Assessment of proposal for the use of waste oil drums and other local material in the construction of housing units in the North of Canada

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TECHNICAL NOTE

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PREPARED FOR Suggestion Award Committee
Department of Transport

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SUBJECT Assessment Of Proposal For The Use Of Waste Oil Drums And Other Local Material In The Construction Of Housing Units In The North Of Canada

There are essentially two proposals contained in this submission. The first pertains to a method of reclaiming #18 gauge metal in the form of flat sheets from the used oil drums that have accumulated as waste material in many areas of the North; the second consists of a proposal for utilizing this reclaimed metal together with other available local materials such as Arctic moss in the construction of more economical buildings for the North. It is important that each of these suggestions be considered separately.

It is difficult to comment specifically on the practicability of the method proposed for cutting and shaping the metal from waste oil drums using simple machines and local labour. Some aspects of this proposal are questionable such as the feasibility of using only manual means to cut #18 gauge metal and to roll it out into flat sheets. Questions such as these can only be answered experimentally by developing machines of the type illustrated in the report. The authors do not appear to have done this.

A more detailed assessment has been made of the second proposal in the submission, that of utilizing the reclaimed metal and local materials such as Arctic moss in the construction of less costly housing units. In making this assessment both the technical and economic implications of the proposal have been considered.

TECHNICAL CONSIDERATIONS

Metal Sheets as Siding and Roofing

Condensation of water vapour within the elements of a structure is a major source of trouble with housing in many areas of Canada and can be particularly severe in the North. Exterior wall coverings, such as metal siding, having high resistance to water vapour flow, tend to complicate the moisture problem by trapping water vapour in the wall. They are therefore not recommended for buildings, such as houses, that are to be heated and some degree of humidity added.

If metal sheets are used on the exterior of such buildings, it is often necessary to apply these metal sheets over a material such as wood sheathing, which has some moisture storage properties, as this reduces the danger of condensed liquid water dripping into the insulation and generally wetting the interior of the wall. In addition it is generally considered necessary to provide for the escape of accumulated water vapour in the wall by venting the space behind the impermeable material. It is preferable, however, to avoid constructions requiring ventilation of this kind since the direct entry of cold air into a wall may seriously disturb the thermal conditions and in certain areas of the North may allow entry of moisture in the form of fine wind-blown snow.

Metal coverings may be used with somewhat less concern on the roof because it is common practice to ventilate the roof space above the insulation and in that way reduce the likelihood of condensation. It is still important, however, to provide a moisture storage medium such as a wood decking beneath the metal sheets, again to prevent condensed liquid water dripping on the ceiling and wetting the insulation. The authors propose in the report that the metal sheet be attached directly to the wall and roof framing system without the benefit of wood sheathing behind. This is not recommended except in those buildings where the humidity may be expected to remain at a very low level as, for example, in dry storage buildings and unheated structures.

The extent to which these metal sheets will provide a weathertight exterior surface will depend partly on the degree to which they can be rolled flat. Uneven sheets will be difficult to seal tightly at the overlap and may permit infiltration of wind and moisture. This is a particularly important factor where no sheathing material is used behind the exterior covering. The aesthetics of these metal sheet coverings is perhaps not a consideration here, but from the point of view of corrosion resistance there would seem to be a need for applying a protective coat of paint. The sheets would be particularly vulnerable to corrosion at the edges where they were cut during preparation. A major difficulty in the use of these sheets, as advocated by the authors, would be the fact that #18 gauge metal is extremely difficult to nail. Laboratory tests indicate that even 3-inch nails will bend without penetrating the sheet. Obviously the need for predrilling these metal sheets prior to attachment to the building frame would seriously limit their use in the manner proposed.

