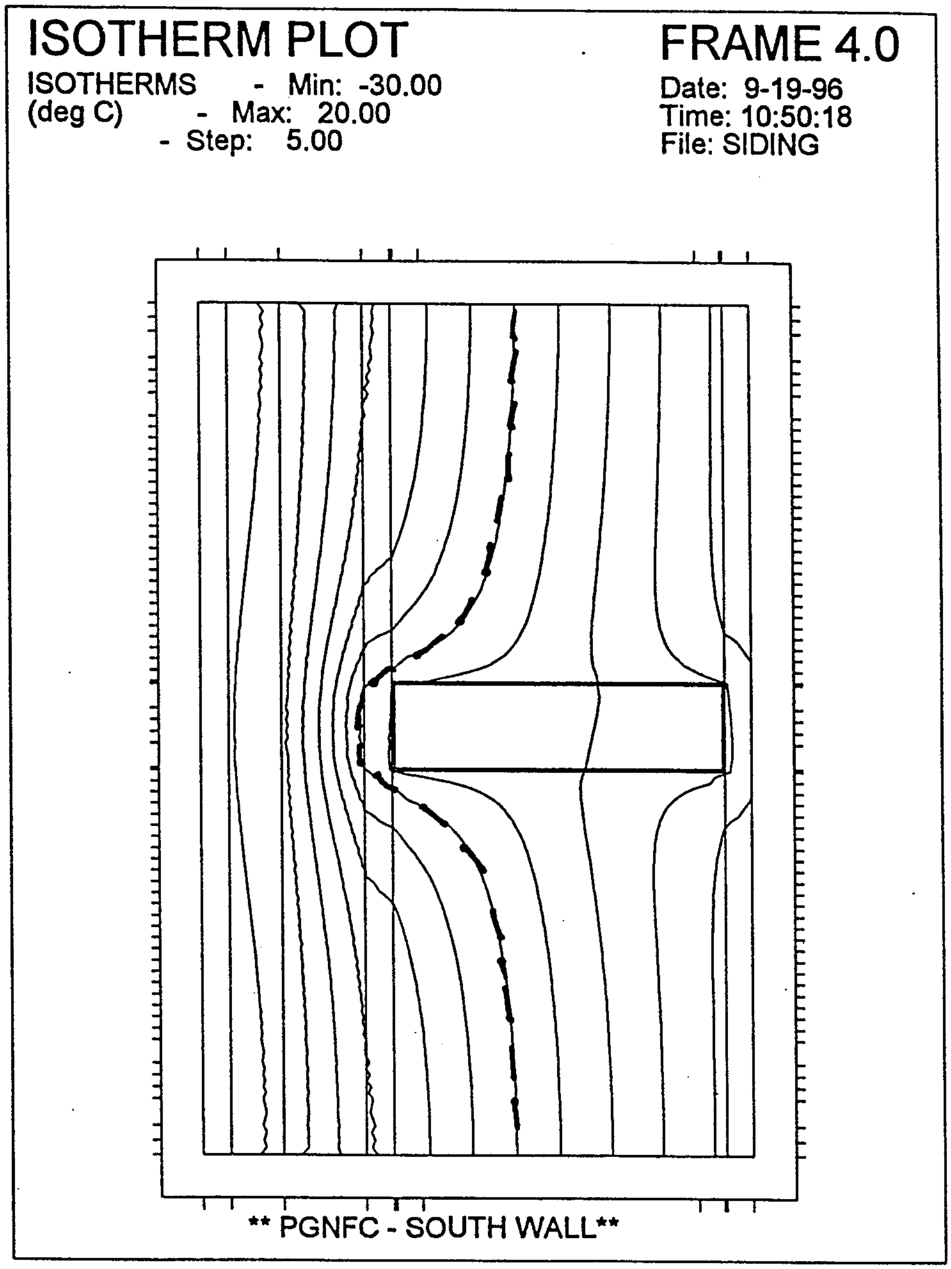
B.
Dew Point Analysis



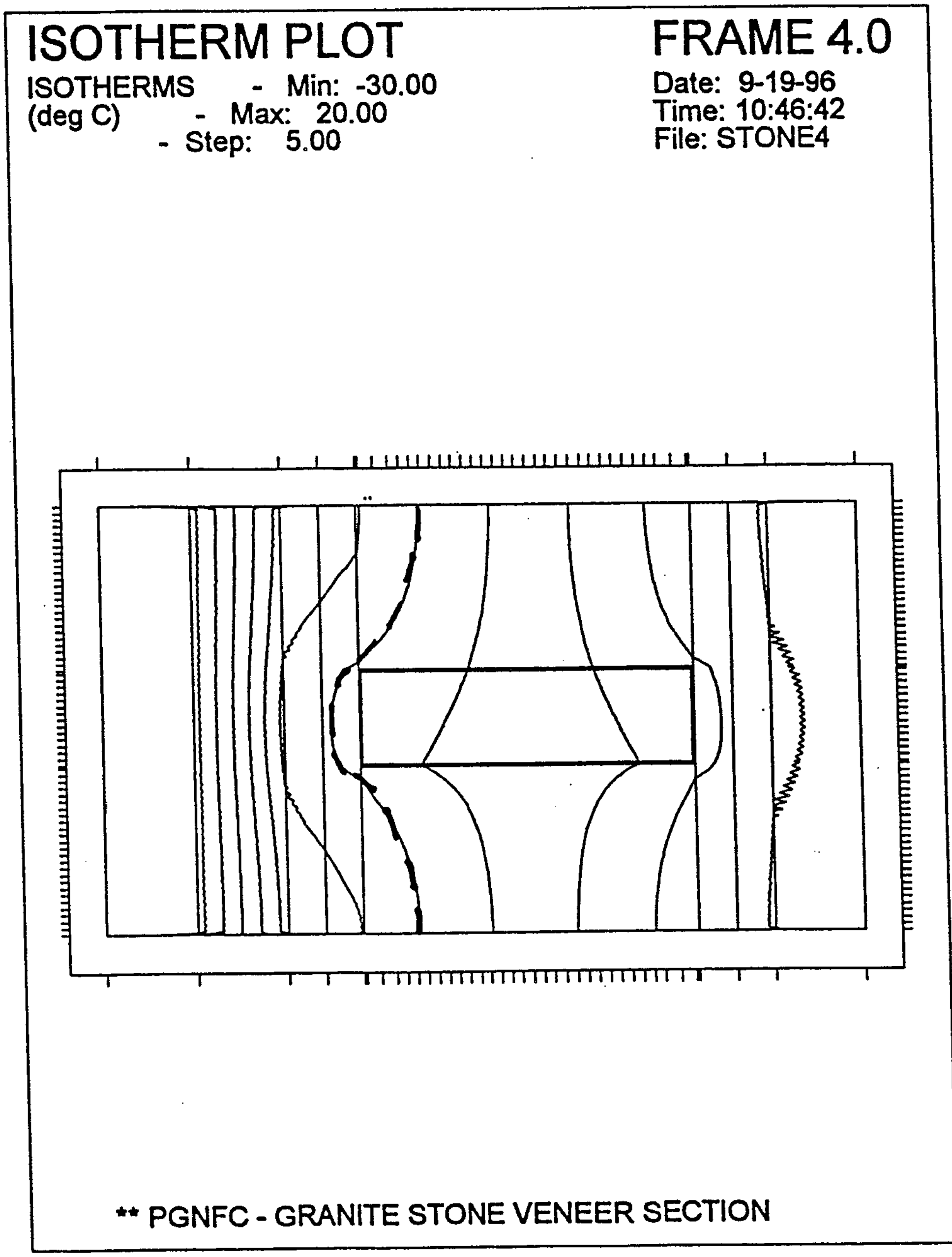
Dew Point Plot for Stucco Section



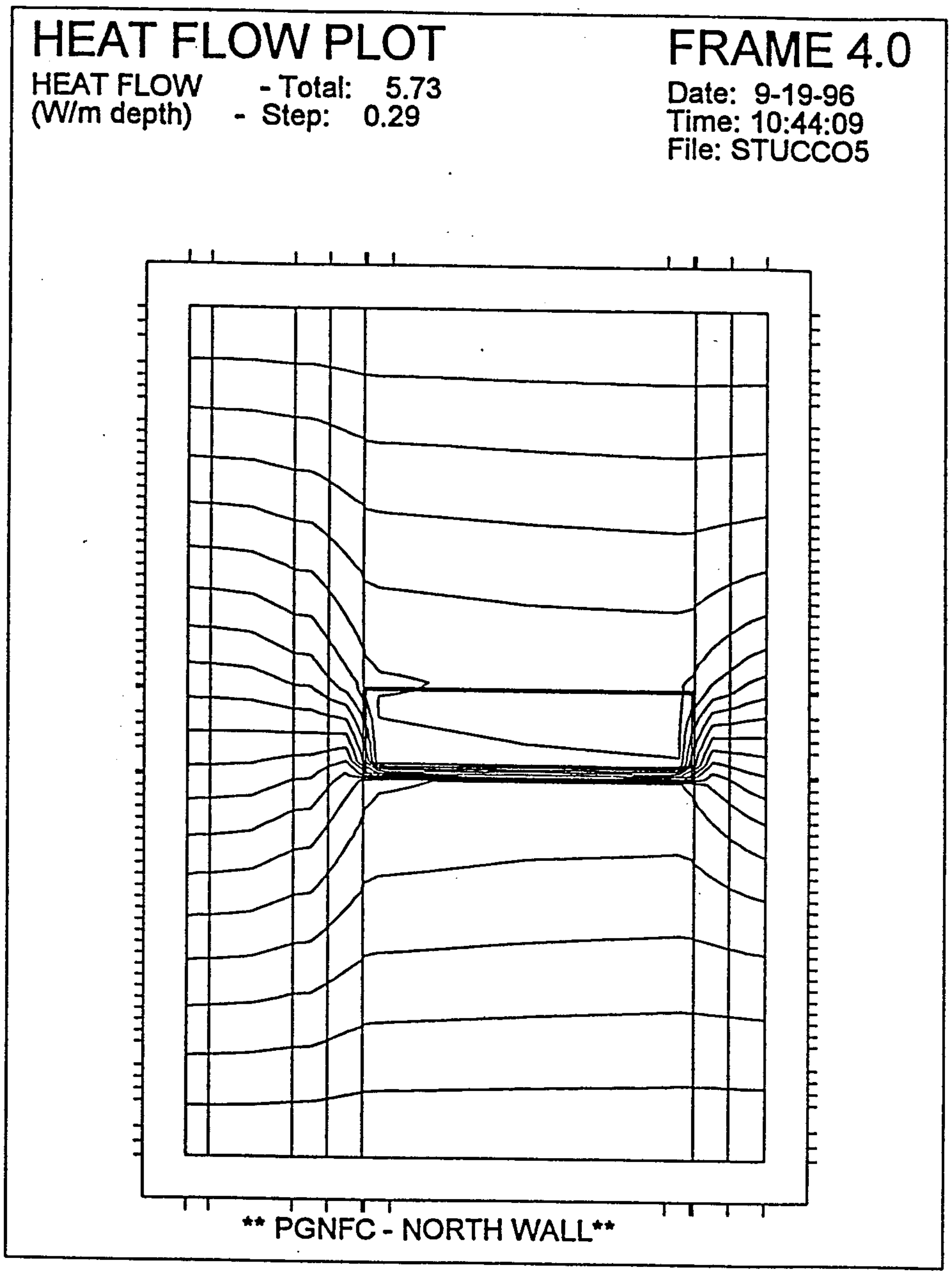
Dew Point Plot for Concrete Block Section



