Review Report

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"What are the recent influences on the physical construction (distinct from services) of human habitat systems (HHS,s), in Antarctica?"

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Abstract

Human survival in Antarctica is intertwined with the ability to get shelter from the elements. History has also shown that these "Human Habitat Systems" (HHS's) have changed over time.

The Unique geo political system in Antarctica has given rise to agreement's and associated obligations for anyone that wishes to be active in the continent. The agreement of consideration in construction of HHS's is "The Protocol On Environmental Protection" (1998). This agreement underlies the other factors which have influenced construction of HHS's since 1998.

Physical conditions in Antarctica continue to impact on style of construction. The positioning of the building and height at the actual site are given consideration. So to have the insulating fire resistant properties of the HHS. Thick walls with insulating and fire retardant panels enclose an interior that is largely geared for the scientific endeavor particular to the HHS. None the less the scientific program must bow to the logistics of transport to and construction in Antarctica. In this respect prefabrication and size constraints have had an impact.

The recent constructions are seen to be generally constructed with a minimum 25 year life.

And the individuals that live within HHS's have conditions that are approaching "normality" when compared to conditions outside Antarctica. With individual well being having an influence on design. However the exteriors of the constructions show less flare, and this reflects the dominance of the functionality of the HHS in Antarctica.

Introduction

The construction of human habitat systems in Antarctica are far removed from the early now historic huts of the heroic age. When looking at that era there is an assumption that the HHS was a bastion for the survival of its occupants and these were the considerations in their construction. In looking at more recent HHS's it becomes obvious that other considerations have been included, but to what extent and for what reasons? These influences are looked at and presented as headings for consideration.

There are now over 40 scientific bases in Antarctica (Dept Conservation Te Papa Atawhai, 2003 : 11), with still more in the planning and construction. Those in the planning include: a base by the Czech Republic (a draft Comprehensive Environmental Evaluation (CEE) has only just been released). Bases in construction include: the new Amundsen Scott Base by the United States at the South pole and a combined effort by France and Italy (Concordia), at Dome C. The recent human habitats have a greater permanence about them than those early huts of the heroic era. Indeed McMurdo station in the summer months can house over 1100 personnel and resembles a small town. These structures need to perform a number of functions not the least being to house personnel over the Antarctic winter (in some cases). Bearing these points in mind, this report reviews some of the latest thinking regarding technologies available, and the change in human thought over time. It addresses the question. What factors are influencing the physical construction of Human Habitation Systems (HHSs), excluding services?

Influence of legal obligations

"There are no one set of laws and regulations that govern the Antarctic region" (Day, 2003 : 4). There are however agreements. It is within these agreements that one needs to look, when dealing with any obligations to a code to constructing a Human Habitat System (HHS). Individual countries also will operate to their own laws and regulations within these agreements. New Zealand for example, will comply with the New Zealand Building Act (1991) and increase tolerance levels where necessary (refer to fire security heading).

Within the Antarctic agreements, there is no specific agreement which relates to a code for HHS's. There is however an obligation for protection of the environment under the "Protocol on Environmental Protection' (1998). This is of interest when considering HHS's constructed prior to 1998.

Under the protocol HHS's will need to consider the following restriction concerning human activity in Antarctica: An environmental evaluation will need to be conducted in line with the human activity". The evaluation required varies in accordance with the perceived level of impact. Minor impact requires a preliminary evaluation (PEE), moderate impact requires an initial evaluation (IEE) and significant impacts require a comprehensive evaluation (CEE). The environmental evaluations must be made public apart from the PEE and IEE. The Antarctic Committee for Environmental Protection takes all CEE submissions and makes comment on them.

In conclusion, there are agreement considerations to be made, and an individual country also has its own regulations to be considered in constructing HHS's. All new HHS's often referred to as bases are seen as being required to produce a CEE as per the Czech Republic draft (MECR, 2003).

