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A PLASTIC SHELTER FOR HOUSE BUILDING IN WINTER

BY

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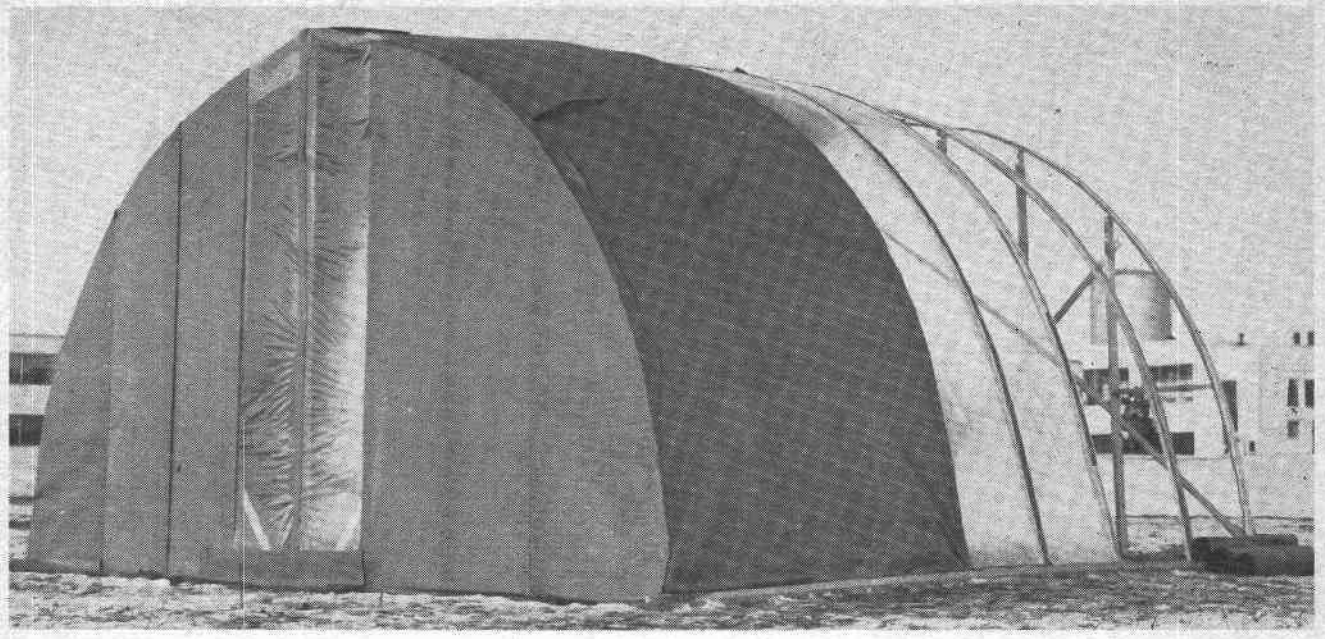


Full details of unique NRC study on winter homebuilding

By A. W. SMITH
Construction Section
Division of Building Research, NRC

A complete one-story and basement house was built under a timber-arched polyethylene shelter in Ottawa last winter as a winter construction costs study by the Construction Section of the Division of Building Research, National Research Council.

It was a temporary one-shot enclosure and it was estimated an improved type, including material, labor, heating and maintenance would cost about $850. But assuming certain salvage value, it was believed that this total cost could be reduced to approximately $400 over five houses.

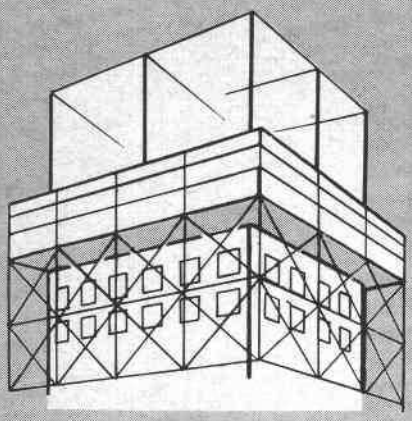
And here is the most significant conclusion drawn from this project, despite its experimental and exploratory nature:

—Comparison with a similar house built the previous summer showed that the cost of the builder's labor for the house under the enclosure was slightly less than the cost for the summer-built house.