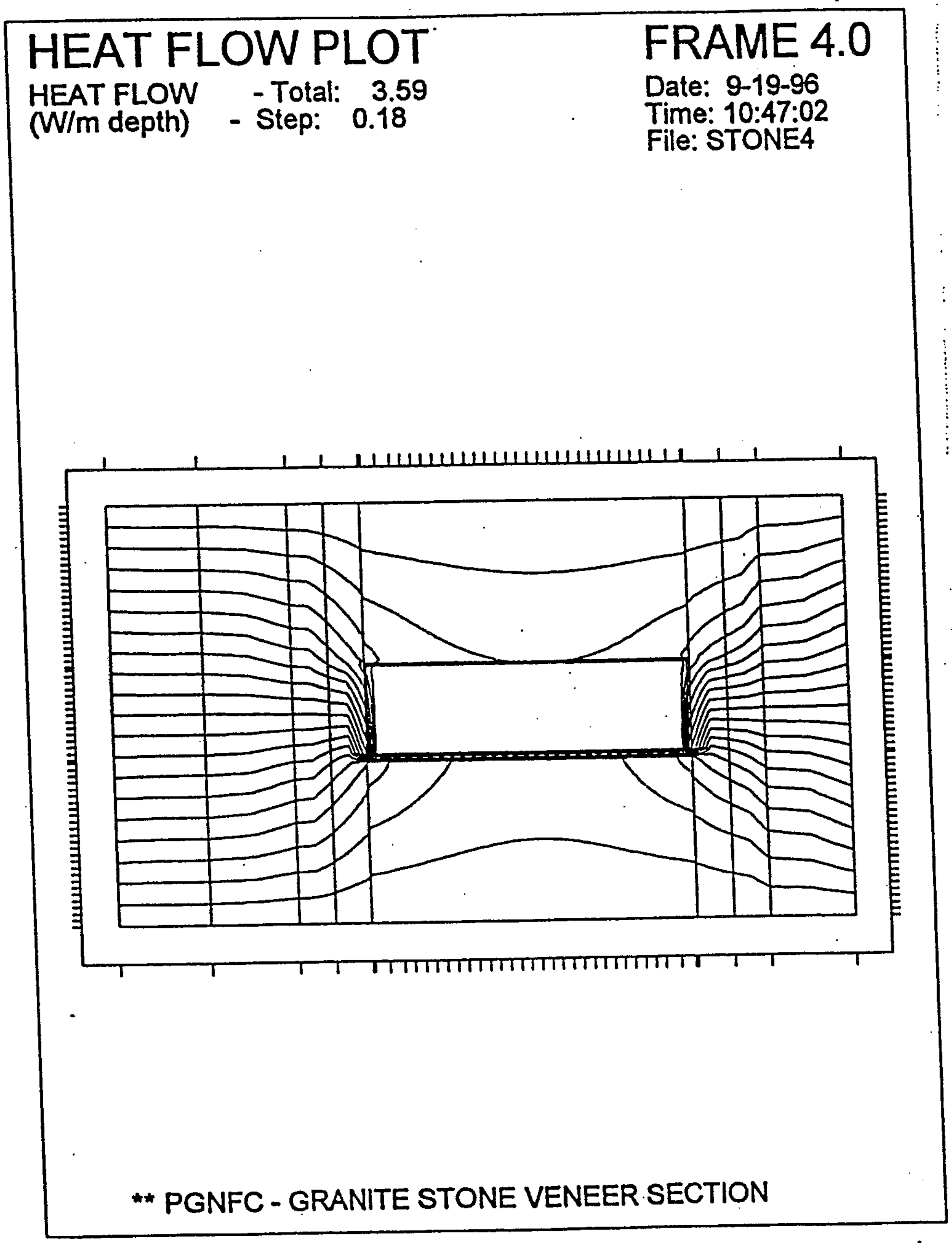
Dew Point Plot for Siding Section



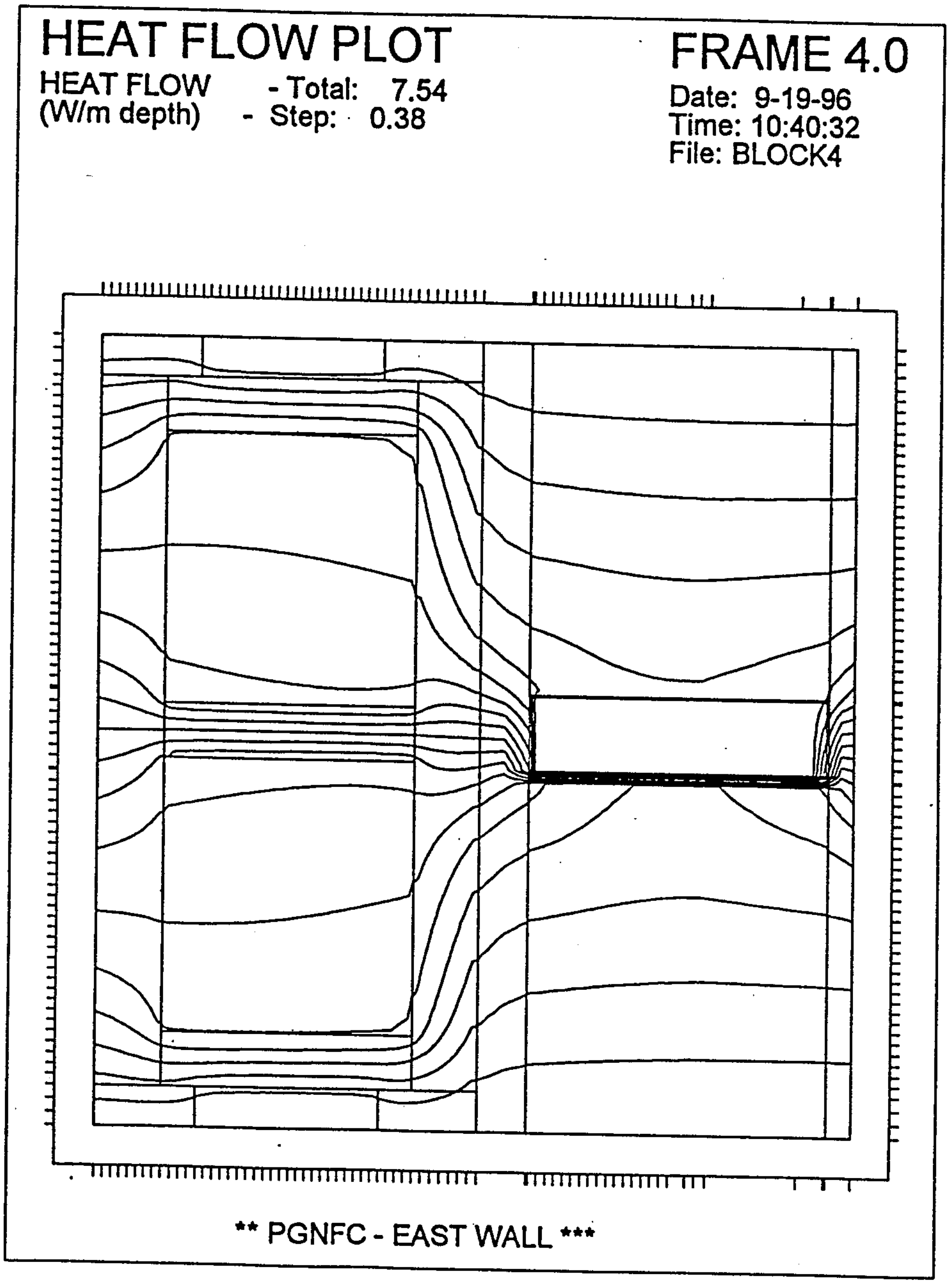
Dew Point Plot for Stone Veneer Section



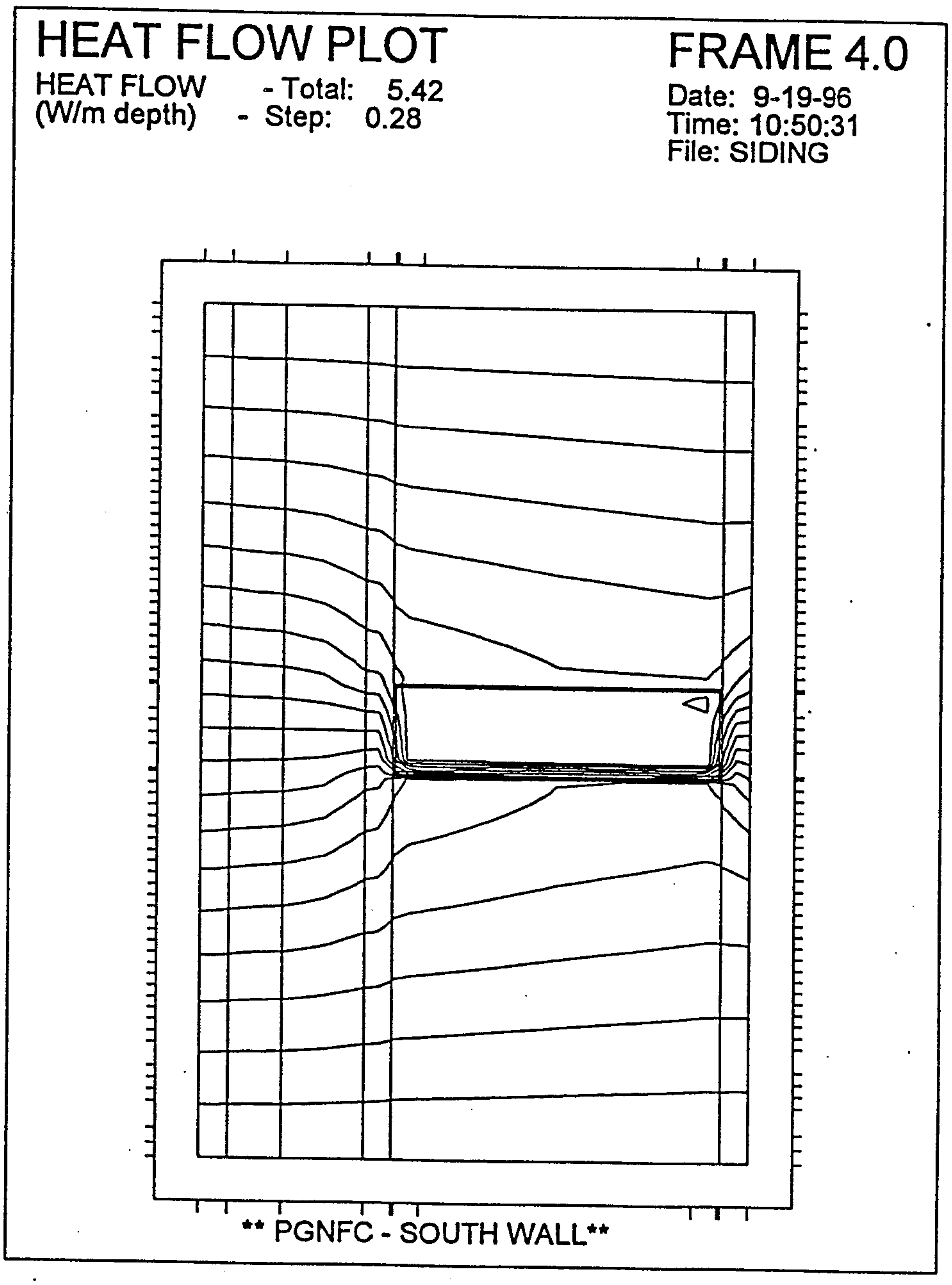
Heat Flow for Stucco Section



Heat Flow for Stone Veneer Section



Heat Flow for Concrete Block Section



Heat Flow for Siding Section

C.
DOE Simulation Results

File: D:\DOE21E\PGNFC\PGNFREF.OUT *Prince George Native Friendship Centre - ASHRAE/IES 90.1 Reference Building*

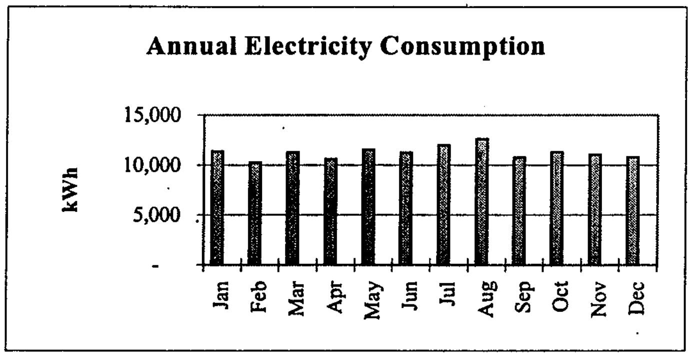
Area: 11,934 ft²

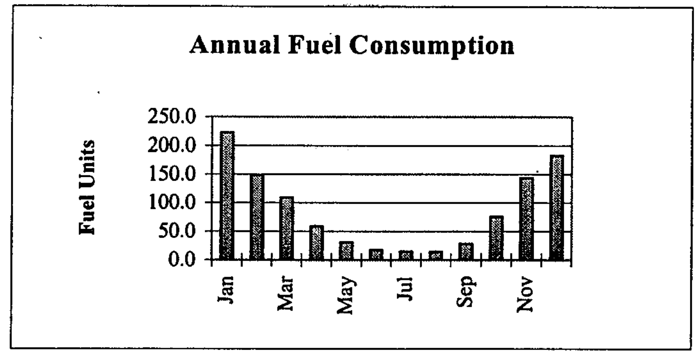
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Total/ft²
E	Lights	kWh	6839	6193	6839	6464	6959	6584	6839	6959	6464	6959	6704	6480	80,283	6.73
L		kW	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	0.0017
E	Equipment	kWh	1176	1067	1176	1088	1215	1127	1176	1215	1088	1215	1166	1060	13,769	1.15
C		kW	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	53	0.0044
T	Cooling	kWh	0	0	0	93	553	1007	1434	1882	574	0	0	0	5,543	0.46
R		kW	0	0	0	13.4	15.6	21.8	20.3	21.9	16.2	0	0	0	21.9	0.0018
