MISAWA HOMES INSTITUTE OF RESEARCH & DEVELOPMENT
TECHNICAL REPORT
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南極の住宅

HOUSING IN THE ANTARCTIC

夏の昭和基地全景　complete view of the Showa base on Ongle Island

設計条件

当総合研究所で初めて「南極の家」に取組むこととなったのは、越冬住宅として居住棟とヘリコプター格納庫の重要な部分を占めるパネル製作を担当することとなったことからです。

この越冬住宅は、文部省の発注により日本大学斎藤研究室で設計を行い、当方はその本体工事のパネル製作を行うこととなりました。

この建物の設計条件としては、1)南極まで及びその他の輸送に関する条件、2)南極における気象条件、3)現地における建設に関する条件、4)現地でそれを使用する条件など大きく4つに分けられます。

1)輸送条件

基地までの約2ヶ月間の船による震動、温度、湿度等の変化に耐え、またヘリコプターの空輸に備え形状は1.5M×5.0Mを限度とし、重量は100kg前後としなければなりません。

2)気象条件

最大風速は60M/sec、積雪は　建物の風下側にはスノードリフト（吹き溜り）が著しいが屋根面にはなく、また、気温は　冬季最低－50℃、夏季平均－15℃～＋5℃、湿度はR.H.45～80%です。

3)建設条件

素人の20名程度の隊員が容易に組立てられなおかつ所定の強度等が維持されなければなりません。また、組立に際してクレーン車も使用できますが、万一の場合は人力でも可能なこととし、約30日間で完成させなければなりません。一方敷地の状態が悪くても可能とし、接合方法はできる限り簡便にしなければなりません。

4)使用条件

使用目的に応じた機能が完全に発揮され、また、荒涼とした南極で一年間の越冬生活を過ごす隊員に人間的なかつ、快適な空間を提供しなければなりません。なお安全性の問題として、火災時の延焼に耐えられるようにもしなければなりません。

DESIGN CONDITIONS

Specifically, we were charged with the responsibility of manufacturing the panels needed for the construction of these houses and buildings.

The members' houses, in order to meet the various climatic requirements, were to be designed by the Saito. Research Institute of Nihon University with a subsidy granted by the Ministry of Education. Misawa Homes then took charge of manufacturing the panels to make the construction of the designed units possible.

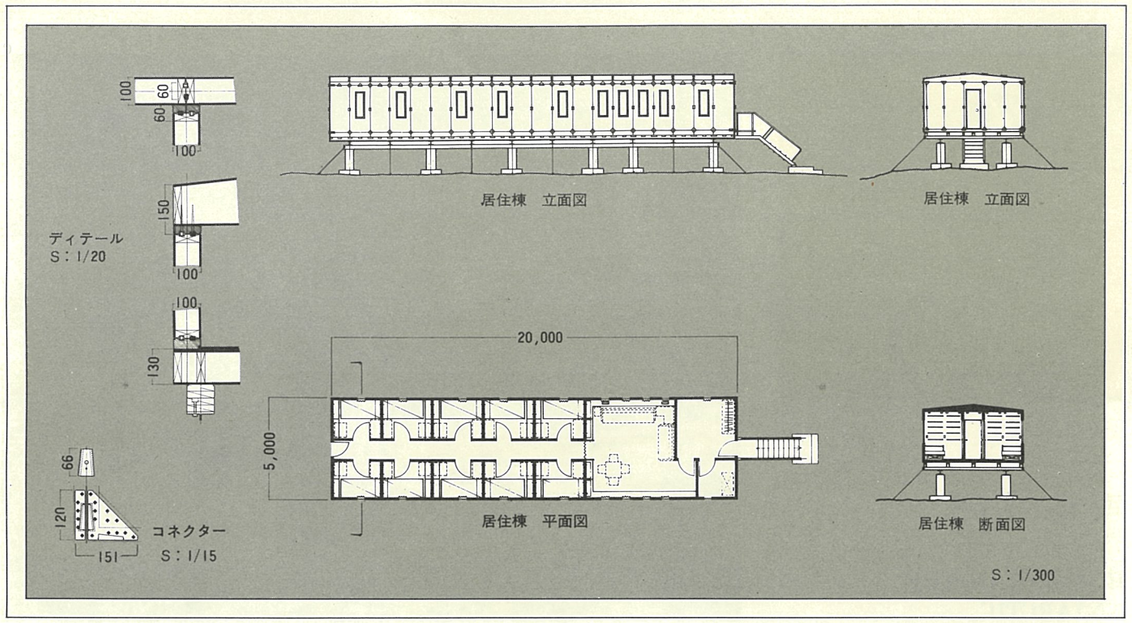
Design conditions of such buildings can largely be classified into four categories: 1) Conditions concerning the transportation of materials to the Antarctic. 2) Climatic conditions in the Antarctic. 3) Conditions concerning the erection of buildings in the Antarctic. 4) Conditions in connection with the use of these buildings in the Antarctic.

