Aluminum as cladding for buildings in Northern Canada

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TECHNICAL NOTE

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SUBJECT Aluminum as Cladding for Buildings in Northern Canada

Aluminum is a relatively new metal in the building field having been in commercial production for only some fifty years. Probably its earliest use in buildings was for sheet metal roofing and today its use is being steadily extended to include structural, weathering, insulating and decorative roles. This note concerns its use as roofing and siding for buildings with particular reference to Canada's Northland.

GENERAL REQUIREMENTS

No specifications have been developed by which the suitability of aluminum as a cladding for buildings can be assessed. Reference to the National Building Code of Canada indicates that metal coverings of aluminum alloy shall have a minimum thickness of 0.019 inches, except for accessory buildings which may be 0.010 inches, shall be fastened with nails or fasteners of aluminum alloy, hot dipped galvanized steel or stainless steel, and shall be made from an aluminum alloy conforming to Canadian Standards Association Specification No. HA4.2, HA4.3, HA4.57 or HA4.65, all dated 1948 and revised in 1951.

In contrast to these minimum Building Code regulations, the Building Standards of Central Mortgage and Housing Corporation require a minimum sheet thickness of 22 B&S gauge which is equivalent to 0.025 inches. The Minimum Property Requirements of the Federal Housing Act (F.H.A.) in the United States, which are similar in scope to C.M.H.C.'s Building Standards, require a minimum thickness of 0.022 inches for aluminum roofing and 0.025 inches for siding provided that these materials are applied over wood sheathing. In addition the aluminum alloy used is required to have a corrosion resistance approximately equal to that of alloys 2S or 3S, these alloys being covered respectively by the C.S.A. Specifications HA4.2 and HA4.3. In the case of roofing the F.H.A. Standards require a minimum ultimate tensile strength of 20,000 p.s.i.

In attempting to appraise aluminum roofing and siding

for buildings it should be noted that where it is intended to use fully supported aluminum sheets (as with roofing or siding over closed wood sheathing), the selection of a suitable alloy is unlikely to involve any question of strength other than that required to prevent damage to the roofing, particularly to the ribs or corrugations, during construction operations and subsequent repairs. The chief criterion of such a material would therefore appear to be its ability to provide a waterproof covering. This involves such factors as durability, particularly its resistance to corrosion, and also its ability to maintain a watertight covering under the action of expansion and contraction due to variation in temperature.

PROBLEMS IN USE

Atmospheric Corrosion

Aluminum products are considered superior to most metals in resistance to atmospheric corrosion due to the thin film of oxide which forms as a protective coating over the surface of the aluminum. This corrosion resistance varies with the type of alloy used, increasing with the purity of the aluminum. For instance, commercially pure aluminum designated 2S is reported to have the highest resistance to atmospheric corrosion. Manganese alloy designated 3S has a slightly reduced corrosion resistance but offers in return some slight increase in strength, while the high strength alloys containing copper which attain their tensile strength by heat treatment have the lowest resistance. To increase the resistance of some aluminum alloy sheetings to corrosion, a protective coating of aluminum is sometimes applied to both sides of the sheet. This technique has been used by the Aluminum Company of Canada to increase the corrosion resistance of their special alloy known as Kingstrong, which has been developed for use as ribbed or corrugated roofing or siding, the whole sheet being given the name Alclad.

While aluminum is generally quite resistant to corrosion a small but disturbing number of cases have occurred where serious corrosion has taken place. It is believed that some of these failures have resulted from conditions where water has been held for extended periods in thin films between lapped sheets so that the protective oxide film is not maintained.

Contact with Various Building Materials

There are also some doubts about the desirability of using aluminum in contact with concrete, plaster or mortar under damp conditions. The Aluminum Development Association considers it advisable to coat aluminum flashings with a bituminous solution wherever they are embedded or in surface contact with concrete, plaster or other alkaline building materials which are exposed to wetting.

Contact with Dissimilar Metals

Another matter of some concern is the susceptibility of aluminum to corrosion by electrolytic action which occurs when dissimilar metals are in contact in the presence of moisture. It is therefore important in applying aluminum to prevent direct metal contact of dissimilar metals. For this reason the National Building Code recommends the fastening of aluminum sheets to the roof deck or wall sheathing by means of nails or fasteners of aluminum alloy, hot dipped galvanized steel or stainless steel. It is also common practice in applying this material to use with the nail fastener a washer of non-metallic material such as Neoprene or impregnated fibre. The purpose of this washer is threefold; to prevent metal-to-metal contact between the underside of the nail head and the aluminum sheet, to seal the opening made in the sheet by driving the nail through it, and to permit thermal expansion and contraction of the sheet without causing leakage around the nail head. A type of washer recently developed consists of a cupped aluminum washer with a rubber washer cemented to the concave side. The aluminum washer prevents the sheet from pulling off over the nail head while the rubber washer provides the necessary sealing action. Occasionally lead washers are used but when the installation is close to the seashore, such washers are not recommended.

Thus, although atmospheric corrosion is unlikely to be a serious problem in the North, improper application of aluminum may give rise to other and more severe forms of corrosion and these can only be avoided by careful attention to details during installation.

Expansion and Contraction

The coefficient of thermal expansion of aluminum is approximately twice that of steel. However, with a modulus of elasticity only about one-third of that of steel, temperature stresses induced in an aluminum member for a given rise in temperature will be slightly less than two-thirds of those in a similar steel member.

