R 457

Technical Report

POLAR CAMP IMPROVEMENTS
REQUIREMENTS AND CONCEPTS FOR COVERED STORAGE FACILITIES

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U. S. NAVAL CIVIL ENGINEERING LABORATORY

Port Hueneme, California

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POLAR CAMP IMPROVEMENTS — REQUIREMENTS AND CONCEPTS FOR COVERED STORAGE FACILITIES

Technical Report R-457

Y-F015-11-01-105

by

G. E. Sherwood and J. P. Cosenza

ABSTRACT

A study of storage facilities in polar camps showed a need for improved facilities for camps on areas of drifting snow. Equipment and materials stored in the open become drifted over and require costly manpower for digout. Damage during storage and digout is also costly. Digout can cost $400 to $600 per piece of equipment following winter storage or prolonged storms.

The use of a lightweight, easily erected, low-cost storage shelter should produce savings in manpower and materials. Available information indicates that such a shelter would cost $1.50 to $2.00 per square foot. A storage basement under a building on a snowfield would also provide covered storage space at a very low cost. It was concluded that a study should be made to determine the feasibility of lightweight, easily erected, low-cost storage shelters for use on areas of drifting snow. Also, a prototype storage basement should be constructed under a Jamesway with a Naval Civil Engineering Laboratory steel foundation so that its practicality for storing supplies, small items, and frozen foods can be evaluated.

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The Laboratory invites comment on this report, particularly on the results obtained by those who have applied the information.

CONTENTS

INTRODUCTION

Adequate storage facilities are of prime importance in the efficient operation of polar camps and stations. Large quantities of supplies have to be stored at these sites, which are usually resupplied only once a year. Items stored in the open are subject to damage from the elements, and on snowfields they become drifted over and eventually completely buried. Consequently, a great deal of costly manpower is devoted to digging out equipment and materials.

Conventional warehouses can be used for polar stations located on land areas, but these structures are not suitable for stations and camps on ice and snow. Limited covered storage facilities on ice and snow usually consist of crude lean-tos, built of crating material, and personnel-type structures which are complex, expensive, and of limited use.

This technical report presents the storage requirements for pioneer and temporary camps and stations as well as some approaches for improving the storage facilities for camps and stations in areas of drifting snow. Shelters specifically for covered storage of equipment and material in such areas are not available, but a variety of materials and techniques appear suitable for the development of relatively inexpensive, quickly erected shelters.

BACKGROUND

Existing storage facilities in polar regions vary considerably with the location, size, and life of the camp. In permanent stations on land, storage problems have been partially alleviated by the construction of large warehouses. However, at outlying camps and work centers in areas of drifting snow, and at surface stations and camps on ice and snow, there has been little advancement in the development of storage facilities. The types of storage facilities used at polar stations and camps can be classified under three general categories: covered, open, and refrigerated.

Covered Storage Facilities

Storage facilities at polar stations on land include warehouses of conventional construction. At McMurdo Station, Antarctica, large heated warehouses are used. The walls are well insulated to avoid condensation and ice coating on the inside face.

Windows are also kept to a minimum to avoid formation of ice on the inside. Loading docks are situated inside so that loading and unloading can be performed where personnel can work more efficiently. The inside loading docks also make it possible to prevent large doors from remaining open for extended periods with a consequent heat loss.

In contrast, covered storage facilities in outlying camps and work centers in the snow areas around McMurdo Station and at the surface stations and camps in Antarctica are very meager. At these locations, covered storage facilities are generally limited to space for such things as dry and canned food, delicate instruments, and spare parts. The storage buildings are usually the same type as that employed for the basic camp. Large doors are not available for moving crates and cargo-handling equipment into these buildings, and none of these buildings are suitable for storing transportation and construction equipment. Maintenance buildings are available for these camps, but they are large, expensive, and complex structures for storing supplies and equipment.[1,2,3] Also, surface camps in areas of drifting snow become drifted over and eventually buried, and to avoid inundation, should be moved every 2 or 3 years.[4] Most existing buildings have to be completely disassembled for movement and re-erected at the new location.

In the undersnow camp at Byrd Station, storage is easily handled by using one tunnel for this purpose. The main supply tunnel is also used for storing rations along the sides, and the space behind buildings is used for storing items for current use.

Tunnels are also used for storage at Pole Station. Although this was originally a surface camp, drifting snow has resulted in most of the camp becoming buried. Narrow storage tunnels were constructed in the snow around this station using timber framing to support the roof. The items stored in these tunnels are protected from the weather and are easily accessible to usage points in the camp.

