Survey of basements in Aklavik

Dickens, H. B.

NATIONAL RESEARCH COUNCIL

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A SURVEY OF BASEMENTS IN AKLAVIK

by

H. Brian Dickens

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PREFACE

An important feature of the work of the Division of Building Research in connection with building in the North is the study of permafrost and its effect upon construction. In recent years much of the Division's work in this field has been carried out in the vicinity of Aklavik with the object of providing assistance to the Department of Northern Affairs and National Resources in the technical problems arising from the proposed relocation of this Arctic community.

One of the problems under consideration is the feasibility of constructing basements at the new site of Aklavik. Technically there appear to be many difficulties in the construction of basements that will perform well in permafrost areas where the soil is subject to settlement on thawing. These technical difficulties tend to make the construction of basements uneconomical. In practice, relatively few basements have been built in such areas and there is virtually no published material on the performance of basements in permafrost.

This survey was therefore initiated, at the request of the Department of Northern Affairs and National Resources, to provide information on the construction and performance of the few basements that had been built in the original town of Aklavik. The data obtained are contained in this report.

The study indicates that the performance of nearly all basements at Aklavik left much to be desired and confirmed the need for special construction features if the performance problems of basements in permafrost are to be overcome. Detailed cost analyses were not made but there is every indication that the cost of basement construction that would perform well would be very high - so high, in fact, that it will usually prove more economical and certainly less troublesome to avoid basements altogether and to provide equivalent enclosed space above grade.

Ottawa,
February, 1957.

Robert F. Legget,
Director.

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by

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In September 1954, the writer made a general survey of the buildings at Aklavik in order to obtain information which would assist in the planning of the proposed move of this Arctic community. The results of that survey were reported in Special Report No. 17 (SPX 17) of the Division of Building Research dated November 1954. To assist further with the proposed move, the writer revisited Aklavik in August 1956 and made a detailed field survey of the condition of the basements in that permafrost area.

The results of this study have been recorded in this report in three parts. Part A provides a general record of the survey and its purpose, and includes a statement on the survey procedure, together with a description of the area and the soil. A detailed record of the results of the survey is given in Part B, in the form of a tabulated summary of the basements surveyed, followed by a detailed description, (with sketches and photographs), of the history, construction, and condition of ten basements that are representative of the types of basements in Aklavik. Part C contains a summary of the findings of the survey and concludes with some general comments on the construction of basements in permafrost.

PART A

GENERAL RECORD OF SURVEY

Survey Purpose and Procedure

This survey was designed to provide field data on the performance of basements in a permafrost area and first-hand information on the construction and condition of basements in use at the present site of Aklavik.

For the purpose of the survey a basement has been defined as any excavated area, regardless of size, construction, or condition, that is in use beneath a building for storage or one of the other functions normally associated with a basement space. There are seventeen basements in Aklavik; each was examined and the information obtained has been recorded in summary form in the table on pages 4 and 5 of this report.

Ten of these basements, representing the major types of basement construction at Aklavik, have been described in detail.

The information obtained, which is recorded in this report, is based on visual observations and talks which the writer had with the local residents during the four-day survey, August 21 to 24, 1956.

The Area

The town of Aklavik, latitude 68° 12'N, longitude 135° 00'W is located approximately half-way down the Mackenzie River Delta on a western channel of the river. The Mackenzie Delta, about 100 miles long and 50 miles wide, is distinguished by low, flat topography, and is interlaced and dissected by numerous lesser channels and spotted with thousands of stagnant lakes.

The settlement of Aklavik, 120 miles north of the Arctic Circle and 40 miles south of the Arctic Ocean, is chiefly a centre for fur trading, government administration, and missionary activities. It has a permanent population of about four hundred, that increases to nearly fifteen hundred when Eskimos and Indians move in from the surrounding delta during the summer months.

Its climate is continental. The mean annual temperature is 15°F. with a July mean of 56°F. The mean annual rainfall is 4 inches and snowfall is approximately 5 feet. Winter begins in late September and lasts for a least seven months. Sixty-six days of the year only, are normally free from frost.

The Soil

The soil at Aklavik is typical of deltaic deposits. Tests carried out by the Division of Building Research in 1953 indicate that the soil to a depth of 35 feet is predominantly silt with layers of fine sand and organic material without a trace of coarser particles.* The organic material ranges from black, hairline streaks to strata 2 feet thick and is composed of a mixture of decomposed and partly decomposed organic matter. The moisture content of the soil occurs mainly as ice and is high, ranging between 50 and 85 per cent by volume. It varies linearly

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* Permafrost investigations at Aklavik (drilling and sampling) 1953, by J.A. Pihlainen and G.H. Johnston, NRC No. 3393, January 1954, 47 p.

with depth for the first 10 feet but below this the moisture content remains generally constant. Ice segregation in the Aklavik soils consists mainly of horizontal ice lenses from hairline to 3/4 inch thick with some small random vertical ice formations.