<u>Truss Construction</u>

On the basis of test work on wood truss construction carried out at the Division of Building Research, it appears that the safe load-carrying capacity of the truss detailed in the report would be somewhat less than the 50 lb. per sq. ft. claimed by the authors when these trusses were spaced at 4-ft. centres as indicated. Characteristics of such a truss can only be adequately assessed on the basis of structural tests in the laboratory. In much of the North, however, the snow load, according to the Climate Section of the National Building Code, does not exceed 30 to 40 lb. per sq. ft. This is the computed maximum snow load on the ground. Roof snow loads will probably be somewhat less and this Division is at present attempting to determine the relationship between this and the actual accumulation of snow on roofs. These trusses spaced at 2-ft. centres would very likely be adequate for any area in the North.

The 2- by 4-in. members set between the upper chords of the truss serve mainly as nailing pieces and contribute little to the over-all strength of the truss. It should also be noted that if 1-inch wood sheathing is to be applied to the trusses before attaching the metal roof covering, as was recommended earlier in this note, then the truss spacing must not be greater than 2-ft. centres. DBR test work has shown that a relatively larger number of nails are required at each truss joint connection than have been shown in the truss details in the report. These are necessary to transmit the stresses at these points and thus enable the full strength of the members to be developed. Holes for each of these nails may have to be drilled if #18 gauge metal gusset plates are substituted for the more commonly used plywood.

Arctic Moss Insulation

No information is available on the thermal conductivity value of Arctic moss but tests carried out at the University of Alaska in 1951-52 on small test buildings insulated with sawdust, local moss, and mineral wool insulation respectively, showed that walls built of 2- by 6-in. framing members with 6 in. of local moss between the members required 50% more heat to maintain the same temperature conditions than a similar wall insulated with 6 inches of sawdust and about 30% more heat than a wall built of 2- by 4-inch studs and insulated with 2 in. of mineral wool batts plus ½ in. of fibreboard. This would suggest that the thermal conductivity (k) value of the moss used in these tests was somewhat greater than the "k" value of sawdust which is usually taken as 0.40. On the other hand, some tests carried out by the National Research Council some years ago on a material marketed as peat moss indicated a "k" value of 0.29 when placed at 3.2 lb./cu. ft. density. It is know that the insulation value of fibrous materials of this type will vary greatly with the density to which they are placed and it may be assumed, therefore, that the moss used in the test buildings in Alaska is placed at a very low density. It may be difficult to place this type of material in a wall at the density required for optimum insulation value. A further consideration in using a material of this type is the difficulty of ensuring that all spaces within the wall are filled with insulating material and that no voids are left across which high heat flow may occur.

In the construction proposed in the report, the thickness of Arctic moss would be 4 in. and it is therefore to be expected that the heating requirements of such a wall, based upon the Alaskan studies, would be still further increased over the requirement of a conventional wall insulated with 2 in. of mineral wool. Unless an improved insulating value can be achieved by careful installation of the Arctic moss then the cost of heating an area enclosed by such a wall might be as much as 40% or more than heating a similar area enclosed by a wall built and insulated in the conventional way with 2 in. mineral wool batts. If full thick batts were used this difference would become even more pronounced.

Quite apart from the question of comfort conditions the cost of fuel in the North would make this type of construction unsuitable even for so-called primitive housing. The selection of insulating material for a wall is particularly critical where the possibility of condensation is increased by the use of impermeable exterior coverings such as has been proposed in this submission. Under such conditions a wall filled with a material such as Arctic moss may become quite damp and lead to serious deterioration within the structure. One final consideration with this material is that when dry it will support combustion.

Moss-clay-sand Plaster

In the absence of field experience with these materials as a plaster finish there is little in the way of a technical assessment that can be made at this time. A major question requiring consideration is the availability of the moss, clay and sand materials throughout the North in the form required to make this plaster. The answer to this will depend in part on the properties required of each material to ensure its suitability for the intended application and how critical variations in these properties may be. The authors of the report imply that a special type of moss is required in producing a plaster of the type described. If similar limits are placed on the other materials, this may mean that the material available at the site will not be suitable and additional material may have to be hauled a considerable distance.