Open Storage Facilities

At McMurdo Station most of the bulky supplies, such as prefabricated buildings and lumber, are stored in open areas. This is possible because the storage area is located on a windswept hillside that is relatively free from drifting snow. Nevertheless, materials are damaged by exposure to the elements, and maintenance of an accurate inventory is difficult. Protective coatings and improved shipping containers eliminate some deterioration, but the problem of locating materials which are partially covered with snow is still critical.

Open storage is particularly unsatisfactory in camps on snowfields. In these locations, the storage areas often become completely buried in drift, and if items are not well located by markers, they are often lost. The necessity of good organization is apparent from the experience at Little America.[5] When the station was supplied in January and February 1956, the material was quickly dumped in an open storage area on the snowfield adjacent to the camp. Little regard was given to recovery, and the following spring there was as much as 15 feet of snow over some of the material. The best guide to locating this material was photographs taken at the time of storage. A bulldozer was used to clear a path down what appeared to be the edge of the supply area, and then, by means of hand shovels and probing, the material was recovered item by item. This process required numerous manhours, and some material was never recovered. During recovery, most of the crates were broken, but the recovered material was in usable condition.

At McMurdo Station in February 1965, breakout of the ice on McMurdo Sound threatened Williams Field. The camp at this location was quickly disassembled and moved to a safe area on the Ross Ice Shelf, where it was stored in the open during the winter. Because of the speed of the move, placement of items was not well organized, and there was considerable loss and damage during the digout of this material the following spring. Open-framework items, such as bedsprings and open-web foundation joists, were never recovered.

Since Deep Freeze 63, a large effort has been put into digging out equipment (Figure 1) and material (Figure 2) stored outside during winter at the Naval Civil Engineering Laboratory (NCEL) camp on the Ross Ice Shelf near McMurdo Station. At the beginning of the Deep Freeze 65 summer season, 48 mandays were required to dig out the following equipment at the NCEL camp: two size 2 snow tractors,[6] two snow mixers,[7] and two Model 40 snowplow carriers.[8] Based on an average cost of $95 per manday for Seabee labor in Antarctica, this effort cost $4,580. Considerable hand digging was required because bulldozers could not get too close to buried items without damaging them. Even so, there was some damage to equipment. When crated items were dug out, the crates were often torn apart, and the contents were damaged. Partially buried items were also damaged by tractors driving over them during periods of poor visibility.

Refrigerated Storage Facilities

The low temperatures prevalent in polar regions are sometimes used to advantage for preserving frozen foods; however, in many locations, the temperature gets above freezing during the summer. Frozen food not protected from solar radiation can also be damaged even at safe ambient temperatures. At McMurdo Station and other coastal stations, mechanical refrigeration is used to keep the food at a safe temperature. At Williams Field near McMurdo Station, reefer boxes were used to store frozen foods, but no mechanical refrigeration was available for these units. These boxes, however, were covered with snow, and the temperature remained low enough inside the boxes to preserve frozen foods.

In some camps, snow caves have been used to preserve frozen foods. Such a cave was used at the NCEL camp during Deep Freeze 65 and 66 (Figure 3). Before this, a covered pit 4 feet wide by 8 feet long by 5 feet deep had been used, but it was often inaccessible because of deep snowdrifts in the pit area. In one storm, an

8-foot-high drift formed over the pit. The new storage cave was built by undercutting this wind-packed drift 8 feet above the pit floor and installing an insulated ceiling supported on fuel-drum columns and timber rafters. The open side of the cave was sealed with snow blocks, which were dug out when the drift was being undercut. The entrance was sealed with a cut-down Jamesway vestibule door. Empty crates were used for shelving, and the food was stacked vertically for easy inventory. A light was installed so that the entrance could be kept closed as much as possible. Construction of this snow cave required 4 mandays. During the warmest part of the summer, when temperatures ranged from 25°F to 35°F, the snow cave remained fairly constant at 20°F. Although this is a little warmer than desirable, it was satisfactory during the two seasons of use.

REQUIREMENTS FOR STORAGE FACILITIES

The general requirement for improving storage facilities in polar camps on areas of drifting snow is adequate shelter to provide protection from the elements and to prevent inundation from drifting snow. Space requirements for these shelters are dependent upon the quantity of supplies to be stored and the size and amount of the maintenance, transportation, and construction equipment to be housed. In addition to the space requirements, there are certain layout and structural requirements for convenience, economy, and adaptability to polar regions.

Space Requirements

Storage space for expendable items is a major requirement for most camps because resupply operations are usually conducted only once a year. The requirement is also increased by the antarctic ration of 5,400 calories per man per day, which is considerably higher than the standard Navy ration of 3,200 calories per man per day. Some outlying camps are established for only short periods of time, so the storage facility requirement is correspondingly less.

