DESIGN AND CONSTRUCTION PROBLEMS AT THE CLINTON MINE OF CASSIAR ASBESTOS CORPORATION LIMITED

J. G. Drewe

The Clinton Mine of Cassiar Asbestos Corporation Limited is located 2,000 feet above sea level in the western Yukon Territory fifty miles northwest of Dawson, Y. T., at 64°28' North and eight miles east of the Canada-Alaska boundary which is at 141° West. Based on road construction, permafrost is discontinuous and widespread.

The western Yukon Territory and a considerable area of Alaska was not glaciated, the most acceptable theory being that it was depressed and water-covered during the various glacial periods. The terrain consists of rounded hills and rounded valleys formed by water erosion (Figure 1). The whole drainage system is a pattern of creeks and rivers in deeply cut valleys. Silt, sand and gravel are widespread and rock outcrops are infrequent. The climate is relatively dry with approximately 12 inches of precipitation annually. Temperatures are often severe from December through February and any equipment used requires special winterization. The summer season, although short, is usually dry and this assists construction.

When the decision was made to construct a plant, Kilborn Engineering of Toronto was employed as plant designers. Humphrey Construction of Vancouver was the general contractor.

Because the overburden in the valleys is often saturated and frozen roads in the area are constructed high on the hillsides, cuts are made with bulldozers and scrapers and allowed to thaw and drain before ballast is placed. All roads are gravel surfaced.

Aerial photographs at scales of 900 feet and 2,200 feet to the inch were used to make detailed contour maps of the mine and plant areas and of the townsite area. These served in the layout of the plant and townsite, the location of major structures, streets and access roads. Tree growth was of some assistance in locating areas with drainage.

In the mine area the overlying argillites and shales contain permafrost, but this ground is rippable where frozen and does not present a problem. Thawing produces wet drill holes occasionally and these require more expensive explosives.

The orebody is in a rounded hill and site testing indicated that a hill across Clinton Creek valley from the minesite would provide sufficient space for the plant in a well drained area. The location of the plant required the installation of a one mile long tramway to convey the ore from the crushing plant to the mill site.

In the plant site area permafrost was encountered at a depth of five to eight feet except under an airstrip cleared several years previously where the frozen ground had retreated to depths of 10 to 30 feet. Much of the overburden was a mixture of relatively dry fine sand and gravel, but there were layers of silt with high moisture content particularly toward the northwesterly end of the ridge and it was recommended that these be avoided. In preparation the plant area was stripped of all vegetation one year ahead of construction and allowed to dry out. Care was taken in the choice of building sites and, based on a recommendation to place concrete footings below the active layer, excavations were made by drilling and blasting to a depth of nine feet for the column and wall footings. These footings were placed on undisturbed ground in the permafrost. The mill building (Figures 2 and 3) and dryer building were located east of the old airstrip and aligned with the crushing plant site at the mine, on rock, and with a rock outcrop on the south slope of the plantsite hill which would provide anchorage for the long span of the tramline across the valley. Ice content of the fine sand and gravel was low and it was felt that settlement of the various structures could be tolerated.

The mill, which has been in operation for one year, is heated and no settlement has occurred to date. There is a pad of compacted gravel under the ground floor concrete slab. The dryer building and dry rock storage building are unheated. The yard areas have been graded away from the buildings and a general pattern of slope to the outer sides of the ridge maintained.

With the exception of sewerage, all pipelines between buildings are carried in a utilidor, 47 inch diameter steel pipe which was available at salvage prices in the Klondike area. The formed sections of this pipe had been brought into the area in the early part of this century by the Guggenheim interests and they were riveted at that time on site as part of a structure of ditches, flumes and siphons to transport water by gravity for a distance of 70 miles from the Ogilvie Mountains to the Klondike placer workings. This pipe is 5/8 inch thick and the 30 to 50 foot lengths obtained were welded together when placed at Clinton. The pipe was laid on compacted gravel so that its top was just below final grade. Expansion bay housings were of concrete. It was considered that this pipe would provide a rigid casing for the steam, condensate, water and fire lines which would not be affected by settlement in areas containing silt layers.

Sewer lines were of asbestos cement pipe laid on compacted gravel at a depth of six feet.