Site Influences

The choice of site has and still influences the design strategy. A solid base and preferably a level site appear to be preferred. With design preference being to have structures on legs (see Heading: Influences of structure position and logistic influences), there is less wastage in pile height on level sites. This is one of the problems at the U.S Palmer station where finding a level site is a major challenge (Antarctic Sun, 16 Nov 2003, Article A : 10). The proposed Czech base at James Ross Island was influenced by the solid subsoil and minimal need for landscaping i.e. the contour was largely flat. The norm for HHS's in the coastal area of Antarctica is to have them founded on solid substrate with piles anchoring into the substrate. This has been the preference of the Australian construction services (Incoll, 1990B : 6). Earlier anchoring devices saw some structures on slabs, held in position by guy ropes. However for HHS's in the interior the sites provide different challenges. Here the challenge is to avoid the HHS from sinking into the snow or ice field with few sites having solid substrate. For example the 1st U.S Amunsden Scott base at the Sth Pole constructed in 1957 is now under ten meters of snow and has drifted 1km from its original site. It will eventually be crushed. In 1971 a geodesic dome was constructed as replacement and by 1985 the same problem was being seen. By 1991 it was already partially buried. A recent answer to this problem is to have the HHS on legs that can be jacked up as time demands. The Concordia HHS at dome C is like the new U.S HHS at the South Pole (due for completion in 2005). It has legs which can be jacked up and the estimation is that it will be raised every 10 years (JNZAS, 2003A : 26).

The orientation of buildings and size has been more recently affected by the flora and fauna at the site. This shows the impact of the Protocol on Environmental Protection (ratified in 1998) on construction considerations. Concordia planning points to the Dome C environment as being "abiotic in the strictest sense of the term" (CRTAF, 1992 : 12). The Czech CEE makes the following comment: "the stations construction and operation might locally disturb or kill the stands of these plants. Never the less the impact is local" (MECR, 2003 : 19). The Ministry for the Environment of the Czech Republic (MECR) refer to plant life as sporadic clumps of *Deschampsia Antarctica*, growths of mosses, algae, and lichens (MECR, 2003 : 19). It will be interesting to see what recommendations the Antarctic Committee for Environment Protection makes on this. It is worth noting that past structure orientations (prior to 1998) saw HHS's located in the middle of penguin colonies (Benninghoff & Bonner, 1985 : 39). The only suggestion noted for allowing an HHS to be constructed in a delicate site was to have any flora or fauna re located. To be considered, will be obvious survival difficulties for the flora and fauna with this re location.

The influence of scientific endeavors

There is a high degree of functionality about the various HHS's. By this it is meant, the buildings serve the endeavors that are occurring within them, and at times give glimpses of the particular research occurring there.

Apart from occasional accommodation of dignitaries and other casual visitors, the prime purpose of most HHS's is to forward scientific research. Consequently the physicality of the HHS needs to accommodate the apparatus and laboratories unique to the research. Concordia for example is at present focusing on glaciological work and also astrological studies. With this are requirement's for celestial viewing. The Japanese program as early as 1962 considered the sciences seriously in their construction needs. "Special types of measuring apparatus need to be brought into the building for the purpose of Antarctic research" (Futami, Minow & Hida, 1962 : 1). The U.S Palmer base leans towards biological studies with the site noted as superb for this endeavor (JNZAS, 2003 : 54). While the new Amunsden Scott base has a major project dealing with neutrinos, and the associated ice cube project. This project requires a range of antennae and "dish" to be housed /constructed. The dish incorporates analog and digital telephony. Further projects include 11 associated with astrophysics and cosmology alone, these all having impact on the upgrading of older structures and construction of the new facility.

Influence's of structure position and logistic influences

The trend is for HHS's to be built above ground on legs. It appears that a major problem in the Antarctic environment is the accumulation of snow drift. With structures on legs, the snow has less of a structure to adhere to on the leeward side.

Roof slope need not be steep, one suggestion is 5 degrees (MECR, 2003 :12) as the snow is easily and continually blasted off and steeper pitched roof lines act as a sail area or barrier to wind. Consequently advice for Australian structures suggests no need for designs to allow for snow shedding (CRTAF, 1992 : 5). However alcoves and recesses should be avoided as they collect snow drift. Rectangular buildings with exits at right angles to the wind and the shortest wall facing the wind appear to be the accepted theory. The new Amunsden Scott base HHS specifically orientates the building's short side into the prevailing wind.