The quantity of supplies required by various size camps for 3, 6, and 12 months are given in Table 1. This requirement is directly proportional to the size of the camp. Given a shelter 16 feet wide with a 4-foot center aisle and material stacked an average of 5 feet high, a 60-foot-long shelter would be required for expendable items in a 25-man camp resupplied annually. A 50-man camp would require two such shelters, and a 100-man camp would require four such shelters. These requirements do not include space for frozen foods.

Storage requirements for fuel vary with the size of the station and the type, size, and amount of the equipment required to carry out the station's mission. Storage requirements for spare parts and other equipment-support items will vary with the equipment.

Figure 1. Equipment storage area at the NCEL field camp during digout.

Figure 2. Digout of the crated items stored in the NCEL field camp.

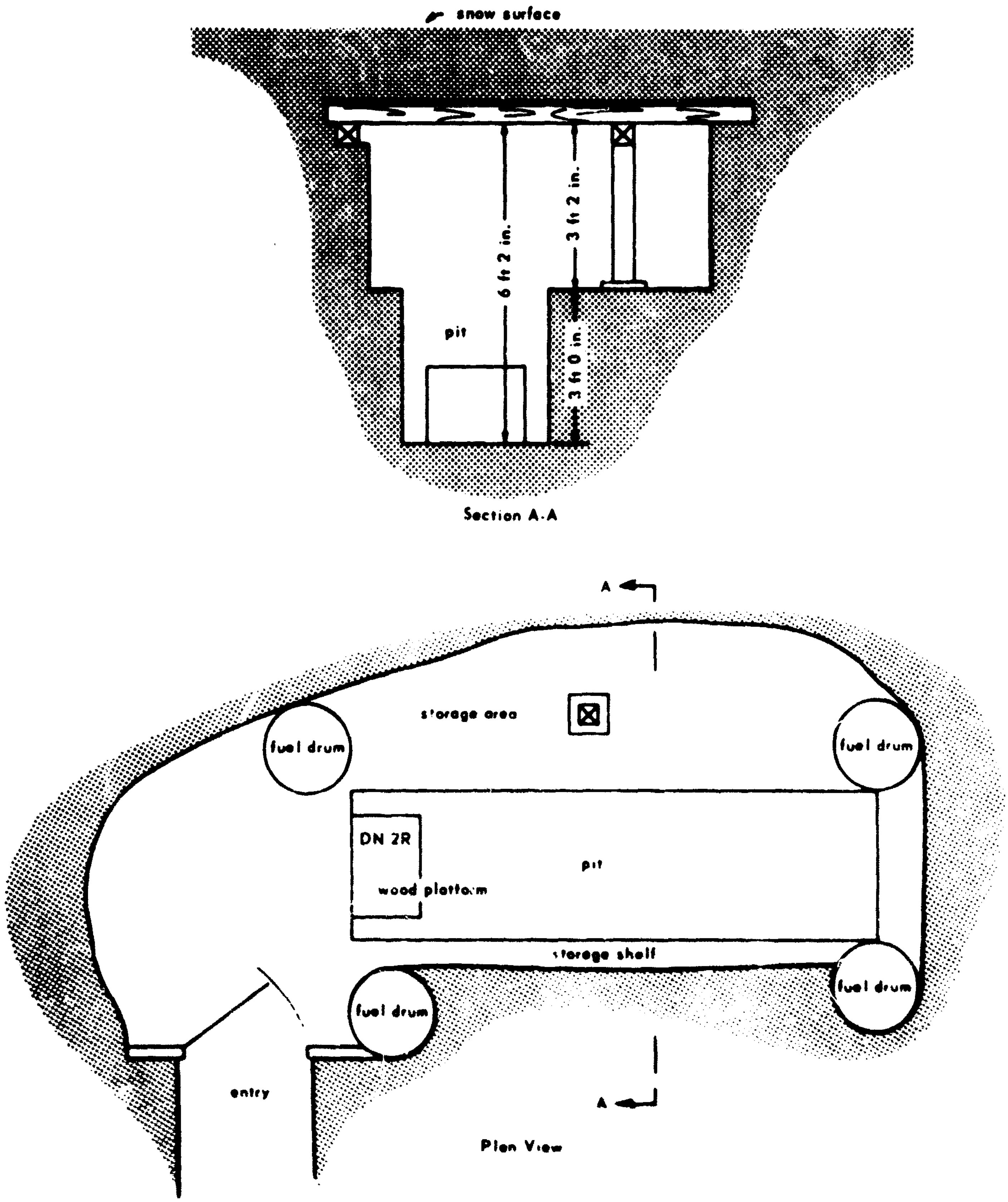

Figure 3. Layout of snow cave used at the NCEL camp during Deep Freeze 65 and 66.

