Public Works Canada
Western Region

Travaux publics Canada
Région de l'Ouest

NORTHERN HOUSING

GUIDELINES & STANDARDS

TABLE OF CONTENTS

BOOK ONE - MANDATORY STANDARDS

BOOK TWO - RECOMMENDED GUIDELINES

INTRODUCTION

These Guidelines and Standards are designed primarily for use in the Yukon and Northwest Territories.

The problems that arise in designing heated buildings in the Canadian North, other than those imposed by permafrost, differ in degree rather than in kind from those encountered in the warmer, more densely populated regions in the South. It is however, this difference of degree that magnifies the importance of "form following function" as prime architectural ideal, making the adherence to basic principles of the functional design of space and structure, a top priority.

The contents of this report deal with the functional aspects of the Building's form, internal spaces and construction as they are affected by their location in an area of severe climate and insolation. No attempt has been made to deal with aesthetics nor the planning of allied fields such as landscaping and community planning, although some of the subject discussed in this report have a direct bearing on the aforementioned.

The requirements and recommendations for both spaces and construction contained in the following Sections are additions to requirements of the National Building Code. It is intended that the National Building Code be applied normally as in any other form of development.

The severity of the winter conditions, together with the limited summer enviroment intensify the utilization of the interior, and, to some extent, the exterior spaces. The functional space requirements and recommendations reflect this intensified use. In most cases the space requirements exceed the requirement of the National Building Code, but at the same time attempt to encourage the multi-functional aspects of combined or enlarged spaces.

Some space requirements namely cold storage, utility, storage space and family room do not occur as such in the National Building Code, however due to the uniqueness of the Northern Housing situation, they have been included as mandatory requirements.

FOREWORD to BOOK ONE

The Treasury Board Advisory Committee on Accommodation reviews all Departmental proposals involving accommodation. This main committee set up a sub-committee to review departments' standards for living accommodation. The purpose of the sub-committee is to propose standards of living accommodation provided for Government of Canada employees. The sub-committee recommends amendments or additions to the Standards Manual for approval by the main committee.

Living Accommodation included in approved Departmental programmes, which are in accordance with the approved standards need not be presented to the sub-committee and will be considered on an individual basis.

Departments will provide the sub-committee with copies of plans for each proposal where areas do not conform to the space criteria shown in the Manual, a review of the net to gross ratio and a description of any deviations for the approved standards.

DESCRIPTION

NET AREA - To be determined from the inside dimensions of each room shown in the space criteria chart.

GROSS AREA - To be measured for the outside surface of the exterior wall studs.

DESIGN STANDARDS

2.1 SPECIFICATION STANDARDS

2.1.1 General:

Construction of Crown-owned houses shall be carried out in accordance with the requirements of the Dominion Fire Commissioner's Standards National Building Code and supplement No. 5 Housing Standards in conformity with local By-Laws and/or Codes.

Maximum use shall be made of local building materials of Canadian Manufacture consistent with sound building economics. The building system used should be suited to the locality.

2.1.2 Construction and Finishes:

The following paragraphs give guide lines for acceptable standards for particular parts of the house. The principles incorporated in these guidelines apply equally to all parts, whether specifically dealt with or not.

2.1.3 Site Works:

Walks and driveways shall normally be provided.

The house lot shall be graded to provide adequate drainage around the building. No unnecessary excavation or grading shall be carried out to change the existing general contours of the lot. Where soil is economically available, grass areas shall be provided back and front, otherwise other forms of ground improvement shall be carried out consistent with proper economy and public safety.

Lots may be enclosed at the discretion of the department concerned.

Landscaping is normally a requirement.

2.1.4 House Roofing:

Flat roofs requiring built-up roofing shall not normally be provided. See par. 3.4.1 in the Section entitled "Technical Design Considerations."

2.1.5 Family Room:

In housing units, separate areas will be provided for family living, such as insulated basements with finished rooms, suspended basements (above ground), family rooms or by other means of providing common multiactivity areas for the family during the severe weather periods and times of darkness.

Where the family room is a separate room, attempt to locate in the lowest level.

2.1.6 Air Lock (Entry):

Provide heated entry room.

2.1.7 Utility Room:

Should be fire and sound proofed when required.

2.1.8 Cold Storage - External:

To be fire proofed if adjoining the main building and vented.

2.1.9 Storage Spaces:

May be increased in locations where supplies are received on an intermittent bulk supply basis.

2.1.10 Kitchen:

In addition to regular items provide space for a dishwasher.

2.1.11 Coat Closets:

Shall be a minimum of 760mm deep.

2.1.12 Electrical Note:

Keep maximum number of electrical fixtures, switches, and plugs off exterior walls/ceilings. Each housing units and/or apartment, will have one exterior outlet, seperately fused with a 15 amp. breaker.

Recessed light fixtures and fans shouldn't be used in areas where air barrier exists.

2.1.13 Mechanical Note:

Avoid placing piping in exterior walls. Care must be taken in locating mechanical exhausts and vents, because of the freeze/thaw problems.

All piping in unheated roof spaces shall be insulated. Bath and kitchen exhaust shall preferably be on the face of the building.

2.1.14 Equipment Notes:

Space and services normally to be provided for the following items: As the washer, dryer, dishwasher and deep freezer may be provided by the tenant, allow space for large units.

Furnace	H W Tank
Laundry Tub	Washer
Dryer	Refrigerator
Stove	Deep Freeze
Dishwasher	External Hose Bibs
Sinks	

2.1.15 Insulation:

The following minimum Thermal Resistance (RSI in $m^2 \cdot {}^oC/W$) shall be provided.

Above Grade Exterior Walls and exterior grade beams	RSI 3.5
Roof - Ceiling	RSI 7.1
Walls (grade beams) 0 to 600 mm Below Grade	RSI 2.1
Floors Over Unheated Space	RSI 4.7

2.1.16 Sound Proofing:

Sound proofing should be considered around furnace room when furnace noise may interfere with living space and must be provided in party walls of attached units.

2.1.17 Doors and Windows:

Insulated metal exterior doors at entrance air locks are recommended. Ventilation should be through windows or panels. Air lock areas should be provided with a door to the remainder of the house.

Because screen doors are a maintenance problem they are not essential if adequate cross ventillation can be provided.

Triple glazing shall be used. Openable sections shall be screened. Maximize use of fixed windows. Panes should be no larger than 600 x 1200 mm for replacement economy and ease of handling.

2.1.18 Air Barriers (formerly vapour barriers)

Polythene air barriers are critical with increased insulation. Minimize breaks through exterior walls for pipes, wires, ducts, etc. Seal all such breaks.

Minimize breaks through ceiling air barrier. Seal around plumbing vents and chimneys.

Maintain continuous barriers on inside of all exterior walls and undersides of roof structure. Where walls adjoin, the barrier must not be broken.

Provide thermal breaks to metal doors, door frames, thresholds, windows and window frames. Exterior doors and windows must be provided with adequate weather stripping.

2.1.19 Flooring:

It is desirable that sub-floors be glued and ring nailed to floor joists.

2.1.20 Roof Ventilations:

Unheated roof spaces must be provided with adequate ventilation.

2.1.21 Remote Areas:

If locations are away from regular transportation routes, where no support services exist, these standards may be modified to suit the circumstances.

OPTIMUM SPACE STANDARDS

NET AREAS

	UNIT	TWO PERSONS	TWO BEDROOM THREE PERSONS	THREE BEDROOM FOUR PERSONS	THREE BEDROOM FIVE PERSONS	FOUR BEDROOM SIX PERSONS
LIVING ROOM	m^2	13.47	14.86	16.26	17.65	18.58
LIVING ROOM (When family room is in combination with living room or other space)	m^2	-	18.58	20.90	21.37	22.30
DINING ROOM	m^2	8.36	9.29	9.29	10.22	10.22
DINING ROOM (In combination)	m^2	7.43	8.36	8.36	9.29	9.29
KITCHEN	m^2	8.36	9.29	9.29	10.22	10.22
KITCHEN (In combination)	m^2	7.43	8.36	8.36	9.29	9.29
KITCHEN COUNTER LENGTH	mm	3000	3750	3750	4250	5000
KITCHEN CABINET STORAGE	m^2	5.57	6.97	6.97	9.29	9.29
BATHROOM	m^2	3.72	3.72	3.72	3.72	3.72
SECOND BATHROOM	m^2	-	-	2.32	2.32	2.32
FAMILY ROOM	m^2	-	13.94	13.94	13.94	16.26
FAMILY ROOM (In combination)	m^2	-	9.29	9.29	9.29	11.15
BEDROOM 1	m^2	12.54	12.54	12.54	12.54	12.54
BEDROOM 2	m^2	-	8.36	10.22	10.22	10.22
BEDROOM 3	m^2	-	-	8.36	8.36	9.29
BEDROOM 4	m^2	-	-	-	-	8.36
BEDROOM CLOSETS PER PERSON	mm	1200	1200	1200	1200	1200
LINEN CLOSETS	m^2	0.46	0.46	0.74	0.74	0.93
BROOM CLOSET	m^2	0.46	0.46	0.74	0.74	0.74
UTILITY SPACE	m^2	7.43	7.43	7.43	7.43	8.36
STORAGE SPACE -Interior	m^2	8.36	8.36	8.36	9.29	10.22
UTILITY/STORAGE COMBINED	m^2	13.94	13.94	13.94	15.33	16.26
COLD STORAGE - Exterior	m^2	6.50	6.50	6.50	7.43	8.36
ENTRY	m^2	2.32	2.32	2.32	2.32	2.32
ENTRY COATS & MISC.	m^2	1.86	1.86	2.32	2.60	2.79

1. Net areas will be figures shown above within 10% plus or minus.

2. Total gross area shall not exceed the total net area by a factor of more than 1.4 without stairwells or 1.5 with stairwells.

