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HOUSING IN NORTHERN CANADA
SOME RECENT DEVELOPMENTS

BY

ANALYZED

H. B. DICKENS AND R. E. PLATTS

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HOUSING IN NORTHERN CANADA: SOME RECENT DEVELOPMENTS

BY H. B. DICKENS AND R. E. PLATTS*

[MS. received 11 April 1960.]

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Introduction

The northern part of Canada is probably the most isolated, sparsely populated, and inaccessible land mass in the northern hemisphere. The Yukon and Northwest Territories comprise an area of $1\frac{1}{2}$ million sq. miles and contain only 34,000 people, 8,300 of whom are Eskimo. Into this vast area only one navigable river penetrates, and the sea lanes around its perimeter are open for only three months in the year. This isolation and scarcity of people are reflected in the following comments of the Royal Commission on Canada's Economic Prospects: "In the whole of the Northwest Territories . . . the military bases, mining camps, trading posts and administrative centres are hardly more than pin-pricks in the surrounding bush and muskeg and barrens. There will be important economic development in this area in the years to come. But it would take the ruthlessness of a Peter the Great to plant any large centres of population there."

Regardless of what the future may hold, the provision of adequate shelter in these regions will continue to be a matter of basic concern. Recent activity has already stimulated considerable interest in the development of building systems and techniques designed to satisfy the special requirements of northern housing.

Contrary to popular belief, these special northern requirements do not arise because of any basic differences in the kinds of technical problems that must be met, but are dictated instead by the peculiar economic and logistic factors of the north. The northern climate is not much more severe than other cold areas of Canada such as the Prairie Provinces. It differs mainly in the duration of cold weather rather than in the extremes of temperature. This leads to the widespread existence of permafrost and so affects foundation design, but climate alone does not call for special superstructure design.¹ Conventional, insulated wood-frame construction such as has evolved in southern Canada performs satisfactorily in even severe northern exposures. Thus the search for alternative materials or building systems for the north arises not from the technical unsuitability of normal wood-frame construction but is dictated

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primarily by questions of cost; northern transport and site labour can increase conventional wood-frame house costs some two to five times over the cost of such construction in the south.

The problems of northern housing normally separate into two distinct parts: the provision of improved Eskimo housing, using self-help labour and indigenous materials where possible, with little economic pressure for minimizing site labour; and the building of new communities and civil or military bases with imported building systems, in which northern economics dictate light weight and rapid erection to reduce the very costly transportation and site labour elements.

Eskimo housing

The Department of Northern Affairs and National Resources, the Federal Government agency responsible for administration of the north of Canada, has undertaken the development of improved self-help housing for the Eskimo, and the Division of Building Research of the National Research Council has been privileged to assist with this project from time to time. The ingeniously developed shelters of the Eskimo were well suited to his earlier nomadic existence, but are not adequate for long-term occupation by settled groups, which now include the majority of these northern people. The snow igloo is at best a seasonal shelter remaining well insulated for only a few weeks; it becomes increasingly damp and cold with continued occupation and there are long cold periods in the autumn when snow is not available. Like the snow igloo, the Eskimo's tents of caribou skin and canvas and his more recent shelters of scavenged packing crates, oil drums, and cardboard are very small and damp. He cannot afford to heat large areas without improving the insulation, and often a family of three to five are accommodated in an area of only 100 sq.ft. (9 sq.m.). The very high incidence of respiratory diseases among the Eskimo has led to increasing concern about his housing, and the first developments aim at larger, better insulated and drier quarters, yet basically simple and at a cost he can afford.

The use of indigenous materials has been carefully explored as a means of meeting this cost requirement. Unfortunately, local materials are few and of limited value in constructing improved housing. Stone has poor thermal qualities. Sand and gravel require large quantities of cement before they can be made into a structural material. Timber is available only in the Mackenzie River valley in the Western Arctic and in sections of Ungava in the Eastern Arctic. There are, however, indigenous insulation materials suitable for self-help projects. Tests by the Division of Building Research have shown that caribou moss (*Cladonia* sp.) can provide insulation value almost equal to mineral wool, when dried and compressed to half its loose volume. In addition, peat sod can be used where available to build up thick walls.

Using these materials an improved Eskimo house has been developed with light rigid frames of 2 by 4 in. (5 by 10 cm.) timber supporting peat-sod exterior walls and an oiled and battened plywood roof. A plywood floor is supported on 2 by 4's directly on the ground in these huts, protected underneath with a sheet polyethylene ground cover and insulated with 4 in. (10 cm.)

of caribou moss. Walls and roof are insulated with 4 in. of caribou moss between the frames, and the interior of the hut is lined with sheet polyethylene which serves as a vapour barrier and wall finish. These owner-built sod huts, 12 by 20 ft. (4 by 6 m.), are very rudimentary, but offer marked improvement over the former primitive houses and are relatively inexpensive.