Table 1. Polar Camp Storage Requirements

Item	25-Man Camp		50-Man Camp		100-Man Camp		200-Man Camp	
	Weight (lb)	Storage Space (ft^3)	Weight (lb)	Storage Space (ft^3)	Weight (lb)	Storage Space (ft^3)	Weight (lb)	Storage Space (ft^3)
3 Months								
Clothing and Small Stores	402	35	804	70	1,608	140	3,216	280
Ship Store	14,870	265	29,740	530	59,480	1,060	118,960	2,120
Provisions - Dry Replenishment	11,435	269	22,870	533	45,740	1,076	91,480	2,152
TOTAL	26,707	569	53,414	1,138	106,828	2,276	213,656	4,552
Refrigerated Food	9,000	300	18,000	600	36,000	1,200	72,000	2,400
6 Months								
Clothing and Small Stores	804	70	1,608	140	3,216	280	6,432	560
Ship Store	29,740	530	59,480	1,060	118,960	2,120	237,920	4,240
Provisions - Dry Replenishment	22,870	538	45,740	1,076	91,480	2,152	182,960	4,204
TOTAL	53,414	1,138	106,828	2,276	213,656	4,552	427,312	9,004
Refrigerated Food	18,000	600	36,000	1,200	72,000	2,400	144,000	4,800

Continued

Table 1. Continued

Item	25-Man Camp		50-Man Camp		100-Man Camp		200-Man Camp	
	Weight (lb)	Storage Space (ft^3)	Weight (lb)	Storage Space (ft^3)	Weight (lb)	Storage Space (ft^3)	Weight (lb)	Storage Space (ft^3)
12 Months								
Clothing and Small Stores	1,608	140	3,216	280	6,432	560	12,864	1,120
Ship Store	59,480	1,060	118,960	2,120	237,920	4,240	475,840	8,480
Provisions - Dry Replenishment	45,740	1,076	91,480	2,152	182,960	4,204	365,920	8,408
TOTAL	106,828	2,276	213,656	4,552	427,312	9,004	854,624	18,008
Refrigerated Food	36,000	1,200	72,000	2,400	144,000	4,800	288,000	9,600

All polar camps have equipment for maintenance and transportation; some have equipment for construction. The 25-man NCEL camp near McMurdo Station had all three types.

Most stations will require low ground pressure tractors and snowplanes for maintenance, and tracked or wheeled equipment for transportation. In Deep Freeze 65 and 66, the 25-man NCEL camp near McMurdo Station had tractors and snowplanes[9] for maintenance; weasels, a trackmaster, power wagons,[10] and a truck-tractor and trailer[11] for transportation; and, snow mixers, snowplow carriers, and other construction equipment for its specialized mission. The overall dimensions for the principal types of this equipment are given in Table 2, because they will govern the design of equipment storage shelters for polar camps.

Layout and Structural Requirements

In the development of shelters that satisfy the storage requirements, the following layout and structural requirements should also be considered:

Layout

1. Ready accessibility
2. Flexibility to meet changing demands
3. Regular and uniform stockpiles for easy inventory
4. Aisles wide enough to accommodate material-handling equipment

Structural

1. Low cost
2. Easy erection
3. White and highly reflective exterior finish
4. Translucent cover
5. Large access doors
6. Expandable in size
7. Adequate tie-downs
8. Adequate insulation for refrigerated shelters so that the temperature would not exceed 20°F

CONCEPTS FOR SURFACE STORAGE FACILITIES

A lightweight shelter for storage facilities in camps on ice and snowfields can be constructed from any number of materials by a variety of techniques. Most lightweight shelters in the past have been canvas-covered frames of metal or wood. Newer materials, such as molded fiberglass panels, polyurethane board, and foams, permit new building concepts for such lightweight, flexible structures as

1. A rigid-panel arched-roof structure
2. An accordion structure that can be collapsed for mobility
3. A fold-out structure with hinged walls and roof
4. A foamed-in-place structure in which the foam is sprayed over a removable form

Rigid-Panel Shelter

Fiberglass can be formed into any shape panel needed for a lightweight rigid-panel structure. Wire-mesh reinforcing can be used in the panels for added strength. Fabricating the panels in curved shapes will also result in stronger panels than those possible with flat sheets. With tongue-and-groove or lap connections between panels and spring-loaded devices to secure them together, a shelter of this material can be quickly erected with a minimum of manpower.