DESIGN CONSTRAINTS

FOREWORD to BOOK TWO

The information set down in these sections contains the thoughts of many persons who have been engaged in northern design and construction work for many years. These guidelines represent an amalgamation of these views on important aspects of this subject. It is strongly recommended that all who are engaging in northern design review this material carefully before proceeding with design work.

TABLE OF CONTENTS

1.1.1 RESPONSE TO CLIMATE

A comprehensive understanding of permafrost and discontinuous permafrost areas and their effect on buildings and foundations, plus the local climatological conditions is an essential prerequisite for planning in a given location. An analysis of sun, wind, rain, snowfall, temperature and duration, with details of their characteristics and interactive behavior, should form the basis of preliminary planning studies.

A knowledge of the major winter winds, particularly as they pertain to heat loss and drifting conditions are often the prime determinants of a building's siting. Buildings should not be orientated to expose large wall areas to the prevailing winter winds, suggesting a linear placement of units parallel to the winds direction. This placement invariably coincides with the optimum positioning of the units to minimize the effects of snow drifting. Winds which are colder than the ambient ground temperature, drift substantially more than winds which are warmer than the ambient ground temperature. The locating of cold storage and cooler utility/storage spaces on the exterior walls exposed to the most severe winter conditions, helps to form a buffer against the greatest cooling effect.

The exploitation of southern exposure maximizes the effect of available sunlight for solar heat gain, as well as for psycological comfort. Internal open planning enables the building to accommodate as much natural light as possible and in addition provides for natural cross ventilation during the summer months. It is therefore advisable to orientate the building so that the prevailing summer winds are normal to the main window walls in detached houses or length of the block in row housing. However, the decision must be taken with regard to the importance of summer prevailing winds versus winter prevailing winds, as to which winds have precedent in the orientating of the building.

The provision of sheltered exterior spaces can extend the season for outdoor activities, though care must be taken with the erection of any permanent (as against temporary) structures, so that they do not have drastic detrimental effects during the winter months.

BUILDING FORM

The cube is among the most thermally efficient practical building form using traditional construction methods. It exposes the smallest external surface area for a specific interior space. To minimize the cooling effects of prevailing winds and maximize the heat gain of solar radiation, the true cubic shape is often distorted to provide an optimum building solution rendering the lowest active heat requirement.

In attached housing, practical considerations become increasingly more important to the extent that the overall building form of a row of attached houses no longer conforms to the cubic ideal, however, each unit is still thermally more efficient than its detached counterpart since its external surface area is reduced still further through the use of party walls. Irrespective of the type of housing chosen, emphasis must be placed on simplicity of form with no projections or cantilevers increasing the exterior surface any more than in necessary.

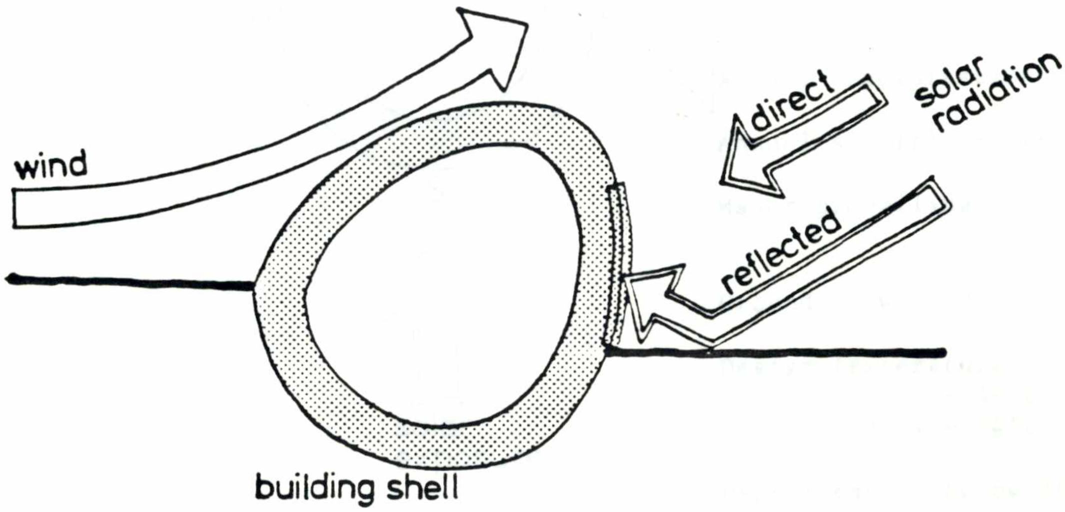
1.1.3 INTERIOR PLANNING

Always allow for maximum thermal efficiency consistant with functional use. Plan for the central location of rooms and allow heat flow to cooler peripheral areas. Maintain a hierarchy of spaces in order that the cooler spaces are located against the exterior walls to lower the temperature differential experienced.

Determine the optimum solar impact for each space and orientate each space in order to achieve the desired condition during the period in which it is occupied. Take specific note of the annual variations of hours and amplitude of sunlight particularly during the summer months in the extreme northern latitudes.

Always provide for the maximum flexibility and continuity between interior spaces. Plan for an intensified winter use through use of multi-functional areas achieved where necessary through the use of temporarily or permanently combined spaces.

BUILDING SHELL



.To increase the thermal capacity of the building shell:-

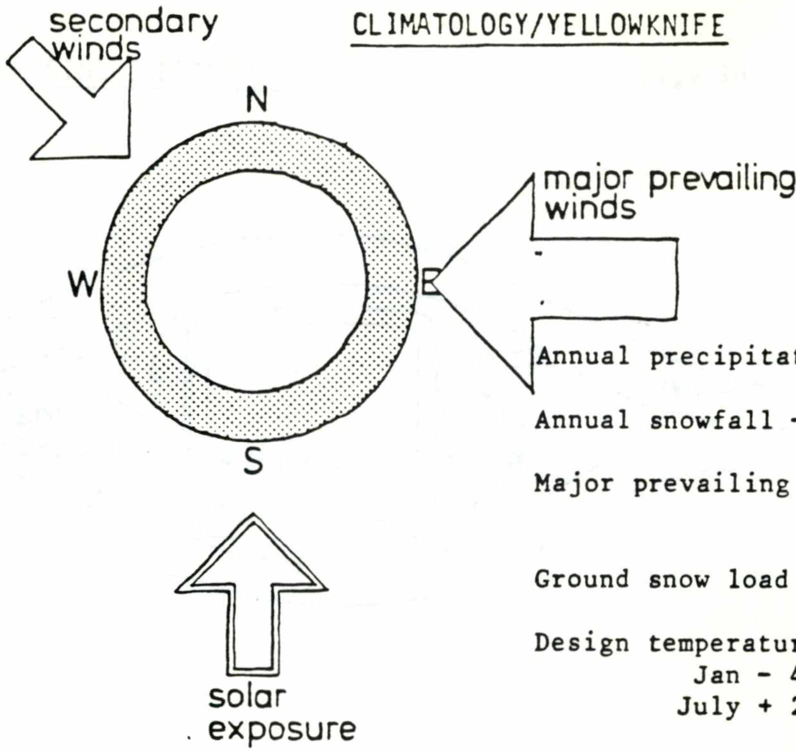
.Use dark absorbative coloured finishes on vertical southern surfaces to absorb as much weak solar radiaion as possible.

.Provide minimal surface exposed towards the main prevailing cold winter winds.

.Avoid light colours and highly reflective surfaces, since these reflect sunlight and hence heat onto the ground. This additional heat gain by the ground upsets the temperature balance that the ground (and lower permafrost) is accustomed to.

.Consider landscaping ie: earth berms, trees, etc., to reduce wind chill.