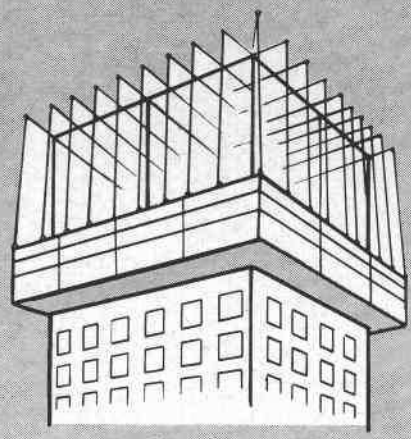
—This cost was some $400 less than that for any comparable winter-built house.

—This saving exactly equaled the operational cost of an enclosure that is used for five houses.

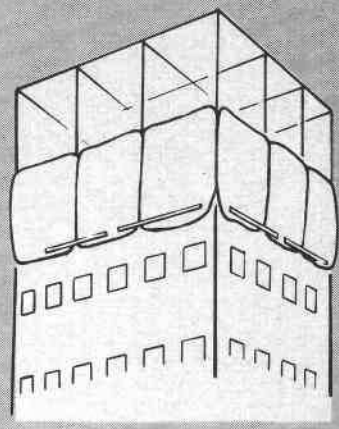
Reprinted from National Builder, November and December, 1958



ENCLOSED SCAFFOLDING



COVERED-IN SUSPENDED SCAFFOLD



HANGING TARPAULINS

BECAUSE A "PERMANENT" type enclosure might be considered too costly for a venture where the return was not accurately known, the Division decided to concentrate on a cheaper "temporary" type. Following study of various kinds of single-story enclosures used to date, it was decided to concentrate on the development of a laminated timber arch structure covered with building paper.

An experimental structure was built and tested under normal winter conditions before building one large enough to enclose a house entirely. Experience here caused the researchers to switch to polyethylene from building paper when construction of a house-size enclosure was put in hand. The bigger enclosure, it was decided, must be built by a local contractor who would keep a record of all costs including those of the house construction.

Armstrong Construction and Equipment Ltd., an Ottawa member of the National House Builders' Association, agreed to do the job and the Division agreed to supervise the construction and pay the cost of labor and materials. The particular house plan selected (40 ft. x 25 ft., one story and basement) required an arch enclosure spanning 50 ft., rising 20 ft. at the centre, and 50 ft. long.

Work began on February 18, 1958. While the basement hole was being dug, the end frames were built and braced to provide a jig for the prefabrication of 17 arch ribs. The arch ribs were made up of three layers of 1 in. x 5 in. timber, bent round the end frames and held in shape with temporary blocking until permanently fixed with 2½-in. spiral nails. These were driven at 6-in. centres and staggered about the centreline of each arch rib.

When each arch rib was completed it was removed from the jig to permit the forming of the next identical arch shape. Clamps were used at the joints to hold the three layers of timber together for nailing, and the joints themselves were arranged to be at least 3 ft. apart by starting with three different lengths of timber.

When the required number of arch ribs had been fabricated and the 2 by 10 foundation plates had been laid and staked in position with short lengths of ½-in steel rods, one of the end frames was tilted up into its vertical position and braced securely.

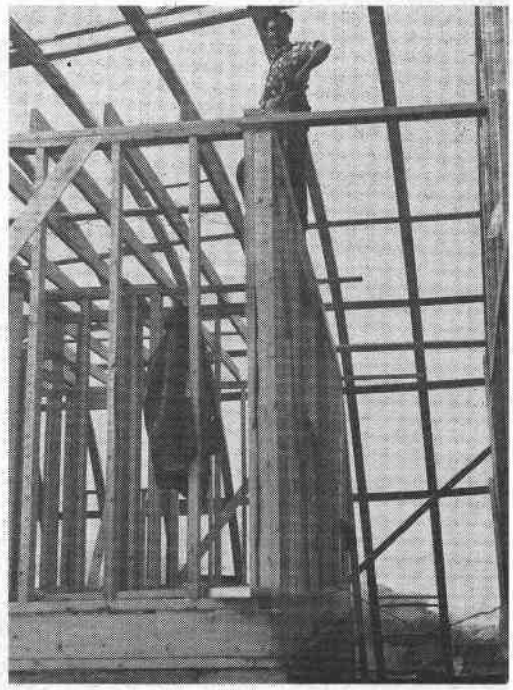
After this each arch rib was tilted into position by a rope attached to its crown and passing through a pulley at the top of the end frame.