With curved panels, an arched-roof shelter (Figure 4) 16 to 20 feet wide and expandable to any length can be developed. The ends can be either flat or a quarter of a sphere. The curved ends are preferable for drift control, for all corners create disturbances which accelerate drifting. The ends must be capable of being easily disassembled if large equipment is to be stored in the shelter.

A hemispherical shelter can also be constructed from fiberglass panels. It has certain advantages for drift control since there is no problem of orientation;[4] however, it has the disadvantage of fixed size. Unlike a shelter with a longitudinal axis, it cannot be expanded with intermediate panels. Such a shelter can be fabricated in a variety of sizes, but after it is fabricated, its size cannot be altered to satisfy changing demands in the field.

Accordion Shelter

A thin material with sufficient strength can be folded to form an accordion-type shelter (Figure 5). The folds give added strength. This principle of strength in folds is frequently employed in roof design for contemporary buildings, the roofs being constructed of plywood, sheet metal, or concrete. Plywood or sheet metal can be used for polar shelters, but a lighter weight material is more desirable.

Polyurethane board has been used by one company to make accordion-type shelters for use as mountain cabins. These shelters proved to be quite satisfactory and were later adopted for use in housing transient farm laborers in Southern California. One such shelter has been produced for $1.50 per square foot, compared to about $5.00 per square foot for a Jamesway. It is arch shaped with flat end walls; however, a dome-shaped shelter can also employ the accordion principle by unfolding in a circular path. Its compactness makes the accordion shelter easy to ship to polar regions and to move from one place to another within the same general locality.

Table 2. Overall Dimensions of Principal Equipment Used at Polar Camps

Equipment	Length	Width	Height
Maintenance			
Size 2 snow tractor without attachments	14'0"	9'3½"	8'11"
Size 2 snow tractor with attachments		13'1½"	8'10"
Size 6 snow tractor without attachments	20'7"	13'8"	10'8"
Size 6 snow tractor with attachments		16'10"	10'8"
955 Traxcavator, low ground pressure	14'6"	10'6"	10'4"
Model 40 snowplane	57'0"	12'0"	9'0"
Model 80 snowplane	96'0"	15'0"	11'0"
Construction			
Model 40 snowplow carrier	55'6"	15'4"	9'10"
Model 36/42 snow mixer	31'9"	9'9"	9'2"
Transportation			
1-ton power wagon	19'6½"	8'0"	7'7"
6 x 6 truck-tractor and 20-ton semitrailer	46'0"	8'0"	9'6"
Thiokol Trackmaster 601	13'5"	8'1"	7'0"
Nodwell RN-110	19'3"	9'1"	8'10"
Weasel M29C	16'0"	5'7"	5'11"