CLIMATOLOGY/YELLOWKNIFE



Annual precipitation - 250 mm

Annual snowfall - 1067 mm

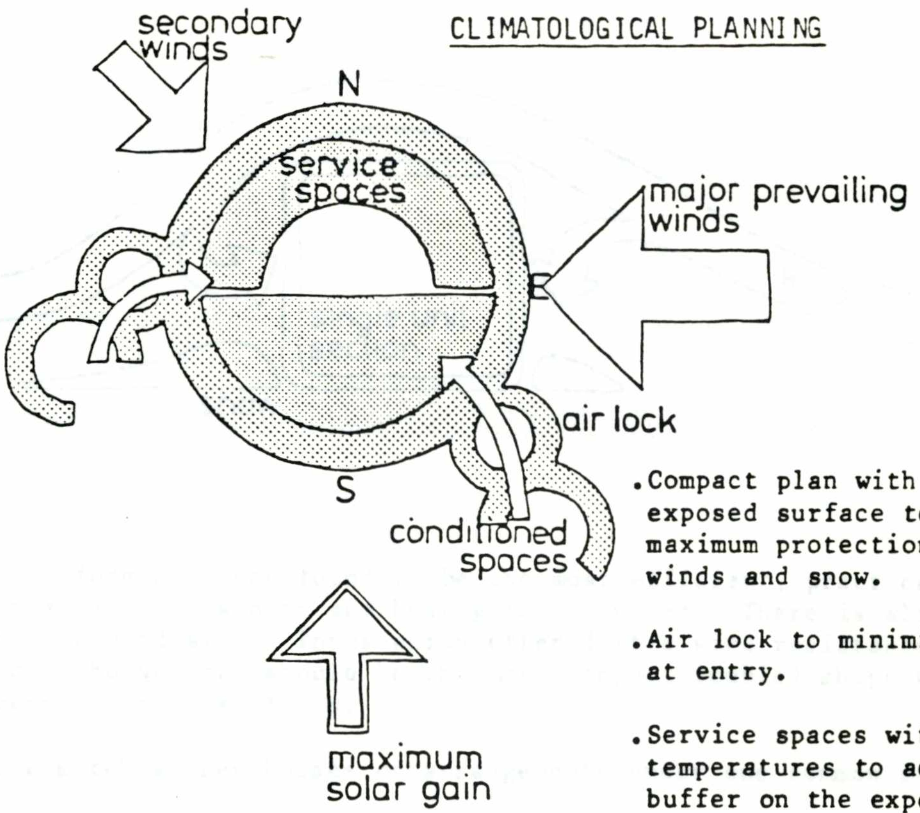
Major prevailing winds - 1/30
26 m/s

Ground snow load - 2.0 kN/m^2

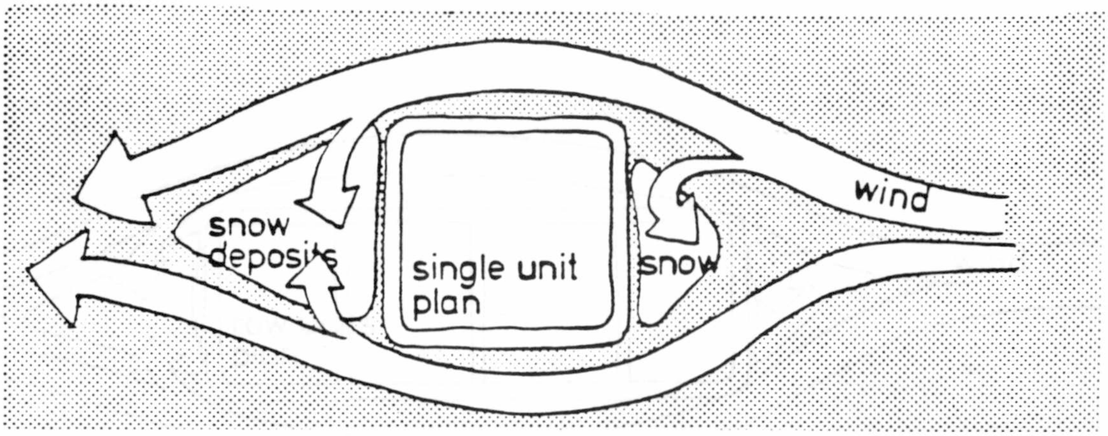
Design temperatures:
Jan - 44°C
July + 24°C

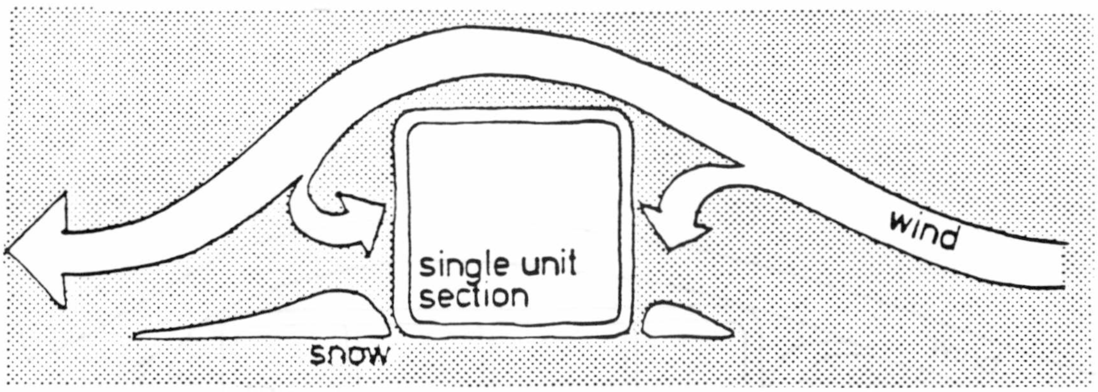
Degree days - below 18°C - 8593

CLIMATOLOGICAL PLANNING



- Compact plan with minimum exposed surface to give maximum protection from winter winds and snow.
- Air lock to minimize heat loss at entry.
- Service spaces with cooler temperatures to act as a buffer on the exposed side to warmer living spaces.
- High use living spaces located on protected side with maximum solar gain.
- Interal open play for maximum natural ventilation and natural lighting.

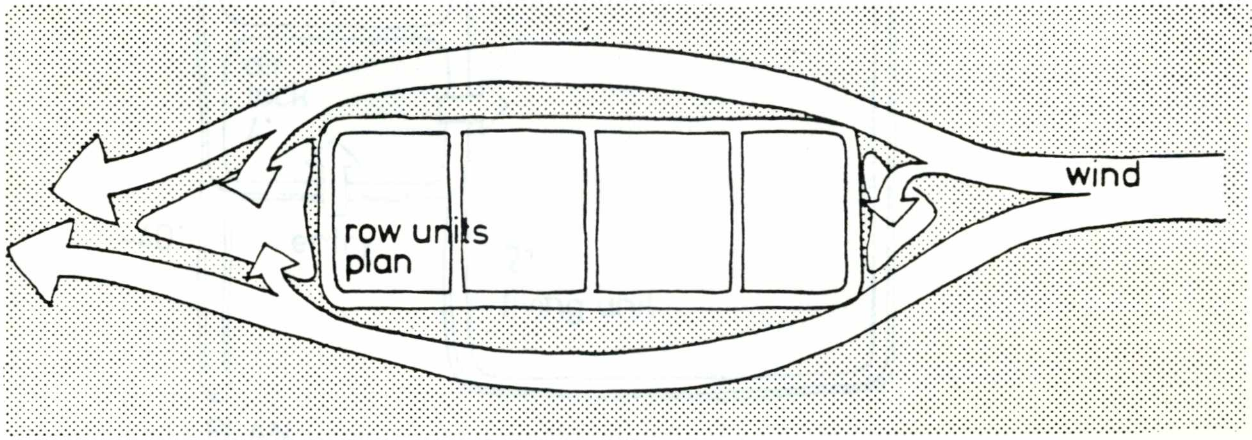




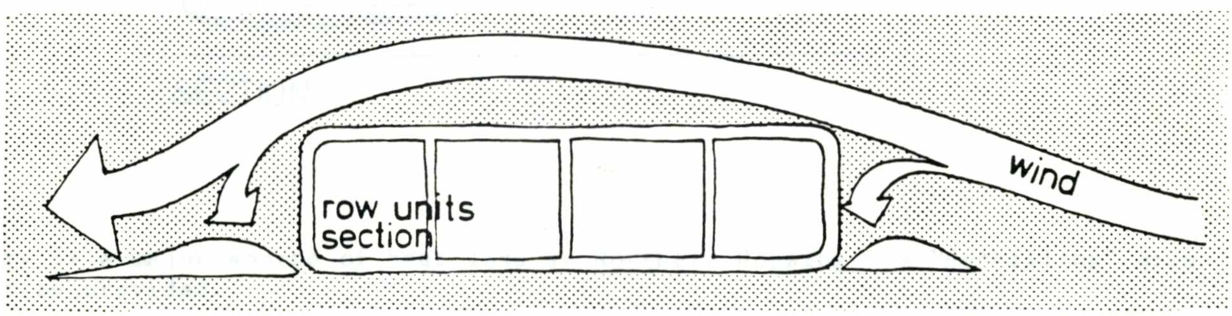
The cubic housing form has been found to be the most efficient, practical shape in minimizing heat loss in winter and heat gain in summer. There is also less snow accumulation around simple forms which offer little wind resistance. Thus the ideal detached house form should be the most compact (cubic) shape with minimally exposed exterior surfaces.

This form suggests two storey houses or arrangements under one common roof for compactness.