1) Conditions relating to transportation:
The materials must stand a voyage of about two months, with vibrations, and a great change of temperature and humidity in transit, as well as air transport by helicopter in the Antarctic. To meet these requirements, the maximum size of the panels was limited to 1.5m x 5.0m, with a maximum weight of about 100kg.

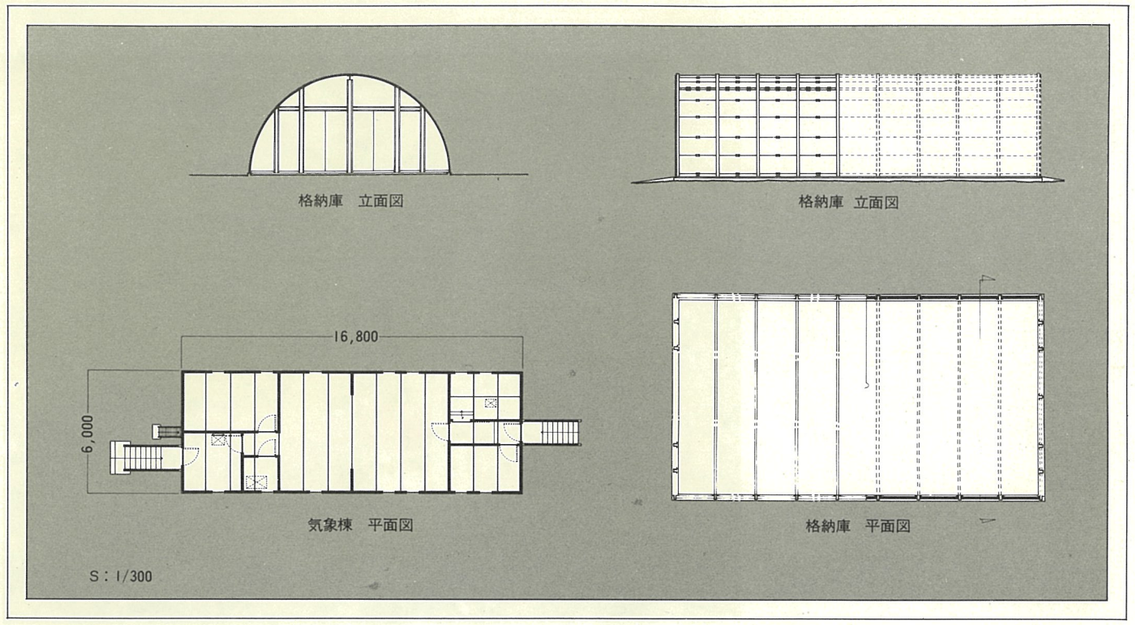
2) Climatic conditions:
The maximum wind velocity is 60M/sec. There is thus considerable drifting of snow to the leeward of buildings but no snow accumulation on their roofs. The lowest temperature in winter is −50°C and the average temperature in summer is between −15°C and +5°C. Humidity ranges R.H. 45%–80%.

3) Conditions of construction:
The houses must be easily assembled by about 20 members of the research group while still maintaining the necessary strength factors. Mobile cranes are available for use, but basically these houses must be prefabricated so that they can be assembled by manual labor within a period of approximately 30 days. The worst possible site conditions must be taken into account so that connections and joints must be as simple as possible.

4) Conditions of use:
The houses must function so as to meet the needs and requirements of the people living in them, and must provide these people with a humanistic and comfortable space, for the inhabitants are to spend one winter in the desolate Antarctic. For safety, the buildings must be completely fireproof to prevent the spread of flames in case of a blaze.



居住棟の立面図、平面図、断面図及びディテール　dwelling unit's elevation, plan and sectional details



気象棟の平面図及びヘリコプター格納庫の平面図と立面図　weather observatory's plan and hangar plan, elvation

方針と計画

パネルシステムの材料として、各種のものが検討されましたが、金属材料は不燃性ではあるが、内外温度差が大きいことを考えると、熱伝導の大きい鉄骨フレームは冷媒となって結露を起す心配があり木材を主体として考えることとなりました。しかし木材は、それ自身難燃処理を施しても防火性が劣ることから、表面の仕上材で不燃化をはかることとしました。ヘリコプター格納庫は、その用途上暖房が不要であり、かつ大スパンを必要とすることから居住棟とは別のシステムで行うこととし、鉄骨アーチにパネルを組込んで行く低床式としました。