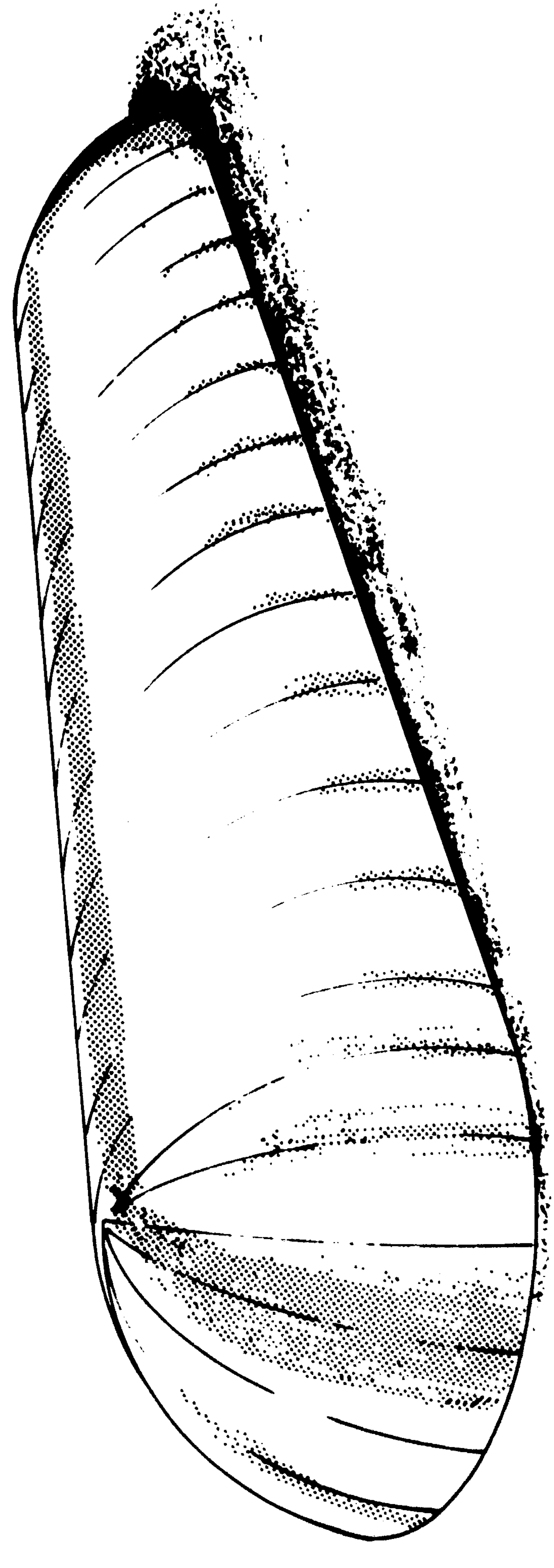

Figure 4. Rigid-panel shelter.

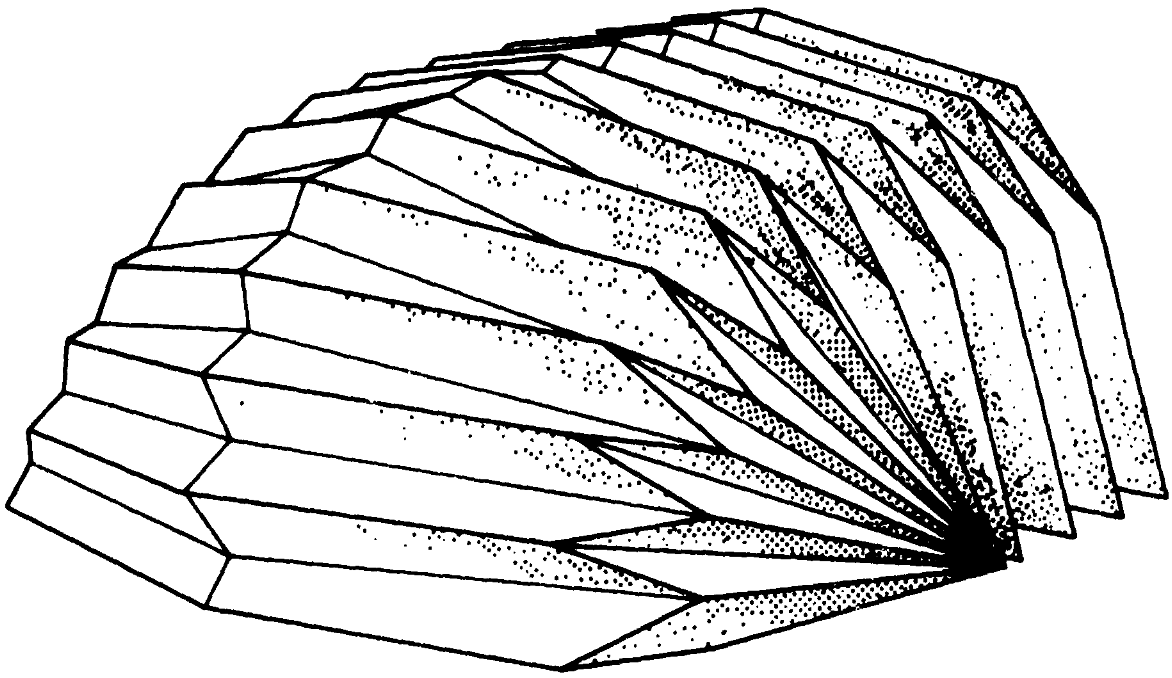

Figure 5. Accordion shelter.

Fold-Out Shelter

The concept of the fold-out shelter is commonly used for portable structures. In some cases, the floor, walls, and roof are hinged to each other so that the entire structure can be folded into a compact package. Other structures have a central portion of a size that can be transported, and this size can be enlarged by sections that fold out from the central portion. Most existing structures of this type are of wood or metal construction. They have to be kept relatively small and cannot be adjusted in size as some other types of shelters can. They might be suitable for very short-life camps in which storage space requirements are small and speed and ease of erection quite important.

Foamed-In-Place Shelter

Shelters can be constructed by the application of foam over removable forms. An inflatable form can be easily erected and removed after the foam has sufficient strength to be self-supporting. The roof of such a shelter would have to be curved to give it enough strength to span the width of the building and to support vertical loads. One of the problems with this type of structure is that it cannot be disassembled for relocation; however, it can be constructed on skids and towed short distances. Once constructed, this structure cannot be altered in size to satisfy changing requirements. The foam material has very limited application because it cannot be sprayed on at extremely low temperatures. It can be used only on the warmest days of summer in the warmer areas of the polar regions. Current research by others is directed toward producing foam which can be applied in colder temperatures.