Proper installation of the metalwork will prevent failures caused by expansion and contraction. Corrugated and ribbed aluminum roofing or siding will expand and contract without damage providing suitable washers have been used with the nail fasteners to prevent leakage around the nail head.

When flat aluminum sheet is used, expansion and contraction must be provided for in the joint between sheets usually by means of batten or standing seams.

Condensation

A further problem which may result from the use of

aluminum as an exterior cladding to buildings is that of condensation. Normally it is undesirable to apply a material which has a high resistance to the passage of water vapour, to the cold side of the insulation in a building. When using a metal covering, therefore, it is generally necessary to provide for the escape of water vapour by ventilation of each space behind the siding material. This may be obtained either by the use of openings in the siding itself or by applying the metal siding over vertical furring strips and venting the space behind the siding by openings at the top and bottom of the wall. In the case of roof construction this problem is not as serious providing adequate ventilation of the attic space is obtained. The problem may become more serious, however, in cases where the metal covering is applied directly over the framing members or over open spaced sheathing boards where the moisture storage capacity of the roof decking or wall sheathing is either reduced or eliminated. In such cases condensation tends to occur more readily on the cold metal sheet and upon a rise in temperature will drip more readily since the metal sheet has no capacity for holding moisture.

Noise from Rain, Hail and Wind

One final problem with the use of a metal covering is the noise that may result from rain, hail and wind, particularly on the roof.

ADVANTAGES

To offset these problems with the use of aluminum as an exterior covering for buildings, there are the advantages of little or no maintenance since aluminum is not generally painted except in cases of exposure in extremely corrosive atmospheres, lighter weight for shipping, good fire resistance, good lightning protection when properly grounded, mechanical strength and rigidity, and minimum effect upon durability by extremes of temperature.

Relative Weights of Roofing Materials

The relative weights of building materials may be of particular significance in the north and for purposes of comparison, the following is a list of the weights of some commonly used roofing materials when installed:

Weights of Roofing Materials Installed

Material	Approximate Weight of 100 sq. ft. installed - lb.
Aluminum 0.020" to 0.032"	35 to 60
Corrugated galvanized steel sheet	
22 gauge 0.034"	180
26 gauge 0.022"	120
Ribbed galvanized steel sheet	
22 gauge 0.034"	175
26 gauge 0.022"	120
Zinc sheet 20 gauge 0.040"	125
Copper Sheet	
16 oz. per sq. ft. 0.022"	130
10 oz. per sq. ft. 0.014"	80
Cement asbestos shingles	275 to 600
Asphalt shingles	130 to 325
Built-up roofing	400 to 675
Asphalt roll roofing	35 to 80

Note: A roofing square is a 100 sq. ft. area of finished roof. These weights may vary considerably, depending upon design of the material, allowance for lapping, etc.

Suitable Gauges

While the use of aluminum sheet in thinner gauges than other metals can often be justified on the basis of aluminum's greater resistance to corrosion, it should be noted that where equivalent rigidity is required the thickness of the aluminum may have to be increased, in some cases considerably, to compensate for its relatively low modulus of elasticity. For instance, steel has a modulus of elasticity three times greater than that of aluminum and thus, to make the rigidities equal the aluminum sheet needs to be about 50 per cent thicker than the sheet of steel as indicated in the following table. Its weight would still be only half that of the steel sheet.

Comparative Gauges for Equal Stiffness	
Gauge of Steel Sheet	Gauge of Aluminum Sheet
26	22
24	20
22	18

SUMMARY

The use of aluminum for the exterior of buildings has most of the advantages and disadvantages generally associated with metallic materials. However, it has the additional advantage of light weight and of superior resistance to atmospheric corrosion. There are no specifications which provide a complete basis for selecting a satisfactory material, but providing suitable alloys such as those listed in the previously mentioned C.S.A. specifications are used and the proper precautions during installation are taken, there is reason to believe that satisfactory service life can be expected under northern conditions.

There are three general types of aluminum roofing and siding on the market, namely corrugated, ribbed and flat sheet. Of these, corrugated and ribbed sheet probably have some advantage in the north in that they are more easily applied and more resistant to damage during rough handling.

The importance of proper installation cannot be over-emphasized and in all cases the manufacturers' directions should be carefully followed. A felt should be used between all aluminum sheeting and the wood backing. Corrugated and ribbed sheets should be installed with adequate side and end laps and the sheets should be applied beginning at the end of the building away from the direction of the prevailing wind to reduce the possibility of wind-driven rain or snow being forced between the lapped joints; nailing should be done only through the tops of the corrugations or ribs. Flat aluminum sheets are generally fastened together using a batten or ribbed seam, standing seam or flat seam, although the flat seam joint is usually restricted to roof slopes of 6 inches in 12 or greater and is not used at all on siding. Metal is not generally recommended for covering flat roofs and the slope on which aluminum roofing is applied should never be less than 3 inches in 12 and should be steeper where the manufacturer so requires. For added protection where the slope is less than six inches per foot or where maximum weather-tightness is required, a bead of caulking compound may be placed between the overlapping section of the sheets prior to placing the sheets.

This note has dealt mainly with the use of aluminum as an exterior cladding on conventional wood frame construction. Where aluminum is used in special constructions, especially those involving metal framing and metal cladding applied directly to the framing, each design should be considered individually and special attention should be paid in each case to thermal properties and to the control of condensation.