パネル構造

この構造におけるパネルは、あらゆる外力に対して抵抗させるための構造強度の検討と同時に、防火性、断熱性また、ジョイント数による累積誤差を少なくするため、パネルの大型化かつ、軽量（約100kg前後）としなければならない等の理由により、木製枠の両面に合板を接着したサンドイッチパネルを構造のベースとして、それぞれの部位、用途に対応する処置を施したパネルとしました。このパネルは、まずカナダ産の針葉樹（スプルース）の無節材で、くるいのないよう含水率を7％とした材を格子状に組み、その内面に6㎜の難燃、耐水合板をエポキシ樹脂接着剤で接着したものに、ジョイント用の結合材をさらに接着します。この結合材は、現地での組立てに際して、ジョイント方法を簡便にするためのコネクターの接合作業が同一面上で行えるようにあらかじめ受け部分をパネル裏面に取り付けます。また壁及び屋根パネルの外装面に、カラー鉄板＃28を接着し、さらに外部に面する床、壁、屋根パネルには、断熱材（スタイロフォーム）を充填します。これらのサンドイッチパネルの表面合板は、構造的にも重要なもので、ウェッブの役をなしており、木材の格子骨組との接着については、接着剤の選定、プレス、木材の乾燥等の点で特に注意をはらって行なわれ、ミサワホーム松本工場において製作されました。

パネル形状

パネルは床、壁、屋根用の三種類があり、パネル寸法は

単位㎜	厚さ	巾	長さ
床パネル	130	1,000	5,000
壁パネル	100	1,000	2,340
屋根パネル	150~400	500	5,000

であり、この屋根パネルはスパン方向に中間継手なしに架け渡されており、中間に支持点を必要としません。この利点としては次の五項目があげられます。

(1)スパン方向に累積誤差を生じない。
(2)天井高が一定し、有効的に使える。
(3)内部空間の自由度が増す。
(4)雨仕舞が簡単となる。
(5)継手が少なく、作業性が良くなる。

接合方法

基礎は現場打ちのコンクリート基礎で、この上部にジャッキを取付け、これに鉄骨の架構（上部の基礎・土台の役目をする）を行い、レベル調整の後、ジャッキは基礎に埋込んでしまう。

これに100×50㎜の結合木材をボルト締めし、床パネルの結合材部分とをコネクターにて緊結する。同様に、床と床、床と壁、壁と屋根のそれぞれについて順次コネクターにて緊結していく。このコネクターは、前もってパネルまたは、パネルの結合材部分にビスで取付けられている受部分と、この受部分を相互に引き寄せるカバー部分より成っており、このカバー部分を打ち込むことによって、パネル相互の木口部分が密着することになる。またパネルの周辺木口には、凸と凹の加工が施されており、更に気密性を良くするために、クロロプレンゴムのエアタイト材が、装填されています。雨仕舞としては、組立完了後、パネルの目地部分にシリコン系のコーキング剤を充填します。

POLICY AND PLANNING

The principle of prefabricating houses is to provide units of standard specifications and quality large quantities. However, in order to meet the local customs and climatic conditions of any particular site, the prefab manufacturer must consider all possible site conditions before drawing up his standard specifications for production. He cannot dismiss any single natural phenomenon which might take place, even if only for one short moment over a period of many years, as long as this phenomenon is considered to influence human living to some degree. Thus the erection of these Misawa units in the Antarctic was seen as a valuable test for the Misawa System as a whole. All the foregoing conditions were carefully studied, and it was decided to adopt a complete prefabrication system for the Showa buildings. The houses for the expedition members were designed to have an elevated floor using a wooden panel system to combat the snow drifts. One possibility which was studied was the use of materials other than wood for the floor. Metal is non-flammable, but steel frames have a larger rate of heat transmission that is apt to cause frosting in a building which is exposed to a great interior-exterior temperature differential. Wood materials are highly flammable and, even if treated with a fire-proofing agent, their flame-spread rating cannot be brought to zero. Hence, it has been decided that a non-flammable surface finish is necessary to increase the fire resistance of the wood panels. As for the helicopter hangers, they need much more space but there is no need for interior heating. For this reason, a different system was incorporated, using steel frame arches with built-in panels, along with a low floor.

THE STRUCTURE OF PANELS

Each panel must resist all kinds of exterior loads, must be non-flammable, and also must have insulation properties. In order to reduce the cumulative error resulting from the number of joints, the panel must have a comparatively large size, yet weigh no more than 100kg or so. These factors contributed to Misawa Homes' choice of a sandwich type panel (plywood pieces glued to both sides of a wooden frame) as the chief building component. These sandwich panels can be slightly modified depending upon their particular functions.

The panel uses knot-free Canadian Spruce with a moisture content of 7% to avoid warping. Spruce members are assembled to form a grid, to which 6mm plywood that has been fire and water-proofed is glued with an epoxy-resin adhesive. The panel to panel joints are also glued. To facilitate assembly on-site, these joints also have connectors that permit the panels to be joined on any working level.