CONCEPT FOR SUBSURFACE STORAGE FACILITY

One possibility for additional covered storage in camps using Jamesways on snowfields is the area under the Jamesway (Figure 6). A steel foundation[12] which requires support only at the longitudinal edges of the building has been developed for the Jamesway. The foundation has skids and can be towed in lengths up to 64 feet. Since no support is required under the center of the foundation, a storage basement can be located under the building. The basement can be excavated with equipment, and the building can be winched over the excavation.

In order to allow sufficient bearing area under both edges of the building, the width of the basement should not exceed 10 feet. The depth of the excavation should be a minimum of 7 feet to allow adequate head room. Access should be possible from a ramp at one end of the building. This ramp may be kept clear only at the time the camp is supplied and allowed to drift over the rest of the time. A personnel access could be made through a trap door in the floor of the Jamesway.

The basement might be used for frozen food storage; however, field tests will be required to determine what temperatures can be maintained. If temperatures are too high, the conditions can be improved by adding insulation to the Jamesway floor and by providing better ventilation. Although this type of basement will satisfy the requirements for bulk storage of frozen foods in camps using Jamesway shelters, it cannot be employed in camps using the T5 series buildings, which have foundations requiring center support. In these camps, frozen food storage can be provided by digging a trench, putting an insulated roof over it, and covering the roof with snow for added insulation. It is recognized that this type of storage is not a substitute for refrigerated ready-food storage, which must be maintained at above-freezing temperatures.

POTENTIAL SAVINGS WITH COVERED STORAGE FACILITIES

Digout of materials and equipment from open surface storage areas following prolonged storms and winter storage periods at polar camps in areas of drifting snow is expensive in time and manpower. Lost and damaged items also increase costs and often delay progress at these locations. For example, during Deep Freeze 62 an

$18,000 snowplane, which was stored over winter in an area of drifting snow, was damaged beyond repair during digout (Figure 7). Loss of drummed fuel stored in areas of drifting snow runs as high as 10%. NCEL has operated a camp on the Ross Ice Shelf about 5 miles from MCMurdo Station since Deep Freeze 63. This camp is secured during the winter months, and most of the equipment and material is stored in the open. Records during Deep Freeze 65 showed that it cost nearly $5,000 to dig out 12 pieces of equipment after 8 months of winter storage. Following a 3-day storm during the same year, it cost $1,200 to dig out two snowplow carriers.

All materials and supplies and most equipment in Antarctica are suitable for storage in 18-foot-wide shelters. Six such shelters, each 60 feet long, would house all the NCEL equipment. Based on the $1.50 per square foot that it would cost for one of the shelter types discussed under the section on concepts for surface storage facilities, these six 18 by 60-foot shelters would cost $9,600. At this cost, the savings during the spring digout at the NCEL camp alone would pay for the shelters in 2 years. If shelters were used to house only the open-frame equipment, such as snowplanes and snowmixers, which require up to 80% of the digout time, only four shelters would be required, at a cost of $6,400. Additional savings would be possible if suitable shelters were available for storage of this equipment during storms. Accurate records are not available of lost time, damaged material and equipment, and missing items at other antarctic stations and camps in areas of drifting snow, but fragmentary reports indicate that similar savings would occur with adequate storage facilities for equipment, materials, and supplies. The shelter cost for supplies alone, which are now stored in personnel-type shelters at costs of $5.00 a square foot or more, should be less than $2,000 for a 25-man camp, $3,000 for a 50-man camp, and $6,000 for a 100-man camp if the type of shelter costing $1.50 per square foot were used.