A 350,000 gallon capacity water tank and a similar fuel oil storage tank were placed on compacted gravel pads on undisturbed ground. The water tank was enclosed in an insulated housing and the space between the tank and the housing was heated.

Soil conditions at the townsite were very different. It is located six miles from the plantsite inside a bend on the Fortymile River, 200 feet above the river. Preliminary tests indicated permafrost at a depth of five feet and a fairly high moisture content. Augered test holes had been made at 600 foot intervals.

It was decided to place all buildings on piles (Figure 4) - drilling 18 inch diameter holes to a depth of 20 feet and placing pressure treated cedar piles with 8 inch diameter tops. The excavated material was backfilled and tamped around the piles for the bottom 13 feet and the top 7 feet filled with gravel. A cone of fine soil was packed around the pile at ground level to keep water out of the hole (Figure 5). In the Fall of 1966 piles were placed for construction the following Spring of the cafeteria and general store building. In the Spring of 1968 a drilling contractor was brought in and pile hole drilling was carried out for the residential houses, men's staff house, ladies' staff house and additional bunkhouses. These were drilled quite rapidly using a truck-mounted drill and tungsten carbide tipped auger bit. Some drilling was done using ordinary auger bits and barrel bits, but these proved slow and unsatisfactory in hard frozen ground.

The overburden consisted of various mixtures of sand, silt and gravel. In areas of silty gravel the permafrost was just under the moss cover and in other areas there was no frozen ground for almost 20 feet. Ice was evident, but there were no lenses of any size. To preserve the trees, clearing was limited to the foundation areas and access to move in the prefabricated housing units. One area, which was clear of trees and had been used as hay land many years ago, was avoided because it displayed a pattern of depressions where the receding permafrost had caused subsidence. This area was poorly drained.

The streets follow approximately the ground surface contours and a careful pattern of drainage ditches has been laid out so that the Spring run-off may be controlled and water kept away from the pile foundations.

The same 47 inch diameter pipe was used as the principal utilidor in the townsite. As before the pipe was laid on compacted gravel with the top of the pipe just below grade. Expansion joint housings were of tight wooden cribbing erected on a reinforced concrete slab and provided with a drain. The utilidor was laid up the slope from the powerhouse and, in the townsite area, formed a 900 foot square servicing all the major structures and most of the houses. It contains steam, steam return and water mains and some electrical service. Fire hydrants were welded into the top of the utilidor so that the valve was in the warm pipe.

Where the steam and water lines branch off from the main utilidor to service six houses to the south, the steam, steam return and water pipe were laid within a few inches of each other on compacted gravel in a shallow two foot deep trench in the active layer. Around the piping, blocked to grade, Gilsogard insulation was compacted in 4 inch layers with a 7 inch cover and 5 inches on either side and beneath the pipe. This material, a granular hydrocarbon with high resin content, excludes ground moisture and contains the heat loss from the various pipes. To the north, servicing another group of houses, the main water line which branches off and returns to the utilidor, is a 6 inch asbestos cement pipe insulated and protected from ground moisture by Gilsogard. Branch water lines in this section are of 3/4 inch diameter copper pipe traced with heating tape to each house. In the unheated crawl space under the houses, the water supply and drainage had to be protected by an insulated housing which was heated. A limited number of bleeders were used to prevent overloading of sewage disposal plant.

The sewerage system is a separate system. Asbestos cement pipe is laid at a depth of 6 feet or more, the excavation being performed in dry weather and the pipe laid on compacted gravel. In some areas planking was laid in the partially backfilled trench where the soil was of a compressible type. Generally, the main sewer lines follow the upslope side of the streets and drain the two rows of houses above that street. Branch sewers to the houses are laid in a similar manner. Asbestos cement pipe was laid in 13 foot lengths using AC couplings which give a flexibility of 7°. In some cases it was felt that half lengths might have been better where the soil was compressible.

The winter of 1968-69 should be a good test of the installation because only 8 inches of snow fell in December accompanied by air temperatures of -40° to -50°F. Some breakage of steam and water pipes will probably occur and valves are located so that any section may be segregated for repair. One sewer line break occurred the previous winter possibly because of permafrost being very close to the trench bottom.