1.2.4. HOUSING FORM - ROW UNITS



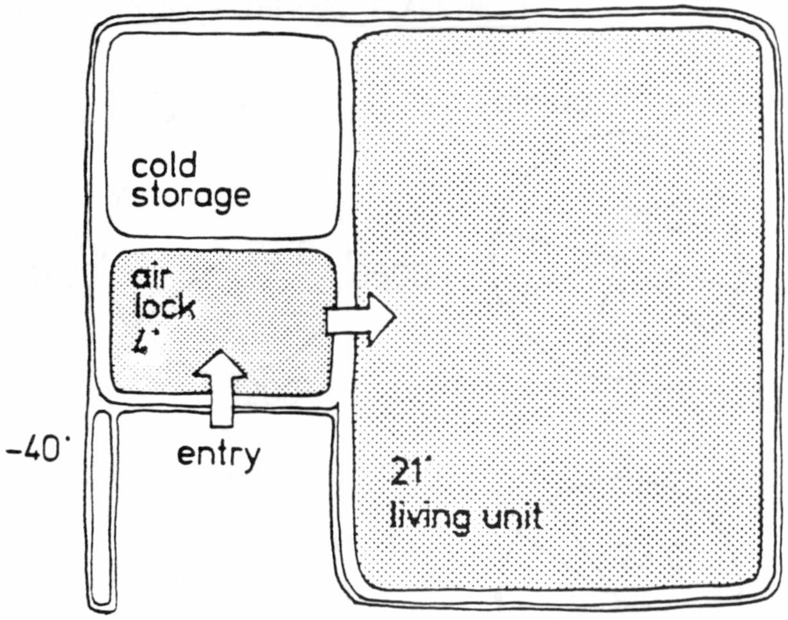
Unit expanion should occur in a row parallel to the direction of the prevailing cold winter winds.



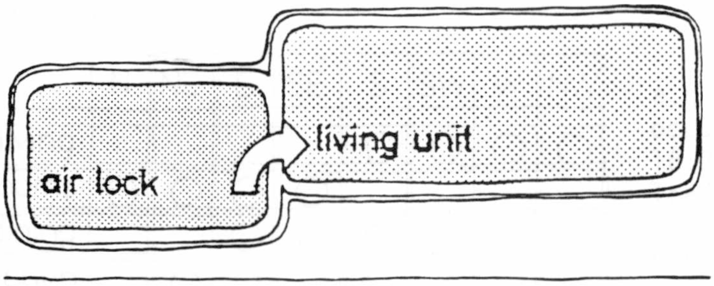
Simplified building form and lower height to width ratio provide a profile which minimizes heat loss and snow accumulation.

Row houses have the advantage of lesser heat loss due to compactness and minimum exposed surface per unit.

1.2.5 UNIT DESIGN - ENTRY



PLAN



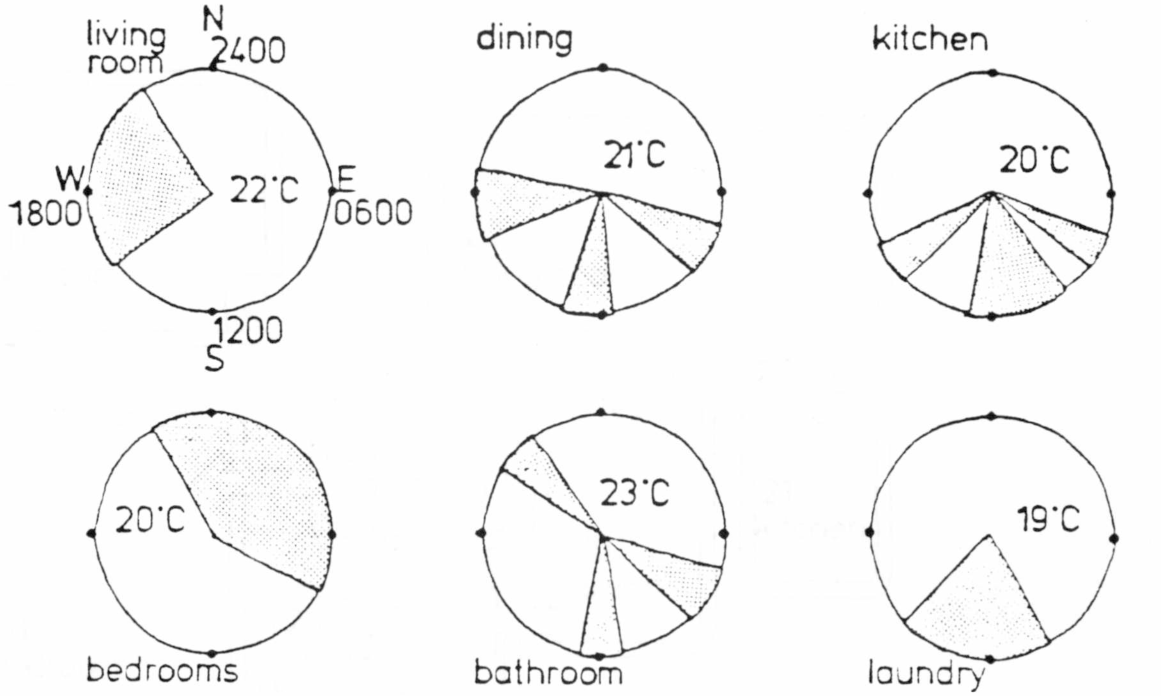
SECTION

Entry is a major source of heat loss in Northern Housing - a "dechilling" area must be provided.

- orientate entry away from prevailing winds or provide a screen to minimize wind impact and snow accumulation.

- locate entry/cold storage at a lower level than the main living areas to form an airlock. The airlock controls drafts and heat loss from the upper living areas.

- the entry/cold storage should provide sufficient storage for food, equipment, tools, supplies and outdoor clothing.

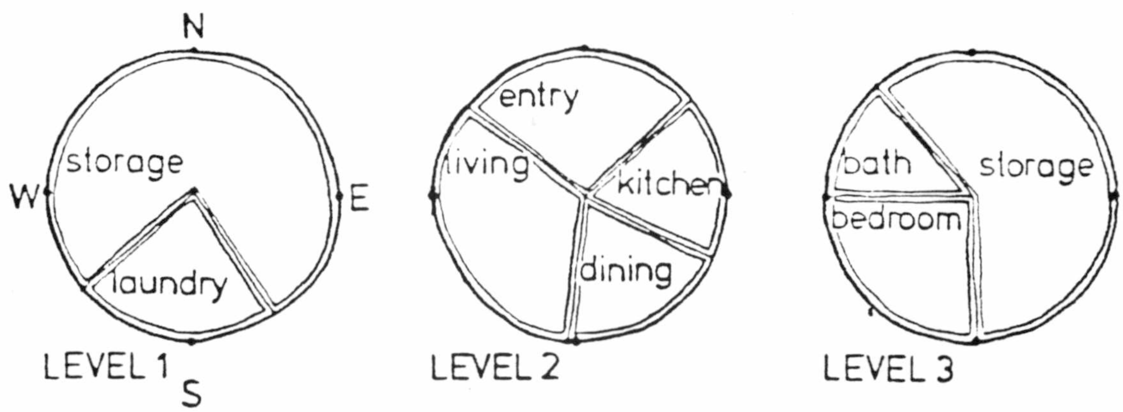


Provide each area with maximum solar impact for the period during which it is occupied.

	N	NE	E	SE	S	SW	W	NW
living					O	O	O	O
* bedrooms	O	O	O	O				
dining			O	O	O	O		
kitchen		O	O	O	O			
bathroom			O	O	O	O	O	
laundry				O	O	O		

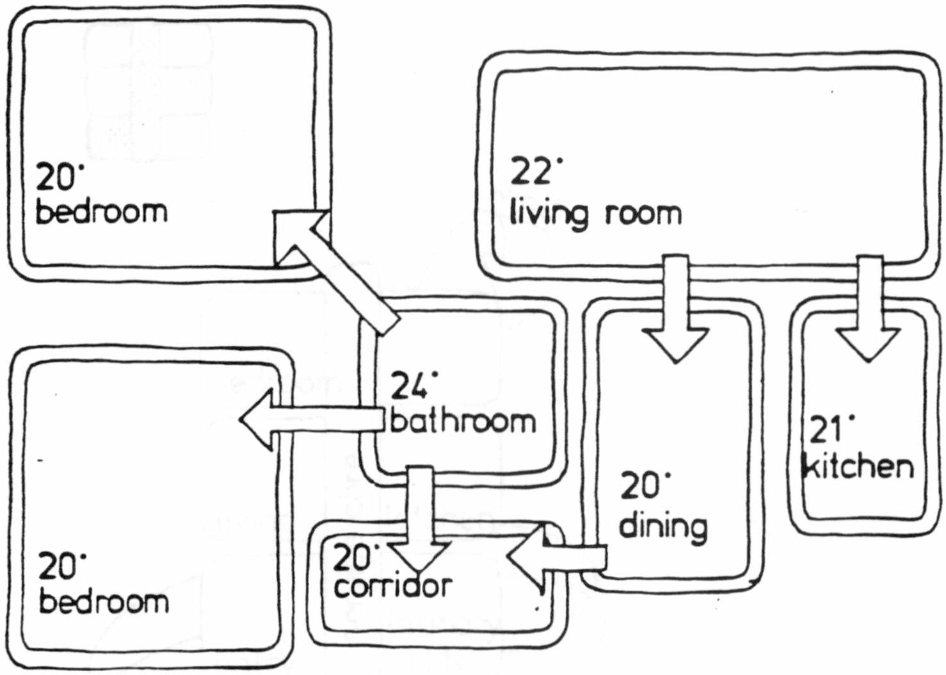
e.g., the living room is occupied primarily between 16.30 hours and 22.30 hours. The optimum orientation to utilize maximum solar impact ranges from SW to NW.