Of consideration also in building is the orientation of the structure with its longitudinal aspect towards the sun (for insulation purposes). That is, if this also works with the prevailing wind considerations. The Czech draft proposal has this in mind and so to does the very recent winning design for the Australian Davis Station (Sydney Morning Herald, 2003 : 30), which features significant amounts of glass on the longitudinal side of the building. The design faces the sun with triple glaze windows sandwiching argon gas (which does not transfer heat energy), the structure also angles well into the prevailing wind.

HHS size is influenced by transport difficulties of getting materials to Antarctica and in turn compounded by the short window of building time due to the climatic and seasonal influence. As a consequence, many of the structures have been prefabricated either totally or in semi kit set form to be put together on site in minimal time with minimal lifting machinery. Kestel (Kestle, 1999 : 18) notes that at Scott base "minimal lifting capacities sees limitations to manhandling".

And in terms of the minimal time influence, the Davis station specifications required the building to be erected in 4 weeks from arrival. The modular appearance of HHS's is not an accident and reflects the limitations set by climate and transport mentioned above. Some structures as in the McMurdo laboratory upgrades of the 1980's do seem very large, yet closer inspection shows the modular nature of the building linked together with a "spine" walkway. The new Amunsden Scott base will also use this principle of modular design and the design specifies that all materials be of a size to fit into a LC130 Hercules aircraft.

Functional storage capacity continues to affect size of buildings. It is noted in one Australian report a sense of frustration arising from the fact that tidiness of a base is proportional to storage capacity. "Stations have large indoor areas available. All efforts should be made to ensure general tidiness" (ADASETT, 1989 : 21). Day also notes in an interview with personnel at Scott base in 2002, that a continuing concern is greater storage space (Day, 2003 : 10).

Fire Hazard Influences

One theory still in operation which counters the modular influence, is the idea of spacing the buildings apart for fire break reasons as is the case in the U.S Palmer station and the proposed Czech station. Concordia at Dome C appears to be somewhat of a hybrid. The two circular

Structure's are separate but linked with a very narrow enclosed walkway. Fire detectors operate in every room (combustion gas detectors,) and the two buildings can be isolated with fire doors.

HHS's at Scott base are influenced by the requirement that all structures be fire rated at 5 times the standard of the New Zealand Building Act 1991. Of interest here is that the buildings must also meet New Zealand earthquake standards.

It is worth noting that fire retardant panels are seen as the norm.

Extreme cold influences

Insulation is the key in construction considerations, although heating systems are the obvious maintainers of warmth, these are in the category of services and outside the boundaries of this review.

Walls are generally thick with a 250mm polystyrene core as seen in recent construction at Scott base, or polystyrene in a sandwich panel such as chipboard. Variations include polyurethane which needs to be only 150mm thick for the same insulation however more recently this has been less available. Steel bolts have been clad in plastic as a measure of insulation. With insulation effectiveness in mind this has recently changed in Scott Base construction. The use of acetyl bolts washers and nuts are now in favor and windows have obligatory double or triple glazing as referred to earlier with the Davis station. This station has also taken a leap forward with its insulation design. The exterior wall is comparatively thin, constructed of a resin bonded material comprised of fiberglass, carbon and Kevlar and a balsa wood core. This is very recent technology and yet to be tested in Antarctica.

The influence of the intended life of the habitat system

"There are those who meet short term needs by providing low quality throw away buildings. Unfortunately history shows that these buildings do not get thrown away" (Incol, 1990B : 7). It appears that this view which alludes to the deficiencies of so called "throw away" buildings is widely accepted. HHS's are now influenced in design by the need for a long life and the ability to be upgraded. The new ablution bloke at Scott base constructed in 1999 is built with a 40 year lifespan in mind, and interiors to be re-fitted every 20 years. This appears to be the longest lifespan of recent constructions or plans in the unfolding. The shortest being 25 years as with the Davis base and the new South Pole base which has a 25 year life built into the design (AFW, 1998 : 58),

To aid re-fitting many structures include an outer shell that is separate from the insulating layer underneath. This shell may be as simple as waterproof plywood (6mm) to offer protection from salt spray and wind abrasion, the life of this solution is 10-15 years (MECR, 2003 : 12).