The ground is permanently frozen to a depth of several hundred feet and only the top few inches, known as the active layer, alternately freezes and thaws with the seasons. The depth of this active layer varies with the ground cover. In areas where the original vegetative cover has not been disturbed the depth of the active layer averages 18 inches. Under roads and other cleared areas the active layer may be 4 feet or more deep. Under some buildings which have been in use for many years the permafrost has receded to depths up to 10 feet.

PART B

DETAILED RECORD OF SURVEY

TABULATED SUMMARY OF BASEMENT SURVEY

(1) Lot No.	(2) Page No.	Building			Basement			Persons Contacted
		Description	Size (feet)	Year Built	Details of Construction	Size (feet)	Year Built	
4	6	R.C.Mission Kost House	27x64	1932	Walls lined with wood sheathing on wood posts - concrete floor	10x40	1953	Father Biname
8	9	R.C.Mission School	50x132	1932	Battered reinforced concrete walls, 8" at top, 16" at bottom - 12" reinforced concrete floor	full-size	1948 1949	"
8	12	R.C.Mission Hospital	35x80	1925	Vertical 6"x6" timber walls caulked and finished on outside with tarpaper, shiplap's pitch - 12" reinforced concrete floor	full-size	1950	"
9	15	R.C.Mission House	30x40	1941	2"x4" stud walls lined with 1"x6" boards to mid-height - 4" concrete floor	15x30	1941	"
9		R.C.Mission Log Building	20x30	1932	Walls lined with 2"x8" planks - concrete floor	12x16	1955	"
12	17	HBC Manager's Residence	30x48	1949	Walls of 2"x10" planks on 4"x4" posts at 3-foot centres braced with 6"x6" posts behind - 4" concrete floor	24x30	1949	Mr. Figgures (Manager)
15		DND-RCCS Station	18x30	1926	Walls lined with 1"x8" boards - floor of 3" boards over wood sills on the ground.	Begun 1926 enlarged to 12x16 later		Warrant Officer Dave. Allison
16		DND-RCCS Dwelling	22x28	1936 (3)	Wood stud walls lined with 1"x8" boards and some transite. Wood strip flooring over wood sills on the ground	full-size	1936	"
17	20	DND-RCCS 1 1/2-storey Dwelling	22x28	1948	10" concrete stud walls, 4 1/2' high - 10" to 12" concrete floor	10x16	1948	"
26	24	RCMP Inspector's Residence	28x28	1950	Conventional concrete basement - 10" walls, footings and 6" floor	full-size	1950	RCMP Constable

See notes 1, 2, and 3 at end of table.

TABULATED SUMMARY OF BASEMENT SURVEY (Cont'd)

(1) Lot No.	(2) Page No.	Building			Basement			Persons Contacted
		Description	Size (feet)	Year Built	Details of Construction	Size (feet)	Year Built	
13		NA and NR Dwelling	30x33	1932	Wood-lined walls on posts - wood plank floor over wood sills on the ground	Begun 1932 enlarged to T-shape later		Mr.Zeeman
27B	28	NA and NR Sub-District Administrator's Residence	23x26	1948	Conventional concrete basement - 10" walls, footings and 4" floor	full-size	1948	Mr.Burton Mr.Cooper
28 and 29		Anglican Mission Cathedral	25x76	1938	Walls of rough wood slabs placed vertically - floor of wood planks over earth-concrete slab under furnace	10x25	1938	Archdeacon Webster Mr.Willis Mr.Edwards
30 and 31		Anglican Mission Hospital	56x80	1936	Walls lined with wood boards of random width and some fibreboard. Wood plank floors on wood sills 18" above earth level with sawdust between	30x30	1936 to 1953	"
32		Anglican Mission School Principal's Residence	22x28	1935	Walls lined with wood board - 8" wide wood plank floor on wood sills	12x14	1935	"
32	32	Anglican Mission School	73x130	1936	Walls of vertical logs at 4' to 5' centres lined to mid-height with wood boards. Unfinished floor except for wood planks laid on wood sills to serve as walkways	begun 1936 enlarged later to include 1/2 bldg.area		"
39	36	DND-RCN Commanding Officer's Residence	21x30	1935 (4)	8" concrete walls. 8" concrete floor placed over rough wood flooring on 2"x8" joists laid in 4" gravel fill	full-size	1953	Mr.Wilkinson and Mr.Cooey

Notes:
1. Lot numbers are based on the Department of Mines' and Resources' plan dated Ottawa, 19 May 1947.
2. Page numbers refer to pages of this report on which detailed descriptions of the basements are given.
3. This building was originally built in 1936 but was rebuilt in 1948 after a fire.
4. This building was built in 1935 by the Hudson's Bay Co. but was sold to the R.C.N. and moved to its present location in 1953.

DETAILED DESCRIPTIONS OF REPRESENTATIVE BASEMENTS

R.C. MISSION KOST HOUSE (TEMPORARY SCHOOL - Fig. 1)

Location: Lot No. 4

Person Contacted: Father Biname

History: The building (27' x 64'), of log construction on surface foundations, was built in 1932 without a basement. The present basement (10' x 40') was dug in 1953 to permit installation of a gravity-type warm air furnace. Previously, the building had been heated by space heaters on the first floor level.