* In extreme Northern latitudes the midnight sun must be taken into account.with bedrooms which avoid the low sun angle at night or which use heavy blinds or drapes to cut off sunlight penetration.



Level variation can avoid optimum orientation conflict of the interior spaces.

1.2.7 UNIT DESIGN - THERMAL PLANNING 2

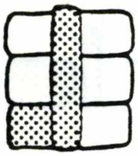


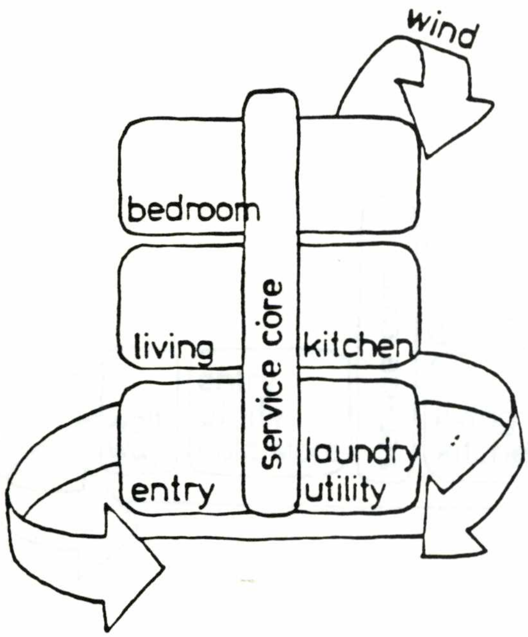
- As some areas are kept at a higher temperature than others, they should be located so that they are protected by cooler spaces from undue exterior heat loss. This graduation of temperature allows spaces to be more effectively maintained at their optimum temperature.

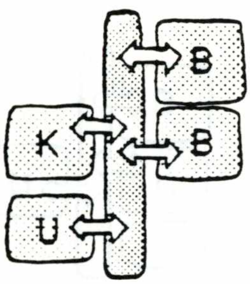
- Plumbing spaces and other service ducts should under no circumstances be located near the exterior walls.

- Airlocks and thermal zoning can help maintain a temperature equilibrium.

1.2.8 COMPARATIVE ANALYSIS - TYPICAL ROW HOUSING ACCOMMODATION 1



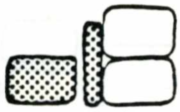


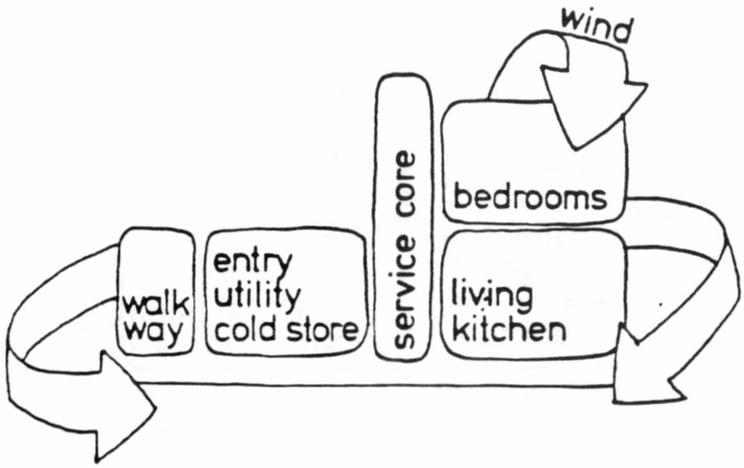


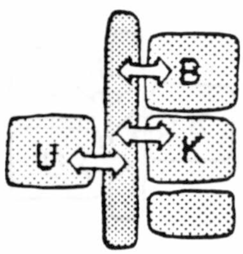
THREE STOREY VERTICAL

- Minimum Roof Area.
- Minimum Foundation Area.
- Lends itself to rowhouse developments.
- In rowhouse development the minimum surface area per unit is achieved.
- Makes maximum use of the lower floor area.

1.2.9 COMPARATIVE ANALYSIS - TYPICAL ROW HOUSING ACCOMMODATION 2







TWO STOREY

.Walkway/Entry/Utility/Cold Storage zone used as a buffer to living spaces.

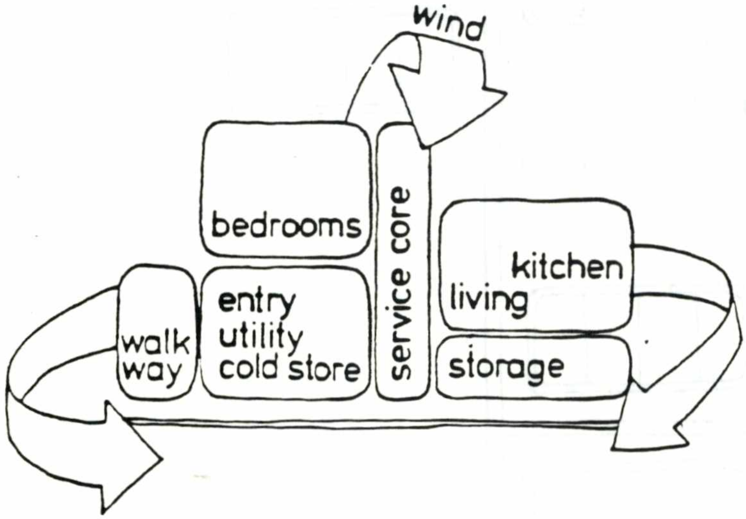
.A larger foundation is needed than for the more compact vertical three storey plan.

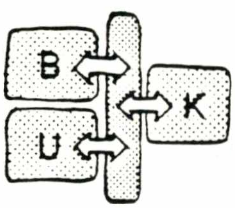
.Minimizes light penetration into and view out of lower floor.

.Smaller roof area than split level but necessarily larger roof area than three storey vertical.

.Extension of basic cubic housing form.

1.2.10 COMPARATIVE ANALYSIS - TYPICAL ROW HOUSING ACCOMMODATION 3





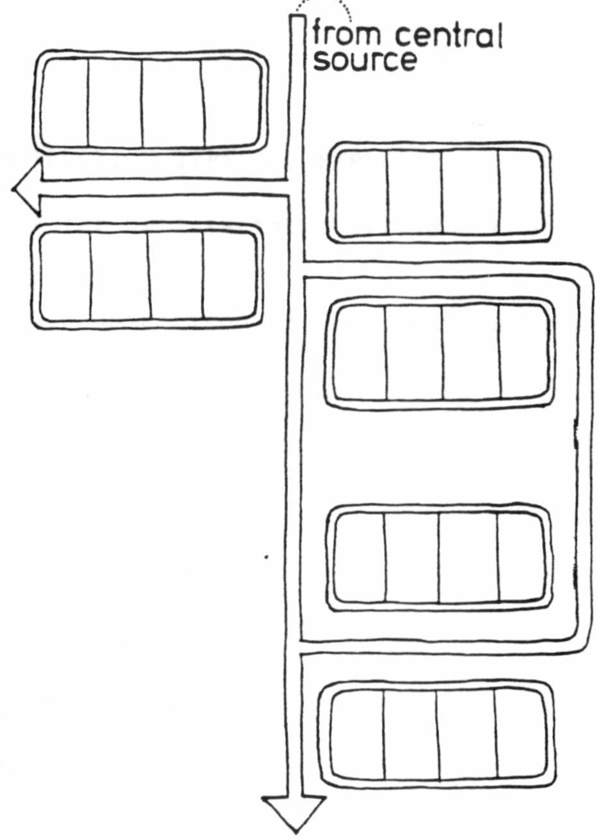
SPLIT LEVEL

Entry/Utility/Cold Store provide a buffer and airlock to the higher temperature living spaces.

Vertical extension of single storey unit produces large exposed roof area and exterior surface.

Relatively high heat loss due to high temperature areas being located on the periphery of the building.

1.2.11 SITE SERVICE PLANNING



.Avoid dead end services.

.Attempt to loop systems to maintain service flows.

.Cluster units around the services to avoid long runs and individual connections.

.Whilst many developments may be under common ownership at their instigation, it is possible that individual unit ownership may be contemplated at a later date. In this instance it is invariably a requirement that individual service connections be made to each unit rather than communal service connections.

SECTION 3 TECHNICAL DESIGN CONSIDERATIONS

TABLE OF CONTENTS

3.1 SELECTION OF CONTRUCTION TYPE AND STRUCTURAL MATERIAL

3.1.1 Basic Requirements for Satisfactory Performance under Northern Winter Conditions:

a) Ensure sufficient strength and rigidity;
b) Provide adequate insulation;
c) Prevent unintentional air exfiltration;
d) Prevent unintentional air infiltration;
e) Control vapour flow;
f) Minimize thermal bridging;
g) Minimize fire spread potential;
h) Control precipitation and meltwater flow.

3.1.2 Basic Requirements - Comparison of Construction Types:

ITEM	Stick Const.	Prefab Panels	Module Const.	Trailer
Strength and rigidity;	VG	F	G	VG
Adequate insulations;	VG	G	VG	G
Prevention of unintentional air exfiltration;	VG	F	G	VG
Prevention of unintentional air infiltration;	VG	F	VG	VG
Control of vapour flow;	VG	F	VG	VG
Thermal bridging;	VG	G	VG	VG
Fire spread;	-	-	-	-)
Control of precipitation and meltwater flow.	-	-	-	)Overall -)designs

VG = very good   G = good   F = fair   P = poor

These are based on commercial practice and with proper production, quality control and field control, all methods can become comparable.