When in position, the arches were fixed to a 2 by 4 ridge beam and two horizontal pieces of 1 by 4 some 8 ft. above each springing. After each arch rib had been raised in turn and the other end frame finally tilted into position, six more horizontal lines of 1 by 4 spacing members were placed on the outside by workmen who used them as a ladder. (This ladder was also used at a later stage for placing the plastic covering.)

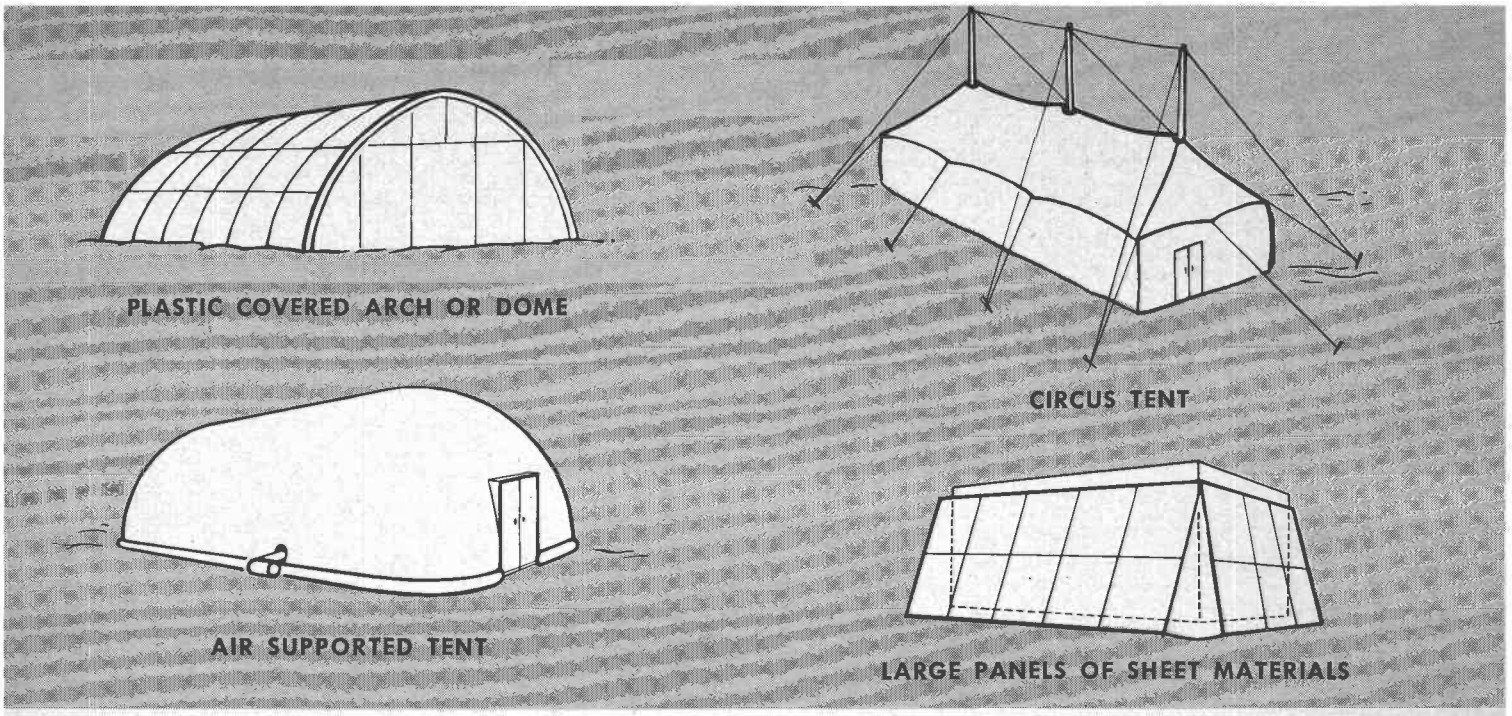
To complete the timber framework, two horizontal lines of 2 by 4 bracing were placed inside the rib structure from a ladder in the basement, and the diagonal bracing was added in each corner.