Influences of the human condition and aesthetics

The interiors of HHS's have changed with demand to have living conditions at a level that encourages human well being. This has become increasingly important with the morale of increasing numbers of personnel needing to be maintained over longer stays including Antarctic winters. Many studies point to the benefits of considerations in the building of structures to ward off winter blues for example. The simple solution of creating light within a building has impact (The Antarctic Sun, Nov 16 2003, Article B : 7). The Australian Mawson base in its interior considerations was reminded that it should be "excluding any features and arrangements which have had adverse effect on well being"

(Incoll, 1990A : 2). And in a similar vein the early Japanese proposal gave "high consideration to the mentality and morale of the expedition members" (Futami, Minow & Hida, 1962 : 2).

These considerations see a move to "normalization' of the interior design. This means, to make the environment as much as possible like "home'. Designs include, focus points for human activity, where interaction at a social level can take place, through to areas of privacy, this has been referred to as graded levels of privacy.

Large windows and light are dominant features, and the design of buildings to be quiet is also noted. This refers to the noise, both from the outside climatic conditions and also from human activities. HHS's with rounded or curved exterior walls are seen to aid the reduction of climatic noise. Recent designs, Davis and Concordia (a cylindrical design) attribute their climatic noise reduction to this. Noise from human activities, i.e workshop and kitchen are now being addressed with these facilities commonly separated into different areas of the building or simply separate buildings. Concordia on this score has a quiet building (labs and accommodation) and a noisy building (kitchen and storage). Noise barriers between lounge and bedroom were included in the Palmer station upgrade over the past 5 years.

The exteriors of HHS's have far less influence from the principles of the human condition and/ or aesthetics. The thought of merging the buildings into the environment carry little weight when looking at the issues raised so far and are best summed up by Incoll (Incoll, 1990B : 6) who states: "thus it can be seen that any attempt to blend buildings into the terrain is counter productive. The way our buildings sit up clear of the landscape is in fact what the local conditions demand".

The issue of color scheme does not arise as a major factor in the design of the HHS. One might expect that from an aesthetic point of view that a color to blend in with the environment would be preferable. Yet counter to this is the argument for visibility of buildings for safety reasons. Another argument is that bright colors lift the spirit. "Bright colors produce an overall effect of cheerful contrast to the drab brown summer rock or to the white of winter snow" (Incoll, 1990A : 4). Scott base in this realm of thinking carries the color scheme known as Scott base green or RBT green, the chosen color of RB Thompson in 1966, to reflect the reversal of white English cottages in fields of green.

Occasionally one does see HHS's with a strong aesthetic component to them. A new building scheduled for construction at Palmer station in 2005, will be a three sided structure, with much glass to take in the views. This building represents the three organizations that will use the international monitoring system. Says architect Steve Meredith. "as an architect, I always strive for aesthetics in my buildings, something unique" (Antarctic Sun, Nov 16 : 10). This appears to be a rarity in terms of influence of HHS's. In an interview with Arthur C Brown (2003) (NSF Representative, New

Zealand, U.S Antarctic Program), the following was raised: how much do current HHS's reflect the principles of functionality and/or aesthetics? His response was that the conditions of the environment enforce functionality. He suggested that the scientific purposes of the enterprise dominate. "Sure some buildings have an interesting flare but this largely reflects the scientific requirements" (Brown, 2003).

Conclusion

"The architecture for polar regions is composed of various conditions, and each of these conditions is directly hinged to the life of each present in Antarctica" (Futami, Minow & Hida : 1). This quote translated from Japanese was made in 1962, and still appears to carry weight today. Namely that of prime concern in the physical construction of HHS's, is the survivability of the personnel and operations within. In form the buildings reflect functionality, and of interest here is that none of the HHS's researched, reflect a cultural influence from the home nationality. Functionality dominates. It is only within the HHS's that one sees latitude to create an environment where the human condition and aesthetics are taken into consideration. Yet by no means are the interiors totally homelike. "Submarine like" was one off hand comment made by Arthur Brown (2003). The buildings in McMurdo as late as November 16 2003 were described by the "Antarctic Sun" (The Antarctic Sun Nov 16 2003 : 10), as "fairly old, new buildings are dictated by function and somewhat by aesthetics".

And possibly Bennets (Bennet, 2001-2002 : 23) puts it best although strongly when he says, "the designed and built elements are totally influenced by the need for shelter and survival. This culture has never evolved beyond survival mode in spite of improving technology the environment still controls human activity". This may be, however it would at least appear that influences on the physical construction of HHS's have at least made survival a little more comfortable.

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