For areas where peat sod and caribou moss are not available, a light rigid framed plywood hut has been developed, in co-operation with the Plywood Manufacturers Association of British Columbia, to achieve low costs in northern-built housing with imported materials (see photograph facing p. 230). The hut uses stained plywood as roof, exterior and interior cladding, and floor, and weighs only about half as much as conventional frame huts using board sheathing and separate board siding. These huts are also supported directly on well-drained ground on a plastic ground cover. Within the floor, walls and roof, 4 in. (10 cm.) of mineral wool insulation is placed and again this is fully protected on the inside with sheet plastic vapour barriers. The cost of materials for the sod and plywood huts is \$200 and \$400 respectively.

Recent housing developments

Prefabrication. In the building of northern communities for military, commercial, and administrative groups, the high transportation and labour costs and the very short construction season favour full prefabrication to achieve minimum weight and erection time. Transport costs of over \$100 per ton by boat and 50 c. to \$1.00 per lb. by air are common, and the boat trip takes a month or more out of the already short working season of about four months. As already mentioned, these factors cause heavy wood-frame houses to cost two to five times as much in the north as do their southern counterparts. With these over-riding incentives of economics and logistics, most advances in northern housing over the past decade have been in the field of light-weight prefabrication. Prefabricated units have been developed which weigh less than half that of conventional site-built wood-frame construction and which can be erected in one-tenth the time. With good advance planning and organization on large projects, these light-weight systems allow very much reduced northern building costs.

As in southern Canada, prefabrication in the north varies from precut wood and metal systems to engineered light-weight panel systems. Northern prefabrication has, however, far outstripped southern progress. In the south, only the simple wood-frame systems have achieved any measure of use, and prefabrication in total accounts for only 2 to 3 per cent of house construction (compared to over 10 per cent in the United States). In the north the more advanced systems have largely displaced the heavier frame "prefabs", and a large share of all recent northern housing is prefabricated.

Precut systems. It is questionable whether precutting should be classed as even a degree of prefabrication, but precutting pieces to exact size in the shop is a first means of reducing on-site labour requirements, and because of this some precut systems have seen extensive northern use.

Precut log units have been popular in the "near north". These were adapted from Scandinavian practice by Canadian manufacturers, using 4-in. (10 cm.) cedar logs machined to a tongue-and-groove mating detail to form the walls, and using conventional precut floor and roof systems. These generally sound and attractive units are prohibitively heavy for "far northern" use, and the logs do not provide sufficient insulation for the high fuel cost areas of the north in comparison to insulated frame construction. Although low in first cost, their cost in place in the north is well above light-weight panel units. Weights, erection times, and cost estimates for these and other prefabricated systems discussed here are compared in the following table.

Type	Package cost in \$	Transportation		Labour and overhead		Contingencies: 30 per cent of Transport + Labour in \$	Total in \$
		Weight in tons	Cost in \$	Time in hr.	Cost in \$		
Wood-frame panel	4,600	21	3,150	120	720	1,160	9,730
Precut log	4,500	23	3,450	150	900	1,300	10,150
Typical stressed skin panel	4,900	12	1,800	60	360	650	7,750
Typical sandwich panel	9,800	10	1,500	40	240	520	12,060
Comparative site- built wood-frame house	3,600	21	3,150	700	4,200	2,200	13,150

Comparative costs of prefabricated systems in Northern Canada

These cost estimates are for finished, but unserviced, buildings of 24 by 48 ft. (7.3 by 14.6 m.) in plan, assumed to be erected on gravel pads at Frobisher, Northwest Territories.

The various metal clad, metal framed buildings are essentially precut shell systems. On the basis of first cost these metal structures appear to offer advantages over wood-frame construction, but for northern use they require the laborious fitting of insulation and application of cladding to the metal shell. This often amounts to the equivalent of building a wood-frame structure inside the shell, an operation that involves much site labour and leads to high final costs. Because of the difficulty of providing unbroken vapour barriers, extensive condensation difficulties have plagued these buildings in northern use. Although formerly used to a large extent for military operations, they cannot be considered a good prefabricated system for heated northern housing. These comments do not necessarily apply to the fully prefabricated and insulated metal skinned panel systems.

Wood-frame panel systems. Panel prefabrication has received the widest consideration for northern use. The first northern applications in the early 1940s consisted simply of conventional frame wall construction in panel form. Since the floor and roof are usually only precut, sometimes with trussed rafters, the erection time for these units is only fair and their weight is very high in comparison with the new systems. As shown in the table their cost position in the north is not favourable. In the late 1940s, wood-frame prefabs began competing with, and are now largely supplanted by, stressed skin units.