The 6-ft.-wide rolls of plastic used for covering the timber framework were cut into 37-ft. lengths and rerolled round a 6-ft. length of timber. The first stage of the covering operation was carried out from a 30-ft. extension ladder. The end of the 37-ft. roll was tacked to the ridge beam with a hammer tacker (using ¼-in. staples) and then unrolled over the arch ribs and tacked to them in a similar manner.

A strip of ⅜- by 1¾-in. paper lath, which had been prenailed on the ground, was placed over the line of staples to increase their holding capacity.



WORKING UNDER THE SHELTER with outside temperatures below freezing point, the tradesmen found conditions warm enough without special heating to move around in open-neck shirts with sleeves rolled up.



The end frames were covered with the same plastic material with a hanging tarpaulin for an entrance.

The dismantling of the shelter with the finished house underneath proved to be a very simple matter.

Two workmen with rubber boots were able to stand on the roof of the finished house and carry the disconnected arch ribs to the end of the building and lower them to the ground. The plastic covering strips were rerolled around a 6-ft. length of timber for storage and future use.

The enclosure performed very well after it had been completely covered and braced securely. However the structure itself suffered considerable storm damage during erection and immediately afterward, but this could easily have been avoided through proper bracing.

These violent storms pointed out weaknesses in the original design and made it possible to say that the modified structure has now proved itself in winds gusting up to 50 mph during a 10-in. fall of wet snow.

As expected, the sun's heat alone was sufficient to keep the inside temperature in the 70's when the outside temperature was still well below freezing. This meant that in clear weather, the propane heaters were not required in the daylight hours.

Unfortunately the storm which caused most damage occurred immediately after the enclosure had been covered in and before the propane heaters had been installed. It is now thought that the damage caused by the accumulation of 10 in. of wet snow on the crown of the roof could have been minimized, if not completely avoided, if the enclosure had been heated. The high temperature that normally exists at roof level would not have allowed the snow to accumulate to such a damaging degree.

Furthermore, a temporary bracing system or even a simple rope tie could have been used to strengthen the structure for the duration of such an unusually severe storm.

It should be kept in mind that the main purpose of this particular enclosure was to provide a simple shelter at the lowest possible cost. It would be very easy to build a stronger, heavier structure that could withstand any storm but the extra cost of labor and materials would not be warranted for such a temporary structure whose effectiveness is determined by its speedy dismantling and re-use as well.

A conservative estimate for a second enclosure incorporating the improvements just noted would include $500 for materials, nearly $300 for labor, and total approximately $850.

Here is a detailed estimate:

Material costs:

1 x 4 arch ribs and spacing members 4,650 lin. ft. (1,550 bf at $120)	$186
2 x 4 studs and bracing 1,200 lin. ft. (800 bf at $120) ..	97
2 x 10 foundation plates (100 lin. ft. at 21c)	21
⅜-in. paper lath battens (2,-500 lin. ft. at ½ c)	12
4 mil polyethylene roof and walls 6,000 sq. ft. x 6 ft. wide ($12 per 500)	144
Tarps, ropes, steel spikes, nails, etc.	40
	$500

Labor costs:

- end frame and arch ribs 4 men 1 day (32 manhours)
- erection and bracing 4 men 1 day (32 manhours)
- covering and clean up 4 men 2 days (64 manhours)
- dismantling 2 men 1 day (16 manhours)