The exterior surfaces of exterior wall and roof panels are sheathed with Color Steel #28. The floor, wall and roof panels which are exposed to the outer air are also filled with insulation material (Styrofoam).

The plywood comprising the surface of the stress skin panels structurally unique, serving the function of a web. The surface plywood is glued to the wooden grid core by a special adhesive agent, and then the panels are subjected to pressure and are cured. The production of these panels was undertaken by the Matsumoto Plant of Misawa Homes.

THE SHAPES OF THE PANELS

There are three kinds of panels; floor, wall, and roof, each having the following sizes:

	Thickness mm	Width mm	Length mm
Floor panel	130	1000	5000
Wall panel	100	1000	2340
Roof panel	150~400	500	5000

The roof panels are laid in the direction of the span without midway joints, and do not require any support in the middle. The advantages of this system are:

(1) No cumulative error in the direction of the span
(2) The height of the ceiling is uniformly level, adding convenience to the use of space.
(3) More freedom in the use of interior space
(4) A simpler system can be adopted for conduits.
(5) With a smaller number of joints, workability improves.

THE METHOD OF CONNECTIONS

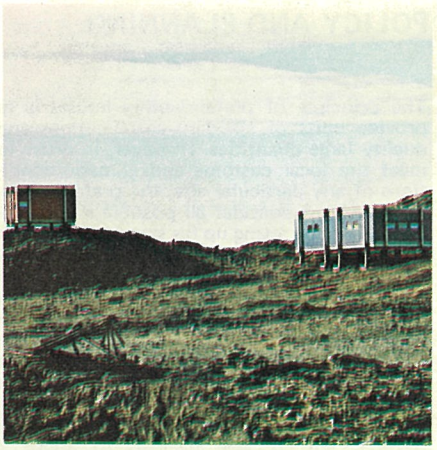
The reinforced-concrete foundation must be constructed on-site. Jacks installed in the foundation will telescope into steel frames that comprise the upper foundation and base for construction. After adjustments to assure that the foundation is level, the Jacks will be buried in the concrete. Wooden joints of 100 x 50mm each are tightened to the steel frame with bolts and are tied to the joints of the floor panels by means of connectors. In a similar manner, floor to floor, floor to wall, and wall to roof joints are carried out, in that particular order.

These joint connectors consist of two parts: one is the female of "receiving part" which is screwed to the connecting portion of the panel, and the other is the male or "inserting part" that pulls the "receiving parts" together. Thus, by driving the "inserting part" into the run created by the "receiving crafts" of adjoining panels, all the wooden parts of the panels are held tightly together. The perimeter of each panel has runs to match the runs on the edges of other panels and, to ensure air-tighteness, these runs are stuffed with a Chloroprene Rubber Air-Tightening agent. To prevent rain leakage, the panel to panel joints are also filled with a silicone-type caulking material.

基地の航空写真 aerial view of the base

国内での格納庫の組立テスト風景
the trial erection of a hanger in Japan

ロケット発射台と組立調整室
rocket launch and control unit



左の建物はレーダーテレメーター、右手の建物はコントロールセンター
radar-telemeter:left, control center:right

今後の展望

プレハブ住宅が普及するにつれて、その建設地も拡大していくこととなり、ここで、その地方の慣習、気象条件等の独自性を、どのように生かしていくかが問題となってきます。

前頁で南極の住宅の設計の概要を述べましたが、これらの技術は、他の開発に役立つものを多く含んでおり、また、このものの構造的なベースとなっているパネルは、実際以前から行なわれているタイプのものとほとんど同じであり、別な観点から、その理論の正しさを証明する結果となりました。昭和42年の第９次南極観測隊から現在までに、第９次として居住棟１、ヘリコプター格納庫１、第10次として、居住棟、ロケット組立調整室、レーダーテレメーター室、コントロール室各１棟づつ、第14次として、気象棟１、計７棟を建設いたしました。

FUTURE DEVELOPMENT

In the above, we have outlined the designs of the building in the Antarctic. Many of the techniques involved will also be effectively used in other projects. The panels used here, however, are basically similar to the ones that are widely in use already. In other words, the panels we have been using for conventional prefabricated housing are justifiable, both theoretically and logically. Starting with the supply of buildings for the 9th Antarctic Research Corps, one living unit and one helicopter hangar, Misawa Homes has to date supplied the following units for Antarctic projects: for the 10th Research Corps, one living unit, one rocket assembly adjustment plant, one radar-telemetery room, and one control room; and for the 14th Antarctic Research Corps, one weather observatory building. Altogether, seven Misawa buildings have been erected in Antarctic conditions.