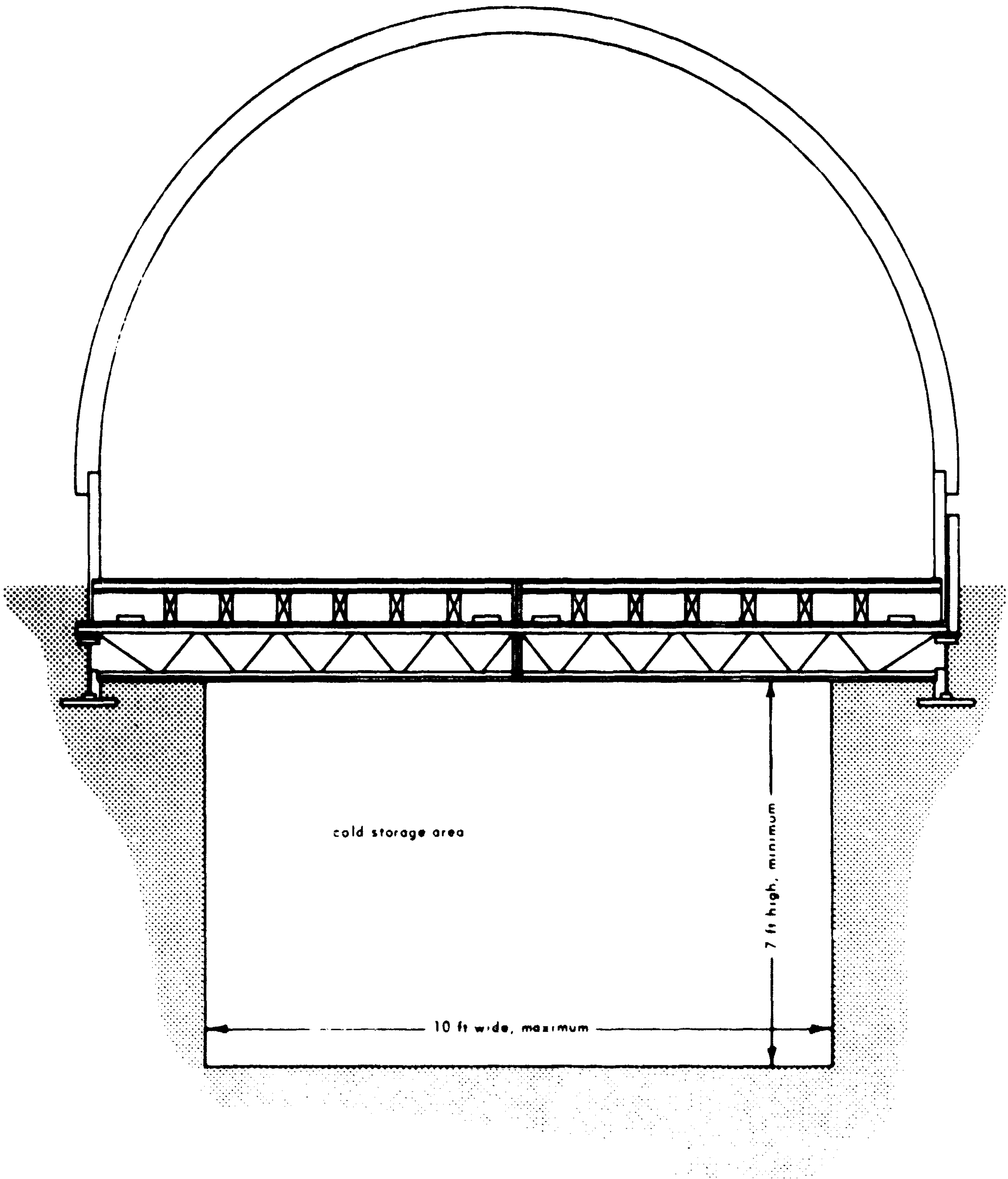

Figure 6. Cross section of Jamesway shelter with storage basement.

Figure 7. Snowplane damaged during digout.

FINDINGS

1. Open storage at polar stations and camps in areas of drifting snow is costly in time and manpower necessary for recovery operations and in loss and damage to stored items.

2. Digout costs alone range from $400 to $600 each for open framework equipment following prolonged storms and winter storage.

3. Existing polar structures are expensive and unsuited for covered storage shelters, but numerous new materials and construction techniques appear suitable for a lightweight, easily erected, low-cost storage shelter for polar use.

4. Available information indicates that adequate lightweight shelters for storing equipment, material, and supplies will cost between $1.50 and $2.00 per square foot.

5. Subsurface storage can be achieved under Jamesways erected on the NCEL-developed steel foundation.

CONCLUSION

Covered storage facilities are needed for polar stations and camps in areas of drifting snow.

RECOMMENDATIONS

1. A study should be made to determine the feasibility of lightweight, easily erected, low-cost storage facilities for areas of drifting snow.

2. An experimental storage basement should be constructed under a Jamesway with an NCEL steel foundation to study the practicality of its use for storing camp supplies, small items, and frozen foods.

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13. ABSTRACT

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The use of a lightweight, easily erected, low-cost storage shelter should produce savings in manpower and materials. Available information indicates that such a shelter would cost $1.50 to $2.00 per square foot. A storage basement under a building on a snowfield would also provide covered storage space at a very low cost. It was concluded that a study should be made to determine the feasibility of lightweight, easily erected, low-cost storage shelters for use on areas of drifting snow. Also, a prototype storage basement should be constructed under a Jamesway with a Naval Civil Engineering Laboratory steel foundation so that its practicality for storing supplies, small items, and frozen foods can be evaluated.

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