Total—144 manhours at $2=$288

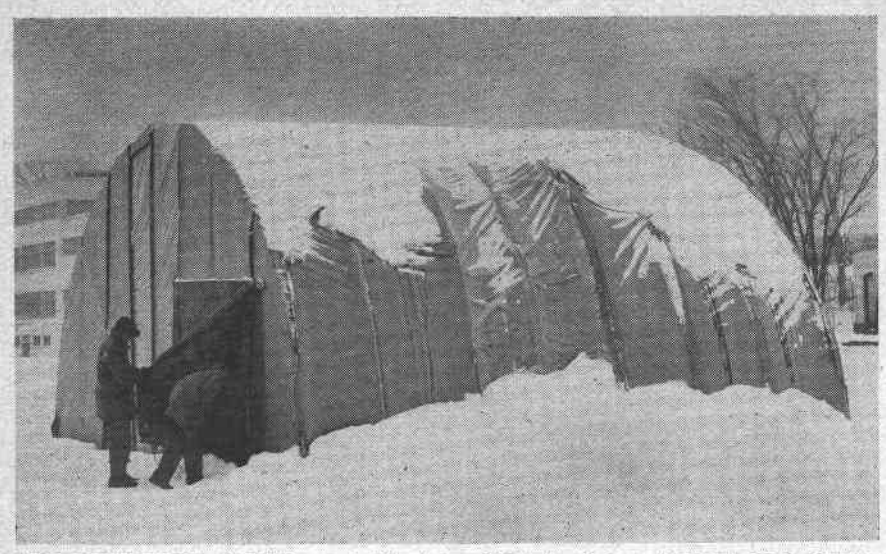
Heating and Maintenance Costs:

propane gas heating for two weeks, repairs to polyethylene covering, etc.	80
TOTAL	$868

What It Means

This experiment opens up wide possibilities which could revolutionize project building in winter. Best use of this style of enclosure depends on finding a simple method of either partially dismantling it or moving it as a complete structure. And, if this can be done, say the researchers, here's what it will definitely be possible to do:

- **★Provide steady, year-round employment for house builders and their associated trades.**
- **★Allow the contractor to build up and maintain experienced gangs of efficient workmen, less prone to accidents.**
- **★Avoid the costly errors to which construction in the open is unfortunately prone.**
- **★Provide more low cost houses for earlier occupation with a minimum of capital tie-up.**
- **★Allow the builder to take full advantage of current prices and so avoid ever-present increases in the cost of labor and materials.**
- **★With care and planning, actually increase the builder's overall efficiency and consequently his profit margin.**



THIS EXPERIMENTAL SHELTER was built at the DBR laboratories, Montreal Road, Ottawa to check on techniques, especially the lamination of arches and the behaviour of the covering material

Assuming salvage of the 2 by 4 end frames, and 2 by 10 foundation plates, along with 2/3 of the plastic covering, it should be possible to reduce this total cost to approximately $400 over five houses:

1/5 of arch ribs, spacing members	$40
1/3 polyethylene covering	50
erection and dismantling	230
heating and repairs, etc.	80
TOTAL	$400

It should be noted that the labor cost is approximately 60% of the total cost per house which would therefore be greatly reduced when the workmen become more familiar with the erection and dismantling processes.

The over-all cost of a single enclosure depends mainly on its speedy re-use and this point cannot be overstressed.

It appears that a minimum enclosure for a house building site will cost approximately $800 and that this cost can be lowered only by re-use.

Many contractors find it possible to build the "shell" of the house, including sheathing and brick-work, in two weeks of uninterrupted work and, by this time, to have the heating unit installed in the basement. At this stage the enclosure could be dismantled and re-erected on the next site, leaving the permanent heating unit to take over and provide a perfectly controlled climate for the remainder of the interior work.

By prefabricating the arch ribs in the fall months, and allowing three or four days for erection and dismantling, it should be possible to work to a 2½-week cycle and so complete 10 houses in the winter season. By using the enclosure in this way, its total cost, including maintenance and heating costs, could be offset completely by savings in manhours alone, to say nothing of the savings on winter-priced building materials and subtrade contracts.