Stressed skin panel systems. The search for light-weight structures led to the development of "stressed skin" systems in the early 1930s, beginning with the stressed skin housing study of the United States Forest Products Laboratories. Stressed skin design utilizes light, strong, sheet materials as structural "skins" (usually plywoods), which are bonded to stabilizing wood webs to form an enclosed panel. These panels can act efficiently in either edge compression or in bending, and when insulated and coated they serve as complete structural wall panels as well as floor and roof panels for relatively long spans. They are usually 4 ft. wide and 8 to 12 ft. long (1.2 m. by 2.4 to 3.7 m.). They are normally insulated with mineral wool and are 3 to 4 in. thick (10 cm.) for northern use to provide sufficient thermal value² (Fig. 1). With appropriate jointing details they may quickly form finished buildings of one or two stories.

Fig. 1. Stressed skin panel.

Introduced throughout most of the north from 1945 to 1950, they have been used in nearly all northern projects to form military barracks, airport buildings, commercial and administration housing and offices, radar line buildings, schools, hospitals and whole towns. To date, these stressed skin units have best met the economic factors in northern housing and have also given satisfactory technical performance. A typical stressed skin assembly is shown in Fig. 2. These and other panel units are usually sited on gravel pads on the permafrost, or on wood piles which are steamed or drilled into the permafrost.

From the first, stressed skin panels have depended on the plastic resin adhesives (phenolics, resorcinols, or ureas) to provide long-term bonding. The development of these and other plastic adhesives, and the further development of light plastic core materials, has led to recent utilization of the stressed skin concept in the form of "sandwich panels".

Structural sandwich systems. The structural sandwich concept also uses light load-bearing skins (plywoods, hardboards, asbestos boards, or metals) in stressed skin action, but here full-size "cores" are used to stabilize the skins more efficiently and at the same time act as insulation (Fig. 3). These core materials are now usually paper-plastic "honeycombs", or foamed polystyrene or polyurethane plastics. Sandwich developments began with the famous British "Mosquito" bomber aircraft, and it was soon realized that the

Fig. 2. Stressed skin panel assembly.

Rigid frame plyhood hut.

Plastic sandwich panel unit.

Some recent developments of housing in northern Canada.

Photographs by Division of Building Research, National Research Council

sandwich is the most efficient possible structural form for either bending or edge compression loading.

In 1950 the United States Navy erected the first sandwich units in the north, using structural floor, wall, and roof panels with thin aluminium skins bonded to paper-plastic honeycomb cores. The weight of these Arctic huts, 24 by 48 ft. (7 by 14.5 m.), would be under 6 tons (5,450 kg.), as against 10 tons (9,070 kg.) for the plywood skinned sandwich units now used in the north, 12 tons (1,090 kg.) for the plywood stressed skin units, and 21 tons (1,900 kg.) for conventional wood-frame units. Transportation savings are obvious.

Fig. 3. Sandwich panel.

Current Canadian developments involve $\frac{5}{16}$ in. (0.8 cm.) plywood skins bonded to a 4-in. thick (10 cm.) foam polystyrene core for wall, roof, and floor panels with a special metal "cam-lock" panel connector. Such connexions permit fast panel erection using only an "Allen" wrench, about half the time required for stressed skin construction using bolted T and batten or splined connexions. A typical building is shown in the photograph facing p. 230. Although these panels achieve very efficient use of materials, their first cost has remained high, about twice that of stressed skin units.

As shown in the table (see p. 226), the somewhat reduced weight and erection time of these technically sound sandwich units do not offset their initial high cost in northern use. United States manufacturers claim that with new manufacturing processes these types of sandwiches are now competitive in first cost with wood-frame or stressed-skin systems. If volume production proves this in Canada, the light sandwich systems should assume a larger share of the northern market.

Conclusion

Although cost is a major determining factor in the selection of northern buildings, and has been a prime concern in this discussion, it is also essential that each building system used in the north be technically adequate for cold weather conditions. The system must provide, in addition to strength and rigidity, resistance to heat flow, water vapour flow, liquid water movement, and fire. The prefabricated panels can individually meet these requirements, but the final performance of the structure is dependent on satisfactory joint

details, and these have often proved difficult. In recognition of the importance of total prefabrication in meeting the problem of northern building, the Division of Building Research has recently completed detailed studies of the currently available systems, the results of which will shortly be published in a technical paper. It is evident that the light-weight systems can meet these performance requirements. In addition, their modular panel design makes them adaptable to any type of building with flexibility in layout, window placement and appearance, and the low final cost of the stressed skin units in particular makes these, and further evolving systems, attractive in the establishment of communities in the north of Canada.

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