The temperature of the perennially frozen ground at Clinton and Dawson is approximately 28° to 29°F at a depth of 10 feet. Currently, a convection cell and thermocouples have been installed at the site proposed for the new hospital at Dawson to determine the effectiveness and cost of permanently freezing the soil over the area of the building.

It is apparent that the solution of construction problems under permafrost conditions is, to a considerable extent, governed by local conditions. Thorough site investigations are necessary. Excavation in dry weather is beneficial. Provision of careful surface drainage is essential to the stability of foundations.

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Discussion

Mr. H. A. Carswell asked what loads were carried on the pile foundations. Mr. Drewe replied that loads were not fixed except in the case of one large building where the piles were loaded in a particular manner. The average house weighs 20,000 pounds and is supported on 18 piles.

Fig. 1 Hilly terrain at Clinton Mine.

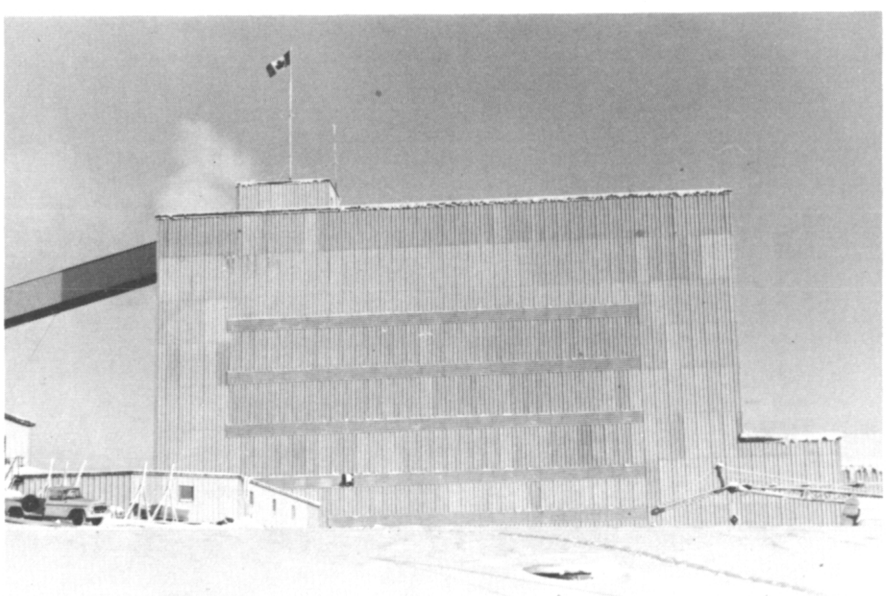

Fig. 2 Mill building at plant site on sandy gravel.

Fig. 3 Service building at plant site on sandy gravel.

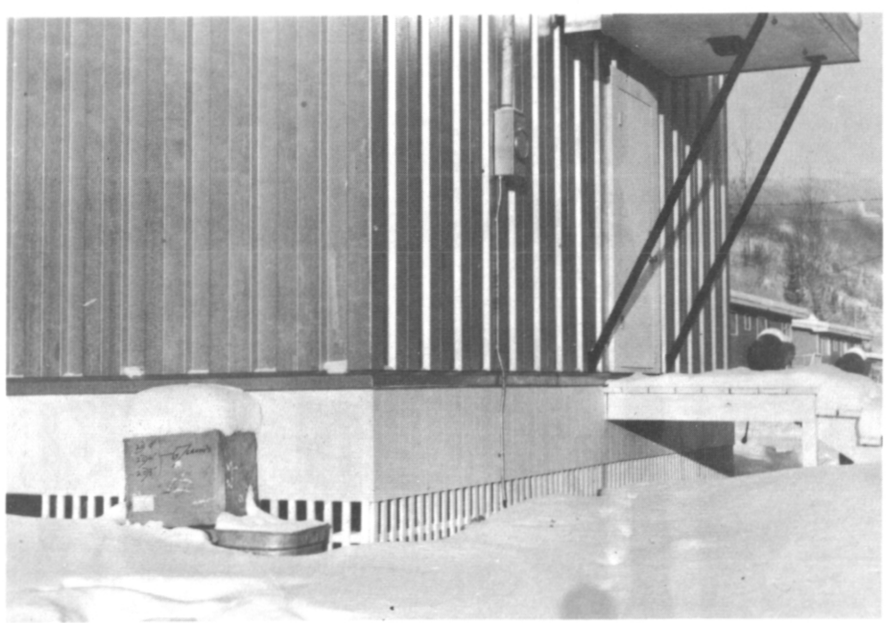

Fig. 4 Telephone Exchange Building on pile foundation
with ventilated skirting.