The size of the laminated timber arches made them difficult to transport any great distance. It has been suggested, therefore, that lighter aluminum sections be used and that the roof structure, whether of aluminum or laminated timber, be fabricated, erected, dismantled and transported in 10-ft.-long sections comprising three or four individual arch ribs. If this method is considered, a mobile crane may be warranted and the erection and dismantling costs could be reduced to an absolute minimum.

Second of two instalments

Fewer manhours offset extra costs in winter shelter building

Building in wintertime has never been considered impossible, but it is usually considered to involve extra cost which the owner has to pay. Direct comparison of summer and winter building costs is not easy to make because of the lack of accurate records of similar work and the variations to be found in planning, pricing and bidding.

Most of the extra cost can be attributed to a combination of four things:

* The heating of the masonry materials,
* Protection of the new work,
* Loss of time through storms and inefficient labor.
* Repair of damaged work and mistakes.

If the extra money usually spent for the items mentioned is used instead to provide for the cost of a heated shelter which completely encloses the construction site, most if not all of it may be recovered. The heating of the masonry materials is accomplished automatically.

There is no need for additional protection of the new work. The men are able to work without interruption in comfort, a condition not usually achieved even in summertime.

It is this saving in manhours that can convert an added expense into an investment which can more than pay for itself.

Big difficulty is spanning the site

The advantages of completely enclosing a construction site are being investigated as part of a more general winter construction research project by the Construction Section of the Division of Building Research, N.R.C. The study started with this investigation of the enclosure of a simple house building site.

The main difficulty with complete enclosure is to provide a roof that will span the whole site. This roof can be a temporary one of cheap, standard, "make-do," reusable building materials, or it can be a more permanent, more expensive, and more portable structure designed for reuse on different sites.

"Permanent" enclosures are available commercially in tent form supported by a light framework or by low pressure air. An air-supported tent large enough for house building might cost several thousand dollars.

Since most contractors would probably consider this too large a sum to invest in a venture where the re-

turn was not accurately known, the Division decided to concentrate on the cheaper "temporary" enclosure in order to determine its cost to the builder and to study any possible savings.

After a study of the various types of single-story enclosures used to date, it was decided to concentrate on the development of a laminated timber-arch structure covered with building paper. This was considered one of the most efficient means of enclosing temporarily a single-story space, with the added advantage that it could be built with the materials and tools normally available on a house-building site.

To learn more of the construction techniques involved, especially the lamination of the arches and the behaviour of the covering material, it was decided to build an experimental structure and to test it under normal winter conditions before attempting one large enough to enclose a house. This experimental shelter was erected in the test area adjacent to the DBR Building Research Centre in Ottawa. Its construction showed the importance of the true alignment and accurate spacing of the arches and made possible a comparison of the plastic and reinforced paper coverings.

It was found that the plastic material, 4 mil polyethylene, remained completely waterproof and therefore tended to shed the snow more effectively than the paper.

The alternate wetting and drying of the reinforced paper covering led to its ultimate destruction after three months when it was completely replaced with the plastic.

In addition to providing more light, the plastic covering greatly increased the "glass house" heating effect of the winter sun. This occurred to such an extent that, in the late winter months, the sun's heat alone made it possible to maintain an inside air temperature some 45 deg. F. above the outside temperature. Even on cloudy days a 20 deg. F. temperature difference was noted.

Although the reinforced paper gave a smoother, tighter, slightly cheaper covering, the plastic was thought to have more significant advantages. Besides having a longer life and the ability to shed snow more efficiently, it transmitted more of the sun's light and heat, was easier to apply and to remove.

It was therefore decided to cover the proposed house-size shelter entirely with this plastic material.