I	Heating	kWh	110	91	94	56	24	7	5	4	23	72	97	99	682	0.06
C		kW	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0000
	Heat Reject	kWh													-	0.0000
		kW													-	0.0000
	Pumps	kWh	611	550	608	502	316	174	108	95	281	535	589	609	4,978	0.42
		kW	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.0001
	Fans	kWh	2646	2343	2568	2390	2475	2339	2423	2441	2332	2543	2514	2541	29,555	2.48
		kW	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	0.0004
	DHW	kWh													-	0.00
		kW													-	0.0000
	All end uses	kWh	11,382	10,244	11,285	10,593	11,542	11,238	11,985	12,596	10,762	11,324	11,070	10,789	134,810	11.30
		kW	31.2	31.2	31.2	43.6	45.8	52	50.5	52.1	46.3	31.2	31.2	31.2	52.1	0.0044
		Energy charge	739	665	732	687	749	729	778	817	699	735	718	700	$ 8,748	$ 0.73
		Demand charge	0	0	0	29	36	56	51	57	38	0	0	0	$ 267	$ 0.02
		Fixed charge	4	4	4	4	4	4	4	4	4	4	4	4	$ 48	$ 0.00
		Total charge	$ 743	$ 669	$ 736	$ 720	$ 789	$ 789	$ 833	$ 878	$ 741	$ 739	$ 722	$ 704	$ 9,063	$ 0.76
		$/kWh	$ 0.065	$ 0.065	$ 0.065	$ 0.068	$ 0.068	$ 0.070	$ 0.070	$ 0.070	$ 0.069	$ 0.065	$ 0.065	$ 0.065	$ 0.067	