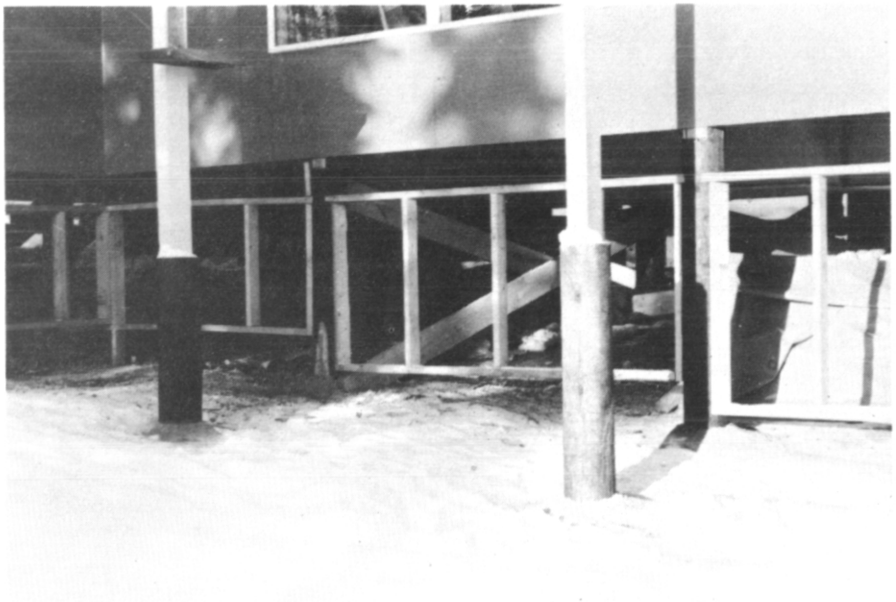

Fig. 5 Cones of silt to keep surface water away from piles.

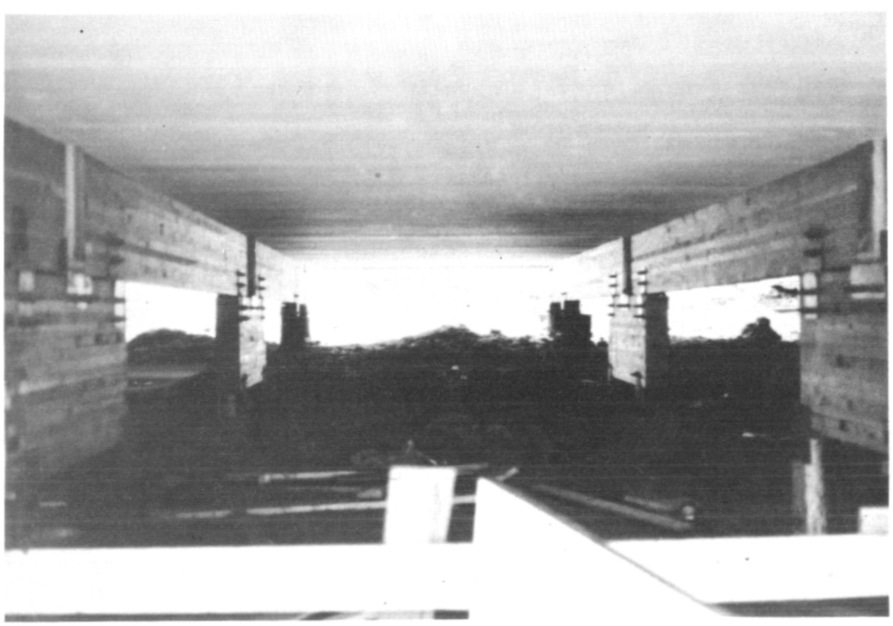

Fig. 6 Cafeteria building on piles with laminated caps.