Ways to minimize dangers of storm damage

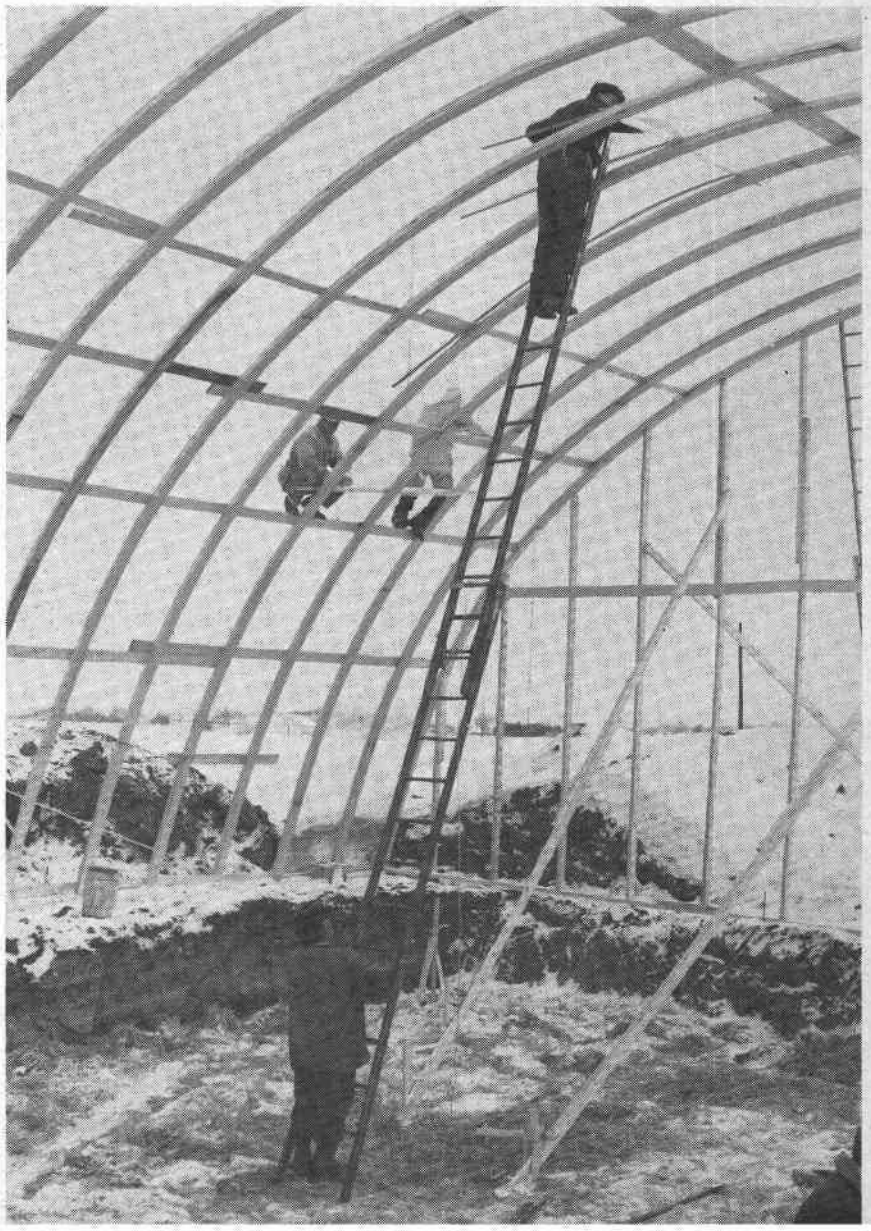
(As given in the November issue of National Builder, the report here discusses storm damage which occurred during erection and immediately afterward before the propane heaters had been installed. There was a 50-mph wind accompanied by a 10-in. fall of snow. Although the roof covering remained undamaged, some of the joints holding the plastic wall panels to the timber end frame did give way under the excessive wind pressure. This damage was quickly and easily repaired by tacking plywood sheets across the damaged panels and no further wind damage occurred.

It is now thought that damage caused by the accumulation of 10-in. of wet snow on the crown of the roof could have been minimized, if not completely avoided, if the enclosure had been heated. Also, a temporary bracing system or even a simple tie rope could have been used to strengthen the structure for the duration of such an unusually severe storm — Editor.)

The main purpose of this extra bracing would be to prevent the sagging of the crown portion of the centre arches and the accompanying accumulation of snow on the flattened surface. This could be done by placing a temporary prop under the centre arch ribs or by fixing the quarter points together with a horizontal rope tie.