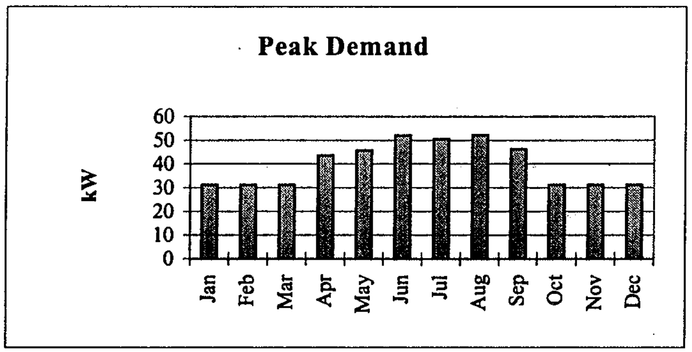
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Total/ft²
F	Heating	GJ	222.6	148.8	109.2	59.0	30.8	17.2	14.9	13.9	28.3	75.7	143.7	182.6	1,046.8	0.0877
U		GJ/hr	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.1	0.3	0.5	0.7	0.7	0.92	0.0001
E	Cooling	GJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0000
L		GJ/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0000
	DHW	GJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0000
		GJ/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0000
	All end uses	GJ	222.6	148.8	109.2	59.0	30.8	17.2	14.9	13.9	28.3	75.7	143.7	182.6	1,046.8	0.0877
		GJ/hr	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.1	0.3	0.5	0.7	0.7	0.90	0.0001
		Energy charge	968	647	475	200	105	58	50	47	96	257	625	794	$ 4,322	$ 0.36
		Fixed charge	13	13	13	13	13	13	13	13	13	13	13	13	$ 156	$ 0.01
		Total charge	$ 981	$ 660	$ 488	$ 213	$ 118	$ 71	$ 63	$ 60	$ 109	$ 270	$ 638	$ 807	$ 4,478	$ 0.38
		$/GJ	$ 4.41	$ 4.44	$ 4.47	$ 3.61	$ 3.83	$ 4.12	$ 4.23	$ 4.30	$ 3.85	$ 3.57	$ 4.44	$ 4.42	$ 4.28	

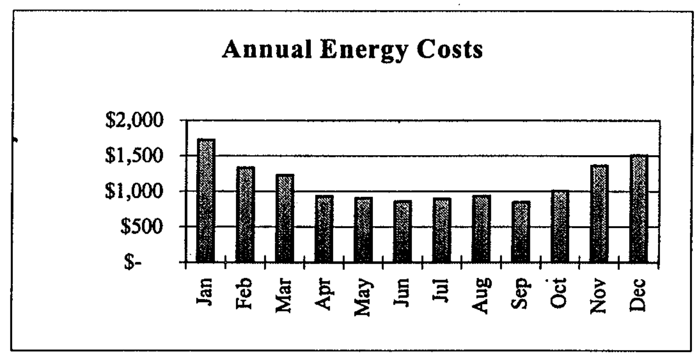
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Total/ft²
Total	Total charge	$ 1,724	$ 1,329	$ 1,224	$ 933	$ 907	$ 860	$ 896	$ 938	$ 850	$ 1,009	$ 1,360	$ 1,511	$ 13,541	$ 1.13

Prince George Native Friendship Centre - ASHRAE/IES 90.1 Reference Building









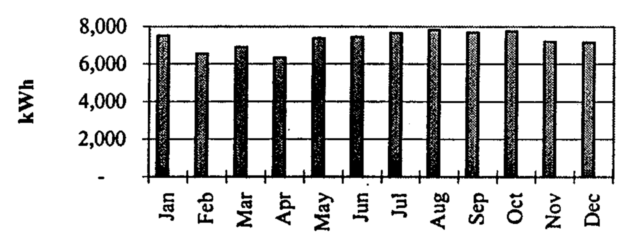
File: D:\DOE21E\PGNFC\PGNFX.OUT *Prince George Native Friendship Centre - Design Building*

Area: 11,934 ft²

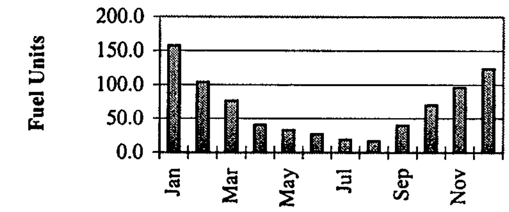
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Total/ft²
E	Lights	kWh	3830	3284	3353	3016	3204	2973	3070	3241	3186	3594	3700	3701	40,152	3.36
L		kW	11.7	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.7	11.7	11.7	0.0010
E	Equipment	kWh	1176	1067	1176	1088	1215	1127	1176	1215	1088	1215	1166	1060	13,769	1.15
C		kW	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	53	0.0044
T	Cooling	kWh													-	0.00
R		kW													-	0.0000
I	Heating	kWh													-	0.00
C		kW													-	0.0000
	Heat Reject	kWh													-	0.0000
		kW													-	0.0000
	Pumps	kWh	395	331	319	302	345	317	279	250	384	391	330	375	4,018	0.34
		kW	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.0001
	Fans	kWh	2117	1876	2051	1925	2618	3028	3129	3129	3028	2566	2007	2032	29,506	2.47
		kW	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	0.0004
	DHW	kWh													-	0.00
		kW													-	0.0000
	All end uses	kWh	7,518	6,558	6,899	6,331	7,382	7,445	7,654	7,835	7,686	7,766	7,203	7,168	87,445	7.33
		kW	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	0.0018
		Energy charge	488	426	448	411	479	483	497	508	499	504	467	465	$ 5,675	$ 0.48
		Demand charge	0	0	0	0	0	0	0	0	0	0	0	0	$ -	$ -
		Fixed charge	4	4	4	4	4	4	4	4	4	4	4	4	$ 48	$ 0.00
		Total charge	$ 492	$ 430	$ 452	$ 415	$ 483	$ 487	$ 501	$ 512	$ 503	$ 508	$ 471	$ 469	$ 5,723	$ 0.48
		$/kWh	$ 0.065	$ 0.066	$ 0.066	$ 0.066	$ 0.065	$ 0.065	$ 0.065	$ 0.065	$ 0.065	$ 0.065	$ 0.065	$ 0.065	$ 0.065	
F	Heating	GJ	157.1	103.6	76.6	40.3	32.7	27.2	19.2	16.5	39.7	70.3	95.9	123.7	802.9	0.0673
U		GJ/hr	0.7	0.5	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.5	0.5	0.69	0.0001
E	Cooling	GJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0000
L		GJ/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0000
	DHW	GJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0000
		GJ/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0000
	All end uses	GJ	157.1	103.6	76.6	40.3	32.7	27.2	19.2	16.5	39.7	70.3	95.9	123.7	802.9	0.0673
		GJ/hr	0.7	0.5	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.5	0.5	0.70	0.0001
		Energy charge	683	450	333	137	111	92	65	56	134	238	417	537	$ 3,253	$ 0.27
		Fixed charge	13	13	13	13	13	13	13	13	13	13	13	13	$ 156	$ 0.01
		Total charge	$ 696	$ 463	$ 346	$ 150	$ 124	$ 105	$ 78	$ 69	$ 147	$ 251	$ 430	$ 550	$ 3,409	$ 0.29
		$/GJ	$ 4.43	$ 4.47	$ 4.52	$ 3.72	$ 3.79	$ 3.85	$ 4.06	$ 4.19	$ 3.70	$ 3.57	$ 4.48	$ 4.45	$ 4.25	
	Total	Total charge	$ 1,188	$ 893	$ 798	$ 565	$ 607	$ 592	$ 579	$ 581	$ 650	$ 759	$ 901	$ 1,019	$ 9,132	$ 0.77