3.1.3 Structural Materials - Selection

Wood - this is the conventional material, and is eminently suitable for northern construction. It provides versatility, flexibility, ease of fabrication, opportunities for semi-skilled labour, and has satisfactory insulation qualities.

Metal - other than for piles and foundation beams there has not been much use of metal as a structural material for housing in the north.

Future applications could employ metal studs and framing, stressed skin insulated panels, and light steel joists as a means of promoting prefabrication coupled with reduced weight and bulk for transportation. Design would have to recognize the very low heat flow resistance of steel. Except for single storey structures, the cost would probably be higher than for wood framing.

Plastic - the use of fibreglass-reinforced-plastic (FRP) in the north may increase where prefabricated insulated exterior wall panels would be suitable. These could be structural elements in housing, but would probably require wood or steel framing for the balance of the unit.

As noted for steel, the use of plastic would probably be more costly than wood framing, except where a sufficient quantity of identical panels could be used.

Logs - where readily available, logs would reduce imported materials, and provide for local labour. Efficient use is probably limited to single storey structures.

The insulation value of solid wood is only moderate, but could be improved with interior strapping and lining, at the expense of the simple and durable natural log finish. Such lining must accommodate shrinking and swelling of the wood, which would increase or decrease the wall height when the logs are laid horizontally. Advantages are simplicity and durability. A log house will probably keep its appearance in the face of abuse or neglect better than other types.

Exterior wall technology is very basic. Solid wood accommodates condensation of vapour permeation, but an interior finish of enamel, varnish or polyurethane would be advantageous. Air leakage usually deposits frost on exterior surfaces as the solid material provides no voids for condensation or ice within the wall. Air infiltration is treated by caulking. Wide eave overhangs are usual to limit water on exterior walls. An exterior finish using F.P.L. formula stain, or an alkyd resin stain would provide against water absorption and mould or moss.

3.1.4 Layout and Planning:

Minimize corners and projections to reduce heat loss areas and cold surface situations.

Minimize spans to reduce depth and length of dimension lumber. Design for common spans to maximize pre-cutting. Design to make maximum use of locally available lumber. 38 x 184 mm spruce is probably the optimum for the area supplied from the Mackenzie River. In the eastern arctic, supply is usually by sea-freight from conventional lumber sources and larger sizes would be more readily available, but 38 x 184 mm would remain a suitable size for handling and economy. Grades and moisture content should comply with Residential Standards Canada 1977. Lumber for floor joists should preferably be dried to a maximum moisture content of 15%.

Prevention of fire spread is critical in small and isolated communities. The local authority governs the spacial separation requirements. This report suggests that the use of non-combustible surface finishes for basements and equivalent spaces, including crawl spaces, be made a mandatory requirement for the North. See also Seciton 3.6.3.

3.2 FOUNDATIONS

3.2.1 Foundations

Type (1): Wood piles anchored in permafrost;
Type (2): Concrete piles bearing in permafrost;
Type (3): Concrete foundation and footing (where no basement, and no permafrost);
Type (4): Concrete piles and grade beams (where no basement, and no permafrost);
Type (5): Concrete basement foundation (where no permafrost);
Type (6): Concrete slab-on-grade (where no permafrost);

3.2.2. Selection of Foundation Type:

Type (1): Deep wood piles set into the permafrost are the usual foundation, unless a basement is required (and possible), and providing the solid type is suitable.

Piles are set in drilled holes, and backfilling with slurry. Re-freezing of the slurry provides bearing and stability. Where the active layer of permafrost is deep (600 - 1500 mm), adfreezing should be prevented in this portion. (Adfreezing is the adhesion by freezing of the surrounding soil to the pile, If ice lensing - commonly termed frost heave - occurs as the active layer re-freezes, there will be an uplift force on the pile).

Seasonal re-freezing of the active layer must be permitted by allowing low temperatures to occur at the ground surface, usually by leaving a clear space sufficient to prevent complete blockage by snow.

The depth of the active layer can be reduced by providing insulation, either by a gravel layer, or manufactured insulation laid on the ground and topped with gravel.

These piles and those described under Type 2, would support the building using floor-support beams. Spacing is dependent upon loads, soil bearing capacity, and joist span design.

Type (2): In remote locations with permafrost and a sand or gravel sub-soil, short concrete piles with spread footings may be more feasible than long wood piles.

Short piles must bear on permafrost and be insulated to prevent melting of the ground below the pile. Prevention of adfreezing is also required.

Type (3): Concrete foundation and footing - may be suitable where there is no permafrost, and a high water table prevents the use of a basement.

Type (4): Concrete piles and grade beams - may be required where Type 3 foundations would apply, but sub-soil is conductive to ice-lens formation (frost heave). These piles would extend to below the frost line, and support a shallower (reinforced) concrete foundation at grade.

Type (5): Concrete basements would be used only where required, unless sub-grade conditions are similar to those of the south.

Basements would not be economic where the sub-grade is rock, and would require costly insulation to maintain permafrost where applicable. Excavation of permafrost may be equal in cost to rock excavation.

Basements will rarely be feasible in houses for the North. Where a basement is possible, eg., no permafrost, the locality will determine whether this is the economic foundation to use.

Treated wood foundations would have a useful thermal advantage over concrete, but require greater material and shipment costs than would concrete, especially if gravel is available in the immediate vicinity.

Type (6): Concrete slab-on-grade would be used only in special situations where conditions permit it, or where other foundation types were not possible. The slab could be insulated and heavily reinforced to act as a raft foundation if the conditions require it.

3.2.3 Other Foundations:

Where surface conditions are suitable, simple bearing pads may be laid on a gravel bed. Ground anchorage should be provided for the building. Wood used for bearing pads should be treated with preservative. The design should enable easy re-blocking if jacking and re-levelling should become necessary.

3.3. LOWER FLOOR DESIGN

3.3.1 Lower Floor Constructions for Pile Foundations:

3.3.1.1. Types of Construction:

Floor Type A — Insulated single floor;
Floor Type B — Insulated Compound floor;
Floor Type C — Deep single floor with duct space;
Floor Type D — Double floor with storage crawl space;
Floor Type E — Double floor with non-storage crawl space.

3.3.1.2 Comparison of Construction Types:

Floor Type	Warm Floor	Ducts and Vapour Barrier Continuity	Vapour Barrier Continuity to wall	Access for Service	Storage Space
A	-	-	*	-	-
B	*	*	*	-	-
C	*	-	*	-	-
D	*	*	*	*	*
E	*	*	*	*	-

* = yes   - = no

3.3.1.3 General Notes:

In split-level plans, half the lowest floor would have Floor Type D or E. The space would be suitable for containing water and sewage tanks in locations where these are used. Floor Type D should have a surfacing to protect and secure the vapour barrier/air seal. General storage use of Floor Type E can be discouraged by designing the smallest reasonable access opening.

3.3.2 Concrete Wall Foundations and Concrete Grade Beam Foundations:

If vented and uninsulated - lower floor constructions would be as for pile foundations.

If insulated and treated as an interior space, simple floor construction applicable to the south could be used.

3.3.3 Basement Situations:

Where sub-grade is solid rock or other material which will maintain adequate bearing capacity insulation is required to reduce heat loss. Otherwise, insulation is primarily to preserve the permafrost.

Except where carpet is used, floor temperatures will be too low for living comfort, but satisfactory for storage purposes.

For living areas, a carpet surface would be satisfactory.

Placement of the floor vapour barrier requires consideration. This is one of the few cases where vapour flow is continuous and uni-directional.

3.3.4 Slab-on-Grade Situations:

The slab is the lower floor. Carpet finish would be suitable. Elsewhere, a special effort to raise the floor temperature would be necessary for acceptable comfort.

3.4 ROOF CONSTRUCTION

3.4.1 Pitched and Flat Roofs:

Pitched roofs using trusses permit longer spans and require less lumber than flat roofs. Clear spans enable increased planning flexibility of interior partitions.

Low pitch roofs usually produce more ice dam formation, with leakage into the building if the membrane is not an impervious type. If a slope of less than 1 in 3 must be used, an impervious membrane system would be necessary.

The reason that "low slope" shingles should not be used is that the manufacturer's application requirements imply that the use of the application cement will result in a homogenous, impervious layer; but in practice the inevitable gaps and cracks do not seal out water which has backed up from an ice dam.

3.5 SERVICES

3.5.1 Mechanical Services:

Services and service spaces should be standardized so that the basic components for all house types are similar.

Houses should be able to improve or expand without changing the basic service component.

All mechanical services should be grouped into a common service space so as to effectively minimize materials and labour.

A vertical service space could include:

- -heating supply ducts;
- -return air ducts;
- -chimney;
- -plumbing stack;
- -vent pipes and ducts;
- -water supply;
- -electrical risers.

Penetration of stacks through the roof membrane should preferably occur in one location. This would be an extension of the service space. The problem of snow blockage of plumbing vents would also be minimized. An effective air/vapour seal is required at the ceiling. The desirability of also adding a roof vent to this common stack should be considered.