The degree of control required in the preparation of this moss-clay-sand plaster is also important since it should be capable of being carried out satisfactorily using local unskilled labour. Finally, there is the question of general performance with respect to shrinkage-cracking and durability. The abrasion resistance of the material may be quite low unless mixed with a quantity of binding agent such as cement, in which case the cost would increase.

Floor Construction

The main weakness with the floor construction proposed in the report would appear to be the possibility of differential movement that might result from shrinkage of the moss-sand-clay mortar or from shifting of the individual barrel ends or metal planks. The floor system would not act as a rigid unit and any movement of the subgrade either from frost action in the active layer or melting of the permafrost would therefore be apt to cause unevenness in the floor and differential movement in the structure above.

Corrosion of the buried metal would be of some concern since it is very likely that the damp conditions conducive to severe corrosion would be created beneath the asphalt sealed floor making the life of the metal sheets in this location relatively short.

In areas where the permafrost must be preserved under a building it is very doubtful that the air spaces provided by the metal planks would serve the purpose of keeping heat losses to a minimum. The metal sheets have a high thermal conductivity and in many cases the air spaces would be blocked by drifting snow in the winter period.

The suitability of an asphalt-type floor for northern housing would depend upon the degree of latitude permitted in the choice of sand for inclusion in the mix, the availability of this sand in the North, the ease with which it can be obtained in the form required, the care and equipment required in preparing the asphalt mix, and the properties of the final product. Little technical data are available here on these aspects of the problem.

It should be realized that a floor of this type may be susceptible to indentation under loads and may also be softened by spillage of the fuel oil used for heating. If a suitable asphalt floor of this type can be placed by local labour economically it may be better to apply it over a gravel pad of the type commonly used in the North and eliminate both the metal and the moss-sand-clay mortar advocated in the report.

ECONOMIC CONSIDERATIONS

There is a lack of basic data on the economics of northern construction and it is therefore difficult to assess the over-all economies that may be effected in the construction of northern buildings by the proposal submitted. The effect of factors such as transportation and labour in the North have not been clearly established in relation to the completed cost of a building for various northern areas and this has led to a considerable variation in the reported cost of buildings at northern sites.

In contrast to the authors' statement that the cost in 1956 of constructing a dwelling in the Arctic with oil heating, sanitation and insulation was over $50 per sq. ft. is the fact that the Eskimo cabins built by the Department of Northern Affairs and National Resources at E.3, the new site of Aklavik, complete with electrical services, oil stove and chemical toilet, was $6000 or approximately $12 per sq. ft. If one adds $500 for improved plumbing facilities the cost is still only $13 per sq. ft. This Division erected two buildings at Norman Wells in 1955 to serve its Northern Research Station at a cost of $20 per sq. ft. These buildings were complete with electrical and plumbing facilities but lacked their own heating units. In the construction at E. 3 local lumber was used and some local labour. In the case of Norman Wells all building materials were brought in from the south together with skilled labour.

Even considering such factors there is a considerable difference between the cost per square foot reported by the authors of this proposal for construction in the North and the costs quoted above. It is because of the uncertainty that now exists over northern construction costs and the importance of the correct knowledge of these in making even a preliminary assessment of the effect on cost of new techniques of construction that this Division is planning a cost study of its own in this field.

Some indication of potential savings in building costs arising from this proposal can be had by considering the economies of using reclaimed metal in relation to conventional construction at a particular location such as Frobisher Bay. A cost comparison of this kind is provided in the following calculations.

Roofing and Siding

Assuming:

(i) that siding and roofing are placed over wood sheathing in all cases;

(ii) that the cost of transportation to Frobisher Bay including handling charges is $65 per ton;

(iii) that the labour required to place these materials is approximately the same in each case.