Prince George Native Friendship Centre - Design Building

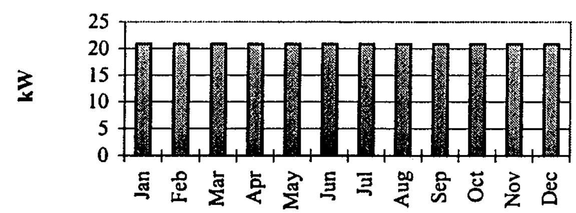
Annual Electricity Consumption



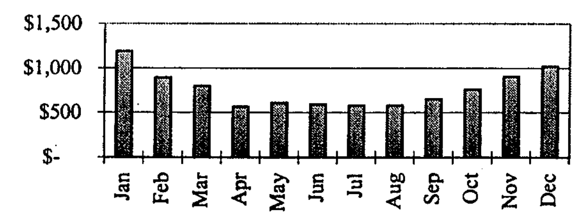
Annual Fuel Consumption



Peak Demand



Annual Energy Costs



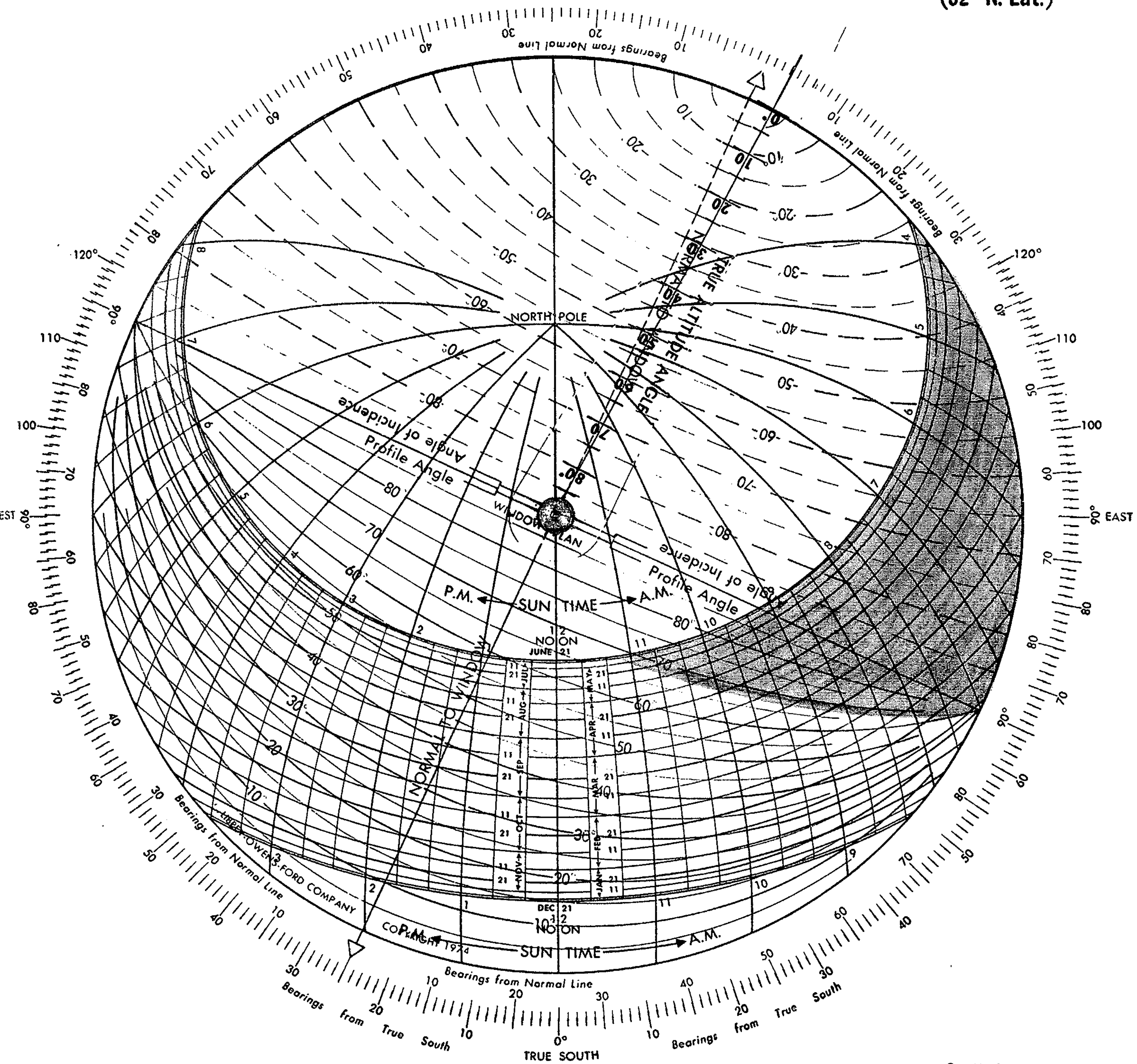
D.
Shading Mask Diagrams

SOUTH

1st Floor at Section B-B

100% shade
50 - 100% shade

52° SUN CHART
(52° N. Lat.)



7-29-96

SOUTH

2nd Floor windows

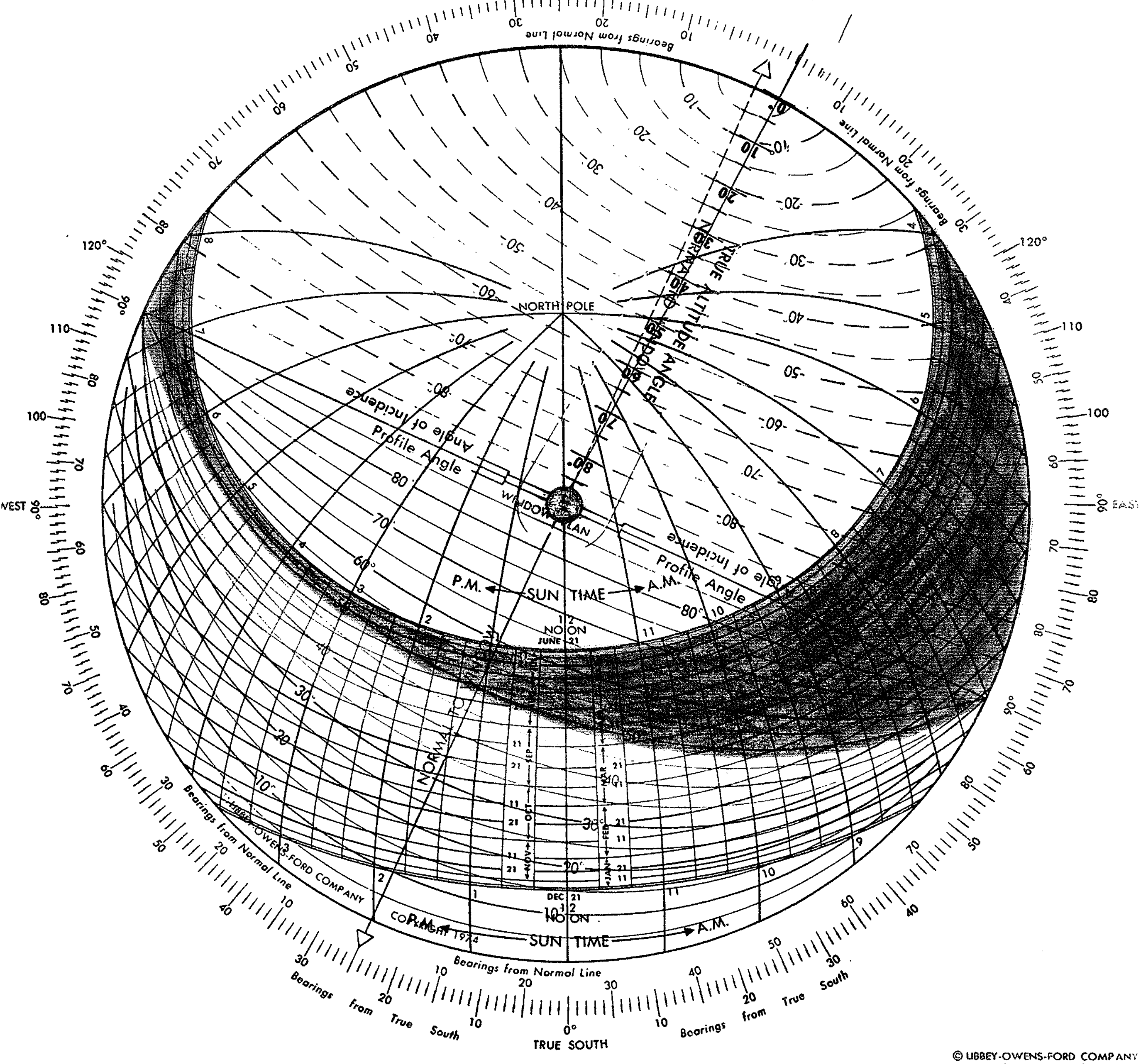
Weighted Average for upper + Lower portions

100% shade

50-100% shade

52° SUN CHART

(52° N. Lat.)