A fresh air intake for forced air systems should be provided, suitably located away from flues and exhausts.

The heating system will depend on the project location. Where a piped service system is used, heating will probably be by a hot water convector system, using a heat exchanger.

Where there is no piped service system, an oil-fired furnace is the usual heating method. This system provides for better ventilation control than a hot water system. See also paragraph 3.6.1.

Where no piped service system is used, water supply may be by truck delivery to a storage tank in the house. Sewage disposal using storage tanks for pump-out removal by truck will probably become more standard in the future. At present, plastic bags are commonly used for toilet sewage, with sink and bath wastes run to adjacent exterior grade, or overflowing to grade from storage tanks when tanks are not large enough, or when collection is not frequent enough.

Hot water tanks should have a minimum capacity of 180 litres.

Insulate stacks and ducts passing through an unheated space to prevent condensation due to temperature reduction caused by conductive heat loss.

Insulate exhaust ducts to prevent condensation caused by backdraft cooling when fans are not operating.

The floor area adjacent to entrances should receive a heat supply designed to melt and evaporate tracked snow, and provide warmth for outdoor clothing and boots.

3.5.2. Electrical Services:

The service space simplifies vertical distribution.

Keep electrical fixtures and outlets off exterior walls where possible. Problems are encountered with obtaining a satisfactory air/vapour seal. If outlets must be located at an exterior wall, consider surface mounted outlets for lights and floor mounted duplex receptables.

There should be no penetration of the ceiling air/vapour barrier. All fixtures on upper floors should be mounted on interior walls where possible.

3.6 GENERAL COMMENTARY

3.6.1 Ventilation:

There is very little requirement for additional winter ventilation for normal occupancy use where heating is by a forced air system having a fresh air intake into the return air ducting.

Mechanical exhaust from kitchen range, kitchen and bathroom should be considered. Summer and winter ventilation is then controllable, not reliant upon wind.

With mechanical exhausting, warmed make-up air should be provided if a forced air heating system is not used. This may require insulated intake ducting, with protection from snow entry or snow melting in the duct, a freeze-proof heat exchanger, and ducting to outlet grilles near the ceiling of living rooms. Lower grilles may be theoretically better located, but unless the intake air is warmed to above room temperature, the grilles would probably be blocked off by the occupants.

3.6.2 Air Moisture Content:

Except when a large number of people congregate, or during some cooling operations (with no exhaust fan), the relative humidity (R.H.) in houses is usually very low in winter. This is due to use, and often to high infiltration. If construction is improved, and air is introduced only as required, the average R.H. will increase. The notes on ventilation are intended to provide for moisture content control.

Interior winter temperature is often held at approximately 26°C to compensate for cold drafts, low temperature corners, and body-to-cold-wall radiation. Improved standards should enable a lower temperature to be maintained.

Design simplicity is required to enable effective sealing against air infiltration. Penetrations of the sheathing require special attention.

3.6.3 Basements or Equivalent Spaces:

To improve resistance to fire spread, a non-combustible finish to walls and ceilings is considered necessary for the area used for storage, equipment, or general activity. Gypsum wallboard would meet this requirement.

In crawl spaces not used for storage, and not containing fuel burning appliances, finishes should not be necessary.

3.6.4 Technical Design Notes:

The designer should be aware that changes made from earlier standards to improve conditions may introduce new conditions which become problems that did not occur with the previous situation.

Some of the recorded problems occur only during short periods of extraordinary occupancy usage, such as the assembly of many people in a house. The users however regard such problems as significant and requiring attention. The designer may well find that practical solutions to such problems are quite complex for a housing situation, and therefore relatively expensive.

The control of air supply and humidity when the exterior temperature may remain for a considerable period at -40°C or lower, in a manner acceptable to the occupants, without requiring the posting of complex operating instructions, presents a considerable challenge.

3.7 SPECIAL CONDITIONS AFFECTING NORTHERN CONSTRUCTION

3.7.1 Organizational Aspects:

Northern construction is affected by factors which, in Southern situations, would be regarded as organizational, and within expected control of reasonably efficient contractors.

The same factors for construction in the North may require the designer/specifier to recognize the need for increased standards in order that the end product will be achieved. The end product intended may however be a basic standard.

Some of these factors are:

(a) Delivery Timing - materials are often delivered later than intended. This could result in handling and fabrication under conditions not contemplated by design.

(b) Damage in Transit - packaging and crating requirements should be clearly indicated. Specific methods should be researched and specified. Where more economic than protection, extra materials could be specified.

(c) Craftsmanship Standards - even skilled tradesmen from southern areas tend to produce a lower workmanship standard when in remote isolated areas.

(d) Site Storage Conditions - when construction is not contemplated before the beginning of winter, materials and equipment may be stored on site under very poor conditions.

3.7.2 Site Preparation:

To avoid problems which can result from the timing of the site preparation, ensure that construction scheduling makes provision for site preparation and foundation installation at the appropriate time, for example:

(a) Deep piles require time to freeze solidly in place;

(b) Gravel beds for bearing pads may require placing one year ahead to provide stabilized conditons, and also to prevent the site work delaying the construction work;

(c) Shallow piles with pads bearing on permafrost should be considered as for (b) above. The most economical excavation may be carried out in late summer after removing any surface vegetation or other insulation layer earlier in the season. Maximum natural thawing will then provide for the greatest possible depth of simple excavation. Control will be required to prevent frost damage to concrete at this late period.

The separation of technical design from technical standards in this report is intended to facilitate its use and for easier referencing. Although there may be some subject matter appearing in both sub-divisions, the following standards are intended to provide more specific direction with respect to construction methods and requirements.

SECTION 4 TECHNICAL STANDARDS

TABLE OF CONTENTS

4.1 CONSTRUCTION ELEMENTS

4.1.1 Roofs:

Avoid flat roofs using built-up felt and gravel. A separate sub-trade and special equipment is required. Vented space design is not readily obtainable.

Use 4 in 12 pitch with asphalt shingles where possible. With optimum insulation and adequate ventilation, ice dam formation is minimized. Tabbing with plastic cement should be required for asphalt shingles to prevent wind damage.

Use 508 micrometres P.V.C. sheet for the eaves protection requirement in preference to the options indicated in Residential Standards. The benefits of using a membrane which remains flexible at low temperatures thereby providing sealed nail penetrations, justifies the extra material cost.

Use prefabricated trusses, sized for convenient handling, to increase speed of erection. Design trusses to accommodate the required insulation thickness, and provide for venting at eaves. Design eaves to exclude entry of wind-blown snow.

If metal cladding is used for roofing, design to prevent or accommodate snow slide.

4.1.2 Windows:

Windows should contain a maximum of fixed glazing. Ventilation should be accommodated using separate opening window vents. A better thermal performance will be achieved and condensation will be minimal. Casement or awning type vents with lever-lock operators should be satisfactory. Wood windows are recommended for good insulating qualities and ease of joint sealing.

Triple glazing should be used, either as hermetically sealed units, or as combinations. (e.g., double hermetically sealed units together with a single exterior pane). Panes should be of limited size, e.g., 600 mm x 1200 mm, for glass economy, replacement economy, and ease of handling. Pane sizes should be modular, and limited to two or three sizes only, to enable replacement stocks to be feasible.

Vinyl clad wood windows are recommended to reduce maintenance.

The use of a combination to obtain triple glazing involves a choice between best design and best practical aspects. An exterior single pane, vented enough to permit air pressure equalization, and removable for cleaning, is the best design. An interior pane with a good air seal, removable for cleaning, is more practical, since the cleaning is more likely to be performed. The exterior pane system would permit the use of plastic or polycarbonate glazing, to resist breakage from external elements where this is considered to be of importance.

To minize condensation, promote supply of heat to windows to offset heat losses by locating windows near the centre of the room wall, and locating window frames flush with the wall inside surface. Drapes will not then tend to prevent air convection. Locate windows to avoid adjacent snow depth being higher than the window sill.

Except for southern exposure or special view situations, the windows should be as small as possible. Net glass area should not exceed the minimum glass area required by Code. Reduced window area requirements are anticipated with the 1977 National Building Code revision.

Recognize that the edges of insulated glass units are thermal bridges. Anticipate higher interior air moisture content by including condensation channels to hold water run-off.

Where a window is intended to provide a secondary means of egress, the opening must be of sufficient size, the window operator must not obstruct passage, and screens must be designed for fail-safe removal. This becomes of increased significance if sliding windows are not used, and windows are triple glazed, as recommended.

4.1.3 Exterior Doors:

Insulated metal exterior residential doors should be used. Storm screen doors are not usually satisfactory. The exterior door should open in. Screened venting may be accommodated in the wall adjacent to the door. As an alternative, a steel "self storing" screen door with removable pins could be provided for summer use, with the solid door left in the open position. The screen door would be removed for the winter. A single exterior door is satisfactory if design provides an air lock space between the door and a living area.

Where a secondary means of egress is provided by the use of a door, an air lock should be provided if possible. Where not feasible, the door should be double weather-stripped and the opening provided with a strong storm-screen door. This outer door should be able to swing in or out. Some pioneer design may be necessary to produce a practical solution to this requirement.