#18 gauge metal reclaimed from oil drums -

Cost of reclaiming metal sheet giving $2\frac{1}{2}$ x 5' ($12\frac{1}{2}$ sq. ft) coverage, by authors' estimate	$ 1.00
Cost/1000 sq. ft. coverage	80.00

Aluminum siding and roofing

Cost of aluminum/1000 sq.ft.	$120.00
Cost of transportation at $65/ton: $450 \times \frac{65}{2000}$	14.00
Cost of aluminum/1000 sq.ft. at site	134.00

The potential savings/1000 sq.ft. from the use of reclaimed metal: 134 - 80 $ 54.00

On the building shown in the report ($21\frac{1}{2}$' x 28') the savings would be

for siding $\frac{54 \times 792}{1000 \times 602}$ = 7¢/sq. ft.

for roofing $\frac{54 \times 616}{1000 \times 602}$ = 5¢/sq. ft.

Plywood siding

Cost of 3/8" plywood/1000 sq. ft.	189.00
Cost of transportation at $65/ton: $\frac{1250}{2000} \times 65$	41.00
Cost of plywood/1000 sq. ft. at site	230.00

The savings achieved/1000 sq. ft. by using reclaimed metal instead of plywood 230-80 $ 150.00

For the building shown in the report the savings would be $\frac{150 \times 792}{1000 \times 602}$ = 20¢/sq. ft.

Gusset Plates for Trusses - Plywood gusset plates require approximately 10 sq. ft. of $\frac{1}{2}$" plywood per truss:

Cost at 19.6¢/sq. ft. 1.96

In 28' long building with trusses at 2' centres 15 trusses are required.

Cost of plywood gusset plates for the building: 15 x 1.96 =	29.40
Cost of transportation of plywood at $65/ton: $250 \times \frac{65}{2000}$ =	8.12
Cost of plywood gusset plates at site	37.52

For the building shown in the report the potential savings using reclaimed metal for gusset plates would be $\frac{37.52}{602}$ = 6¢/sq. ft.

This would be offset by the cost of cutting the metal gusset plates and of drilling holes for nails through the metal gusset plates where required.

CONCLUSIONS

As this note indicates a number of reservations exist concerning various technical aspects of the method of building proposed in the report. With the type of construction proposed the danger of condensation and thus deterioration within the elements of the structure is increased. The practicability and performance of the moss-sand-clay plaster and of the special floor construction is not known. The latter is at best only suitable for well drained granular sites and is unlikely to satisfy the requirements for a foundation located in permafrost areas where the soil is subject to some movement on thawing.

Some of these questions can only be resolved by a more extensive technical evaluation than has been made here. Sufficient is already known, however, to indicate that the type of construction proposed is more suited to unheated storage buildings or other buildings in which the humidity is kept at a low level. When used for heated dwellings in the North, performance difficulties are very likely to arise. These performance factors need to be carefully evaluated in relation to any cost reductions that may be achieved.

In this connection and based on an initial study of the economics of the proposal it is difficult to see how the savings achieved by the proposed building system could approach the amount suggested by the authors. These predicted cost savings therefore need careful analysis. Calculations suggest that the use of reclaimed metal for siding, roofing and truss gusset plates of a building as a substitute for conventional materials might save from 20 to 30 ¢ per sq. ft. on a building of the size shown in the report. This is based on the assumption that the labour of applying these materials is essentially the same. It should be realized that such savings are achieved at the risk of increasing the chances of condensation within the structure of the building which may in turn increase the maintenance costs of the building and decrease its useful life.

The authors suggest that some further savings could be achieved by substituting Arctic moss as insulation in place of mineral wool but this must be offset against increased fuel cost resulting from lowered insulating value. The economics of the use of this material as insulation is also dependent upon the availability of the moss and the relative labour requirements of gathering and preparing it. Cost reductions achieved by the use of the moss-sand-clay plaster finish on the interior and by substituting the proposed floor construction for the conventional type are not readily estimated in any detail on the basis of present information. In any case these particular aspects of the construction are also the ones on which there is little technical information.

Finally, the method of reclaiming metal sheets from waste oil drums should be considered quite apart from the proposed building system and may be worthy of some further investigation. The extent to which the development of this idea is of value will depend upon the requirements that exist for metal in this form at northern locations and the uses to which such metal can be put. This is again a matter requiring further study.