7-29-96

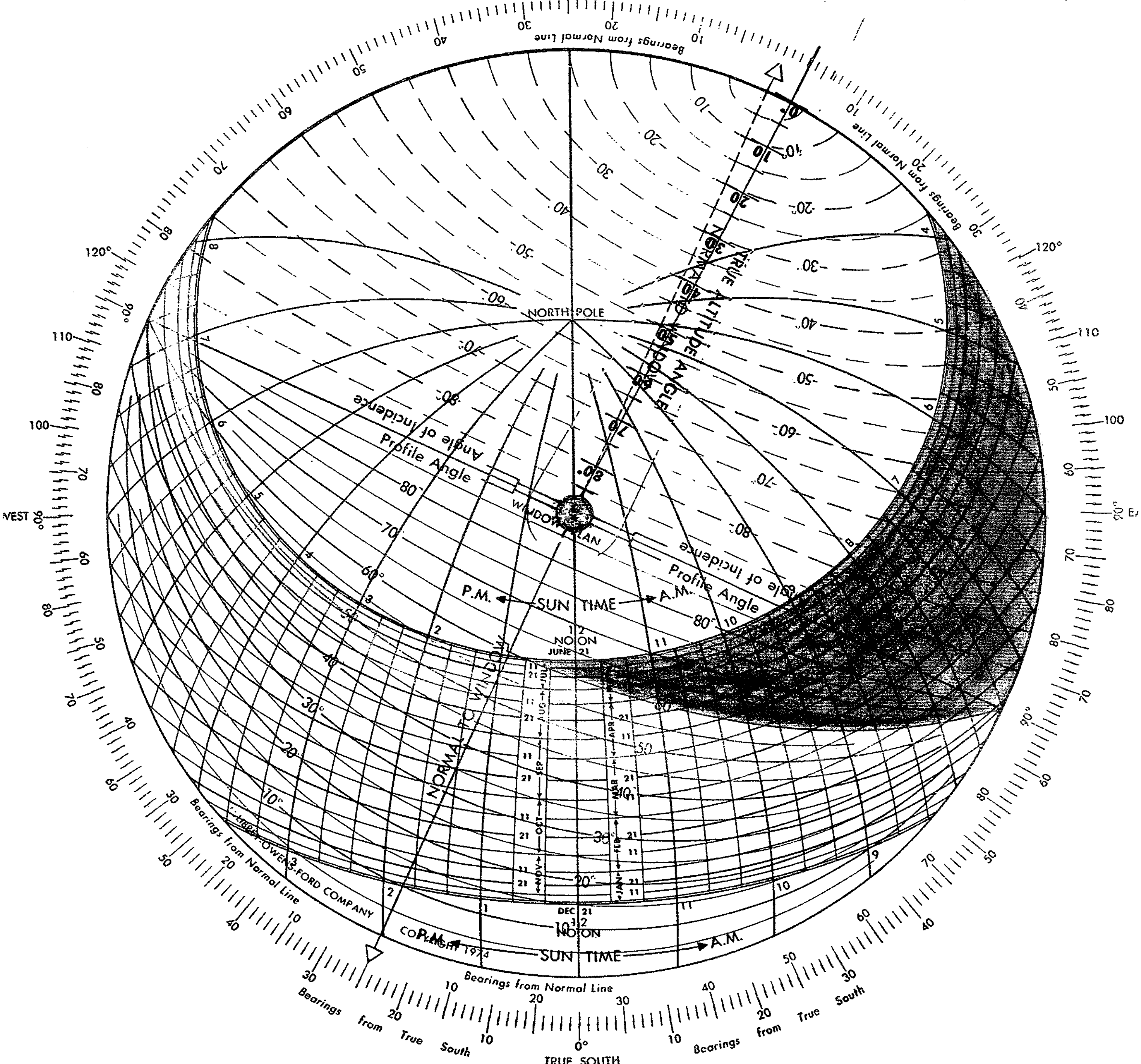
SOUTH

3rd Floor windows
.9m overhang at head
1.9m high window

100% shade
50 - 100% shade

52° SUN CHART

(52° N. Lat.)

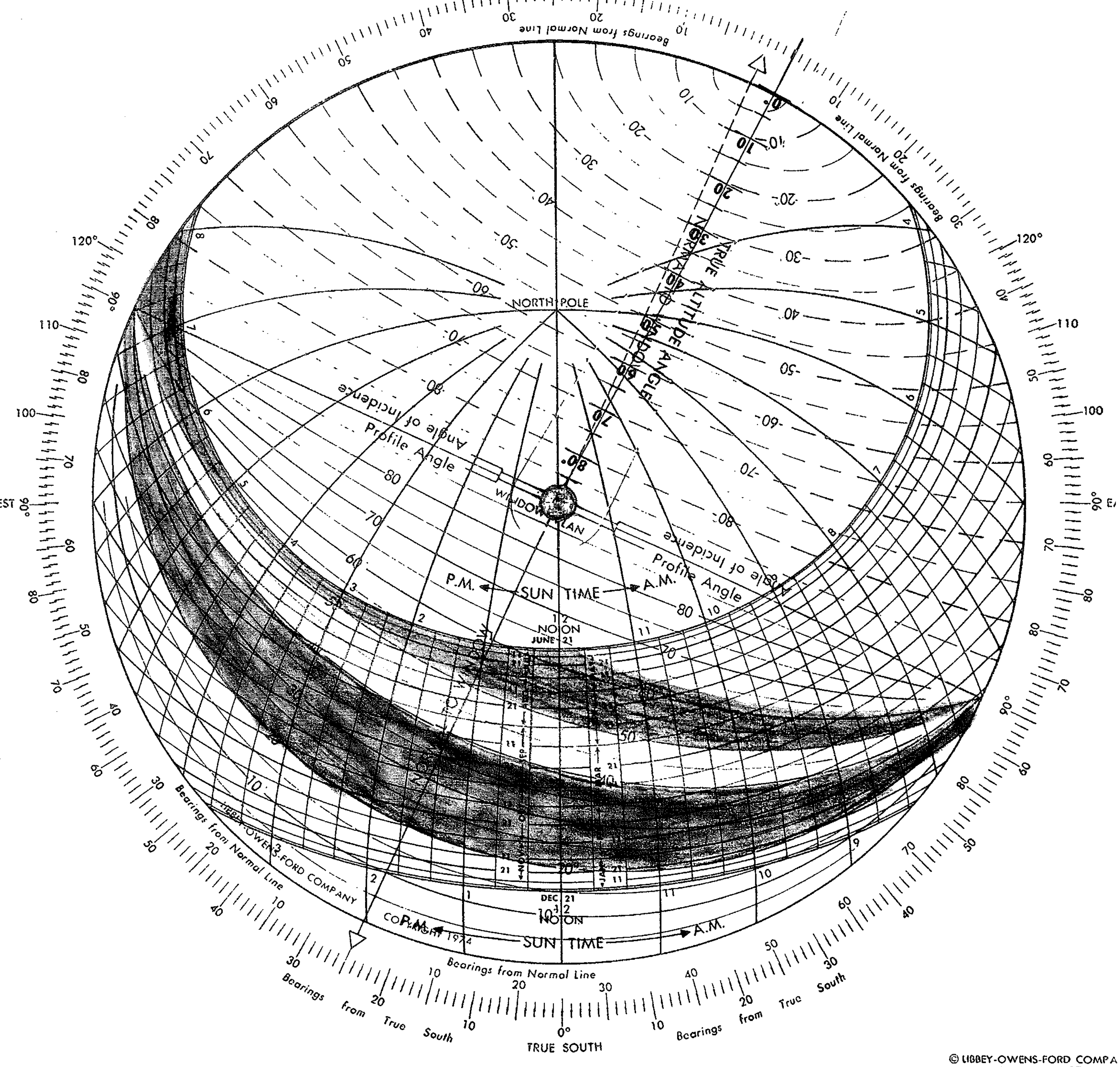


7-29-96

SOUTH
5th Floor at Section [A-A]

75% shade
50-75% shade
potentially distracting shadow band

52° SUN CHART
(52° N. Lat.)