Second doors are a problem because they may not be used in winter unless an emergency arises. If unopenable due to ice, deep hard snow, or frozen hardware, they fail to serve their purpose.

Any door which is not protected from blowing snow is prone to damage if snow becomes packed in the frame rebate, and the hinges are strained. This condition could be avoided by a design approach which places the door (enlarged) against the frame instead of in a rebate.

4.1.4 Exterior Finishes:

Low-maintenance cladding should be used as a general rule, although stained wood siding is suitable in the larger centres. Pre-painted metal siding is preferable in remote locations. Cladding of asbestos-cement shingles or siding is more subject to damage.

Metal siding should be treated as a "rain-screen" cladding. Trim members at top and bottom should shed water, but not be sealed. Any moisture within the wall construction (from air leakage due to imperfect installation of the air/vapour barrier for example) will be able to permeate and evaporate to the exterior.

The above note with respect to metal siding is also applicable to other exterior surfacings, and to the building paper, which is a moisture barrier, and not to be a vapour barrier. Installation of the interior air/vapour barrier will never be perfect, but problems of condensation will not arise if the vapour flow from the wall to the exterior can carry sufficient moisture to exceed the flow into the wall from the interior.

Darker coloured finish on south exposure will absorb solar radiation and reduce heat losses during sunshine hours.

A light coloured finish on the south exposure will reflect solar radiation heat to the adjacent ground surface, which would increase the depth of the active permafrost layer, unless an insulating pad is used.

4.1.5 Insulation:

Present energy cost in the North justifies the use of the maximum practical quantity of insulation. Future projection of fuel cost indicates that increased insulation, up to the level where an increased quantity shows a relatively low improvement in thermal value, can be considered as an investment.

The National Research Council is preparing a publication on the subject of proposed guidelines for energy conservation in new buildings. The insulation values recommended in this report are consistent with the N.R.C. proposals.

To accommodate additional wall insulation, wall framing using 38 mm x 140 mm wood studs at 600 mm O.C. is suggested.

Films which use reflecting surfaces as the insulation system require open air spaces for their efficiency. These have not proved satisfactory for northern requirements.

Batt type insulation which completely fills spaces between framing members is satisfactory, and is usually the most economical.

Where basements are provided, it is good practice to place a thin layer of batt-type insulation between the underside of the wood sill and the top of the concrete basement wall prior to bolting down the wood sill. This layer of insulation helps to take up irregularities in the concrete surface as well as reducing air infiltration/exfiltration.

4.1.6 Air Infiltration:

Air infiltration can be responsible for a considerable amount of the heat losses for a small house. Prevent heat loss caused by air flow through the insulation by caulking the joints of exterior sheathing, and any penetrations passing through the exterior sheathing.

4.1.7 Air Exfiltration:

The air/vapour barrier is designed to prevent air leakage and vapour permeation. The permeation aspect is usually adequate, as the vapour quantity involved is relatively low, and requirements are met by conventional materials and workmanship.

Air leakage is an entirely different situation. It is probable that the majority of condensation and ice problems which have occurred inside walls and in roof spaces are due to air leakage.

Problems are still occurring, even when air/vapour bariers are specified and indicated on the drawings. Some of the reasons for this are:

a) The designer makes blanket requirements which would require a high degree of skill, and considerable extra installation time by the installer. As an example, "vapour barrier must be continuous" may be a correct requirement, but the methods for achieving this will not likely be included in a tender, or carried out by the installer, unless covered by specific descriptions and details for all the varied situations, and closely inspected on the site.

b) In Southern housing construction, discontinuity of the air/vapour barrier at floors is the usual practice. Due to tight-fitting joints and sheathings, the result is usually satisfactory, or at least tolerable. There has consequently been little attention directed at this aspect. Designers are not identifying this as a problem situation in residential construction, and contractors do not consider such construction as inadequate in the South.

4.1.8 Hardware:

Exterior hardware should be medium duty type to minimize frequent maintenance. CGSG Specification 69GP3.

Locking hardware should be of easily available stock to enable replacement as necessary.

Exterior door handles of the lever type would permit easier operation with heavy mitts.

Exterior knob-type locksets should have the maximum knob setback to permit easier operation with heavy mitts.

Interior hardware to CGSB 69GP4.

4.2 GENERAL REQUIREMENTS

4.2.1 N.R.C. Publications:

Technical design must conform to the principles developed by research, including the following publications of the National Research Council:

CBD 16	Thermal Insulation in Dwellings
CBD 23	Air Leakage in Building
CBD 36	Temperature Gradients through Building Envelopes
CBD 37	Snow Loads on Roofs
CBD 42	Humidifed Buildings
CBD 64	Pemafrost and foundations
CBD 89	Ice on Roofs
CBD 72	Control of Air Leakage is Important
CBD 128	Adfreezing and Frost Heaving of Foundations
CBD 146	Control of Snow Drifting about Buildings
CBD 175	Vapour Barriers: What are they? Are they effective?

4.2.2 Miscellaneous Items:

4.2.2.1 Resilient Flooring:

Vinyl asbestos tile has not performed satisfactorily in some cases. With improved construction and design, the material may not exhibit the shrinkage and delamination attributed to Northern Conditions. In housing, sheet vinyl would in any case be a preferred material for floor covering where carpet is not suitable. Thickness of vinyl to be 3 mm inches.

4.2.2.2 Basement Construction in Permafrost:

It may be possible to design a house basement suitable for ice-bearing permafrost ground, but the effect of site exposure during construction, unintended usage (e.g., excessive interior temperature) and like contingencies should be considered.

4.2.2.3 Sealants:

The exterior shells should be designed such that the reliance on caulking for a sealant is kept to the absolute minimum, and the caulking should be a non hardening type such as silicone-base products.

Imperial Equivalents
(for measurements shown on pages 4,5,7,13,27,31,37,40,42.)

Page	Clause	Metric amount	=	Imperial amount
4	2.1.12	760mm	=	2'-6"
5	2.1.15	RS1 in m^2	=	R in ft x ft Hr F/BTU
		RSI 3.5	=	R 20
		RSI 7.1	=	R 40
		RSI 2.1	=	R 12
		RSI 4.7	=	R 26
	2.1.17	600 x 1200mm	=	24" x 48"
7	SEE NEXT PAGE			
13		250mm	=	8"
		1067mm	=	43"
		1/30 26 m/s	=	1/30 50mph
		2.0 kN/m^2	=	42 psf
		-44°C	=	-51°F
		24°C	=	75°F
		below -18°C - 8593	=	15,634
27	3.1.4	38 x 184mm	=	2" x8"
	3.2.2	600 - 1500mm	=	2' - 5'
31	3.5.1	180 litres	=	40 gals
32	3.6.2	26°C	=	70°F
33	3.6.4	-40°C	=	-40°F
37	4.1.1	508 microns	=	20 mil
	4.1.2	600 x 1200 mm	=	24" x48"
40	4.1.5	38 140 mm	=	2" x6"
		600 mm	=	24"
42	4.2.2.1	3mm	=	.090"

(Being the Imperial equivalents of the Metric values on page 7

OPTIMUM SPACE STANDARDS

NET AREAS	UNIT	TWO PERSONS	TWO BEDROOM THREE PERSONS	THREE BEDROOM FOUR PERSONS	THREE BEDROOM FIVE PERSONS	FOUR BEDROOM SIX PERSONS
LIVING ROOM	sq.ft.	145	160	175	190	200
LIVING ROOM (When family room is in combination with living room or other space)	sq.ft.	-	200	225	230	240
DINING ROOM	sq.ft.	90	100	100	110	110
DINING ROOM (In combination)	sq.ft.	80	90	90	100	100
KITCHEN	sq.ft.	90	100	100	110	110
KITCHEN (In combination)	sq.ft.	80	90	90	100	100
KITCHEN COUNTER LENGTH	lin.ft.	10	12	12	14	16
KITCHEN CABINET STORAGE	sq.ft.	60	75	75	100	100
BATHROOM	sq.ft.	40	40	40	40	40
SECOND BATHROOM	sq.ft.	-	-	25	25	25
FAMILY ROOM	sq.ft.	-	150	150	150	175
FAMILY ROOM (In combination)	sq.ft.	-	100	100	100	120
BEDROOM 1	sq.ft.	135	135	135	135	135
BEDROOM 2	sq.ft.	-	90	110	110	110
BEDROOM 3	sq.ft.	-	-	90	90	100
BEDROOM 4	sq.ft.	-	-	-	-	90
BEDROOM CLOSETS PER PERSON	lin.ft.	4	4	4	4	4
LINEN CLOSET	sq.ft.	5	5	8	8	10
BROOM CLOSET	sq.ft.	5	5	8	8	8
UTILITY SPACE	sq.ft.	80	80	80	80	90
STORAGE SPACE - Interior	sq.ft.	90	90	90	100	110
UTILITY/STORAGE COMBINED	sq.ft.	150	150	150	165	175
COLD STORAGE - Exterior	sq.ft.	70	70	70	80	90
ENTRY	sq.ft.	25	25	25	25	25
ENTRY COATS & MISC.	sq.ft.	20	20	25	28	30

1. Net areas will be figures shown above within 10% plus or minus.

2. Total gross area shall not exceed the total net area by a factor of more than 1.4 without stairwells or 1.5 with stairwells.

INDEX