If there is enough rope available it is probably better to tie the quarter points to a single ground stake in the centre of the shelter as this gives added protection against the uneven loadings due to high winds. Only the centre arch rib, or two at the most, need be braced in this way and only when unusually heavy loadings are expected.

Wind damage which occurred to the plastic end walls could be avoided



PLASTIC ROLLS 6 ft. wide were cut into 37 ft. lengths and re-rolled round a 6 ft. length of timber. End of the 37 ft. roll was tacked to ridge beam and then unrolled and tacked to arch ribs.

by a closer spacing of the timber studs. A 33-in. spacing instead of the 36-in. one used, would allow a much greater overlap of the covering material to produce a more easily made and stronger joint.

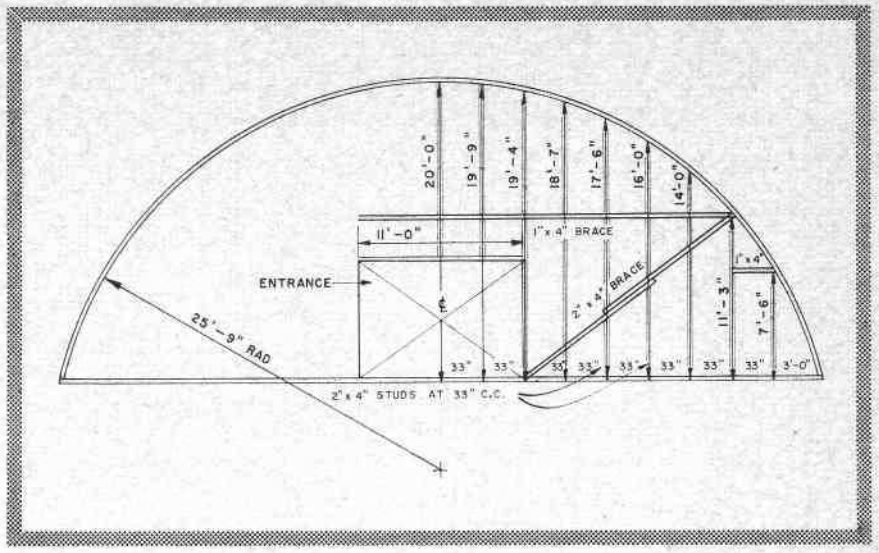
From the reuse aspect, however, it may be better and certainly easier to cover the end frames with plywood, masonite, or tarpaulin. The closer spacing recommended for a plastic covering on the end frame could well apply also to the arch ribs.

In this instance 1 x 5 timber was used for the arch ribs because it was more readily available than the standard 1 x 4. It is thought, however, that the 1 x 4 size could have been used quite successfully since the strength of these arch ribs depends much more on their depth than their width. Another 1 x 4 could be used in place of the paper lath batten to increase the holding capacity of the ¼-in. staples as well as to strengthen the arch rib itself and so provide an insurance against severe snowstorms. Plywood or masonite battens could be used and tacked with the plastic covering in one operation using longer staples.

Since the end frames are too heavy to be carried any great distance, it is recommended that they be built at each end of a basement excavation and merely tilted into position. It is also recommended that the soil from a basement be piled at each side of the excavation to leave a clear flat working area at each end.

The greatest opportunity for saving is during the covering operation. Sheets of 12-ft. wide polyethylene could be handled quite successfully by two men and would simplify this operation considerably. It would be necessary to work from two extension ladders to fasten the initial portion of the polyethylene roll at the crown of the arches.

The enclosure described in this paper must be completely dismantled and recovered each time it is used. As noted previously, the operational cost of erection and dismantling is 60% of the total cost per house (approximately $250), indicating that there is still room for improvement.



THIS SHOWS THE DIMENSIONAL details of the end frames of the shelter built over the site for the winter bungalow. It serves as a jig for shaping arch ribs.

DISMANTLING THE SHELTER with the house closed in was simple. Two workmen in rubber boots stood on the roof and carried the disconnected arch ribs to the end of the house and lowered them to the ground.

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