7-29-96

Project:	PGNFC 1st floor south at B-B, overhang alone											
Latitude				53								
Window height				2.2		Horizontal projection			1.4			
Window width				1.3		Space btw glass and ovrhng			1.1			
Window orientation (N=0)				205		Vertical projection			0			
						Space btw glass and fin			0			

Percentage of shaded glass (all for the 21st day of each month)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
6:00	-	-	-	100%	100%	100%	100%	100%	-	-	-	-
7:00	-	-	100%	100%	100%	100%	100%	100%	100%	-	-	-
8:00	0%	30%	100%	100%	100%	100%	100%	100%	100%	30%	0%	-
9:00	0%	1%	76%	100%	100%	100%	100%	100%	76%	1%	0%	0%
10:00	0%	0%	29%	96%	100%	100%	100%	96%	29%	0%	0%	0%
11:00	0%	0%	12%	50%	94%	100%	94%	50%	12%	0%	0%	0%
12:00	0%	0%	3%	30%	59%	74%	59%	30%	3%	0%	0%	0%
13:00	0%	0%	0%	19%	42%	53%	42%	19%	0%	0%	0%	0%
14:00	0%	0%	0%	11%	32%	42%	32%	11%	0%	0%	0%	0%
15:00	0%	0%	0%	4%	25%	36%	25%	4%	0%	0%	0%	0%
16:00	0%	0%	0%	0%	22%	34%	22%	0%	0%	0%	0%	-
17:00	-	-	0%	0%	23%	39%	23%	0%	0%	-	-	-
18:00	-	-	-	0%	35%	68%	35%	0%	-	-	-	-

Note: Times listed are solar times. Add one hour for daylight savings in summer.

7-29-90

Project:	PGNFC 3rd floor south											
Latitude			53									
Window height			1.9		Horizontal projection			0.9				
Window width			2		Space btw glass and ovrhng			0				
Window orientation (N=0)			205		Vertical projection			0				
					Space btw glass and fin			0				

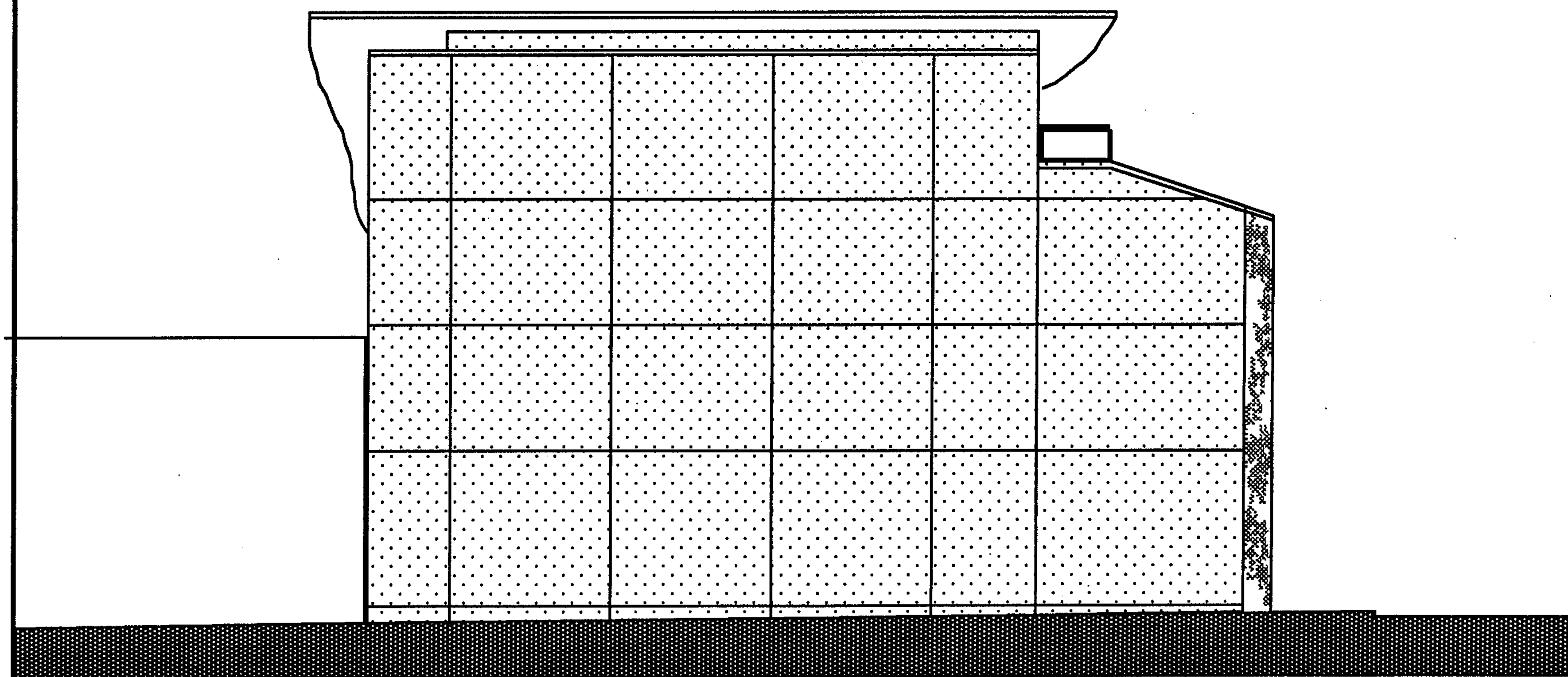
Percentage of shaded glass (all for the 21st day of each month)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
6:00	-	-	-	100%	100%	100%	100%	100%	-	-	-	-
7:00	-	-	100%	100%	100%	100%	100%	100%	100%	-	-	-
8:00	1%	59%	100%	100%	100%	100%	100%	100%	100%	59%	1%	-
9:00	15%	38%	94%	100%	100%	100%	100%	100%	94%	38%	15%	8%
10:00	17%	32%	59%	100%	100%	100%	100%	100%	59%	32%	17%	13%
11:00	17%	28%	47%	75%	100%	100%	100%	75%	47%	28%	17%	13%
12:00	16%	25%	39%	60%	81%	92%	81%	60%	39%	25%	16%	13%
13:00	13%	21%	34%	51%	68%	77%	68%	51%	34%	21%	13%	11%
14:00	10%	18%	29%	45%	61%	68%	61%	45%	29%	18%	10%	8%
15:00	6%	13%	25%	40%	56%	64%	56%	40%	25%	13%	6%	4%
16:00	0%	8%	19%	36%	54%	62%	54%	36%	19%	8%	0%	-
17:00	-	-	12%	32%	54%	66%	54%	32%	12%	-	-	-
18:00	-	-	-	26%	63%	88%	63%	26%	-	-	-	-

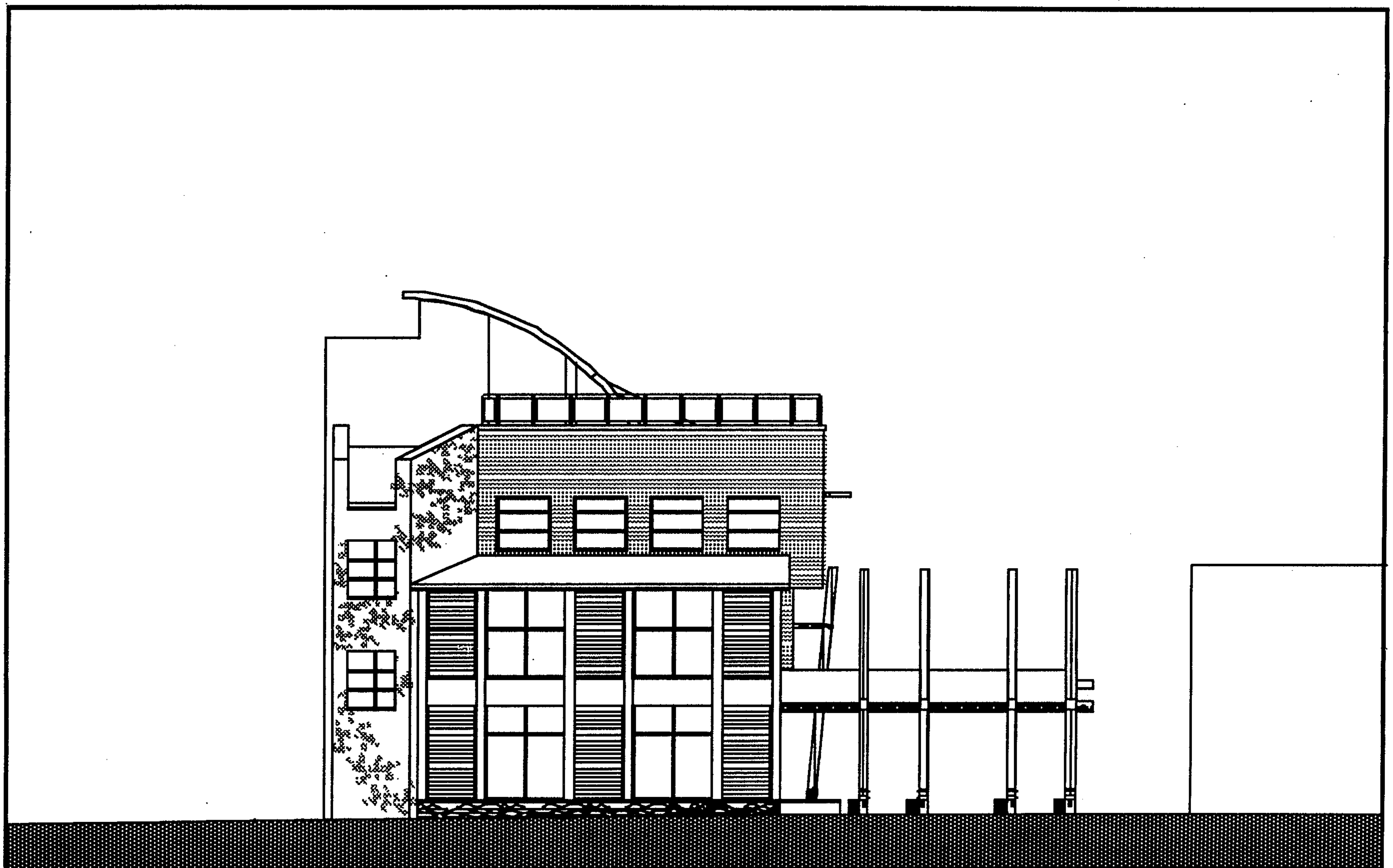
Note: Times listed are solar times. Add one hour for daylight savings in summer.

7-29-9?

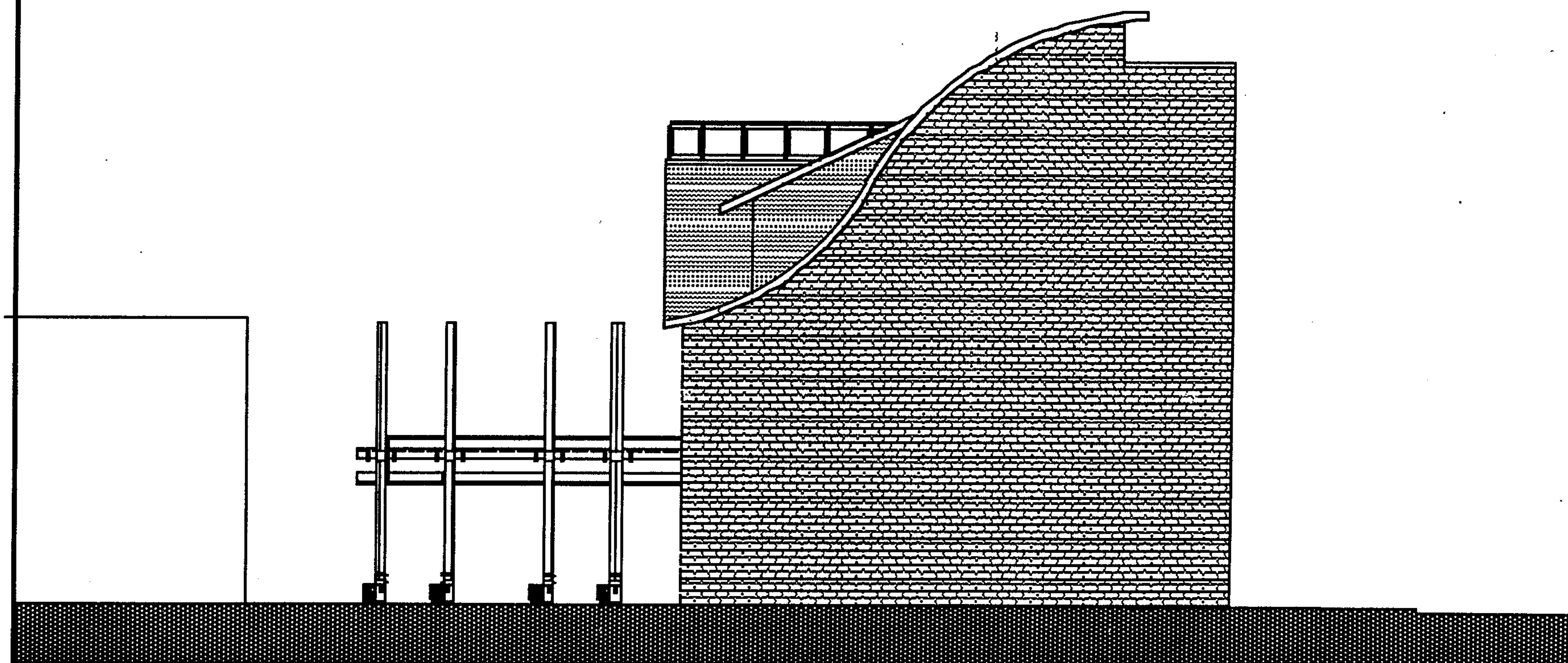
E.
Building Elevations



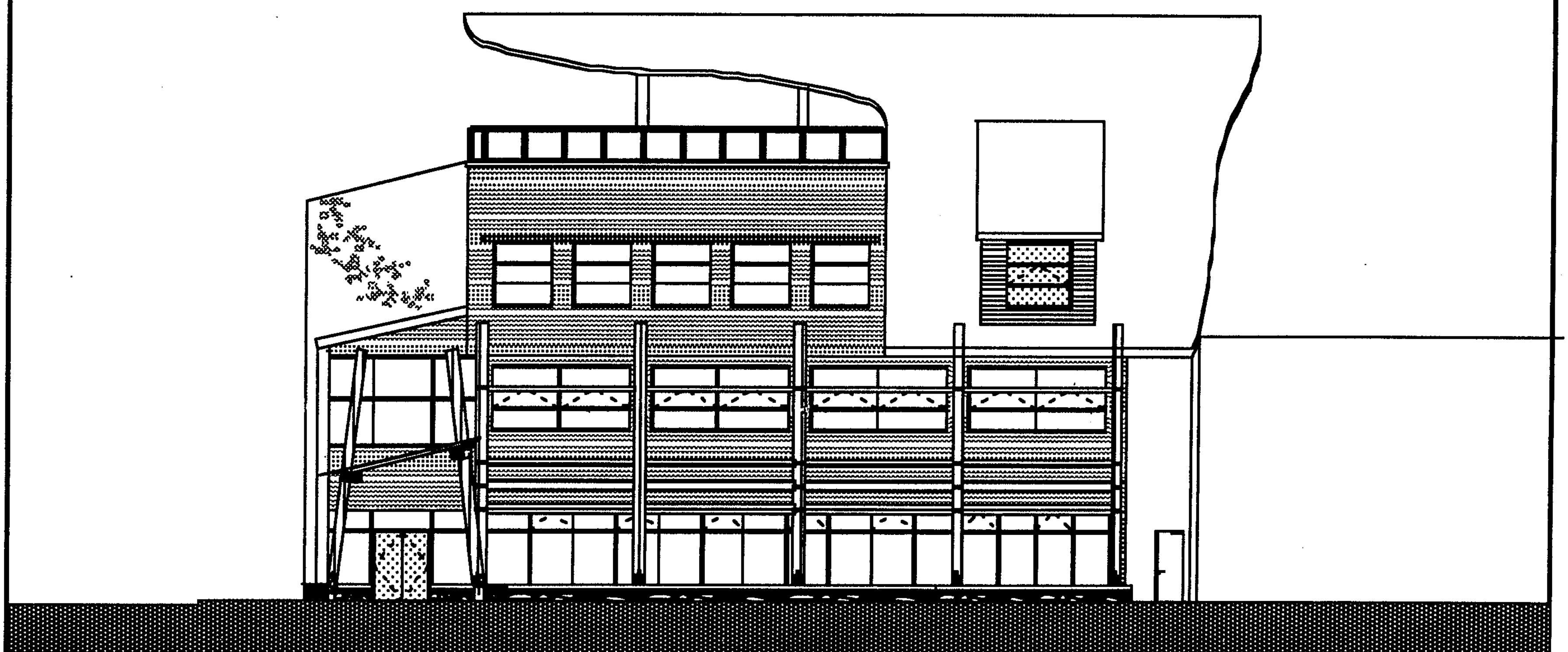
North Elevation
1:200



West Elevation
1:200



East Elevation
1:200



South Elevation
1:200