Basement Details: (Fig. 2). The floor of the basement is concrete. The walls consist of vertical wood members at approximately 3-foot centres lined to mid-height with wood boards. The floor above is supported on log joists resting on heavy timber beams and posts (Fig. 3). Drainage-water collects in a sump pit in the floor and is pumped out at intervals with a hand pump fastened to the basement wall.

Condition: The concrete floor is badly cracked and there is evidence of considerable leakage into the basement through the floor. A groove 1 1/2 inches wide and 1 inch deep has been cut into the concrete floor presumably to lead accumulated water to the sump. The wood walls have been pushed-in several inches by the pressure of the earth behind. At a few locations wood cross braces have been placed to keep the walls of the basement in place. The posts supporting the main beams have been shimmed up as much as 4 inches to compensate for settlement that has occurred (Fig. 3).

Remarks: The ground under the building was still frozen when the basement was dug in 1953. The heat from the furnace has since thawed the unexcavated ground around the basement, causing settlement and a generally wet condition.

This basement is similar in construction and condition to the basements under the R.C. Mission Log Building and the Anglican Mission Cathedral.

Figure 1 R.C. Mission Kost House.

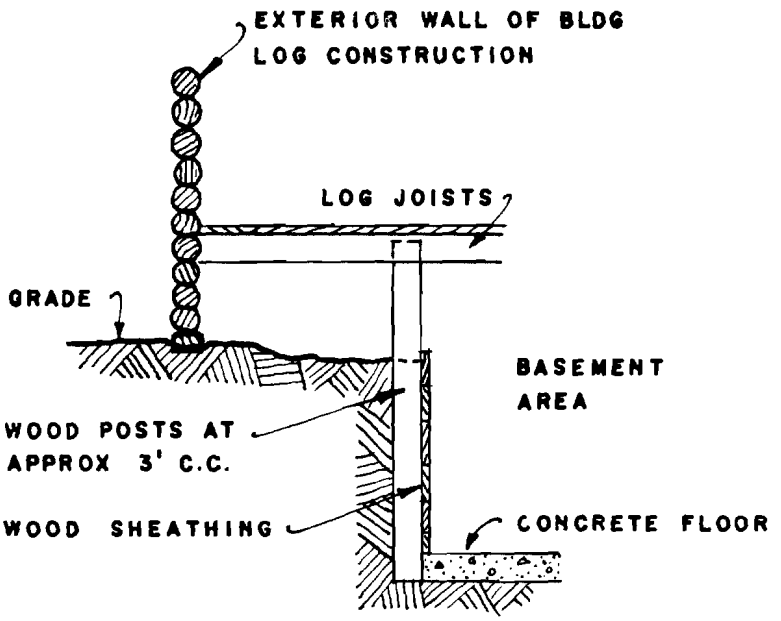


FIGURE 2 BASEMENT SECTION

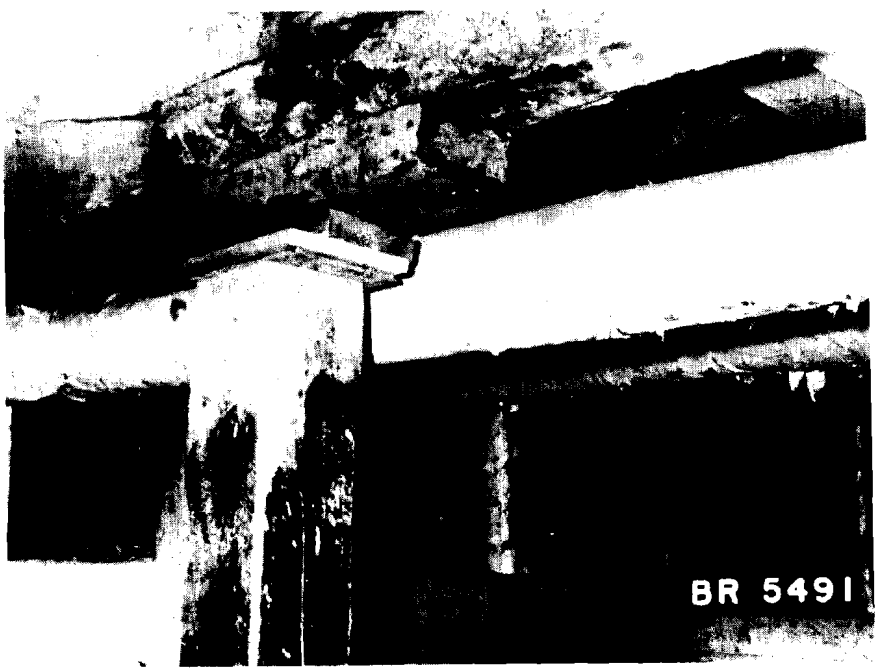


Figure 3 Basement Construction.

R.C. MISSION KOST HOUSE

R.C. MISSION SCHOOL (Fig. 4)

Location: Lot No. 8

Person Contacted: Father Biname

History: This frame building (50' x 132') was built in 1932. At that time a 30- by 80-foot excavation was made under the building to provide space for warm air furnaces and storage. The walls of this excavated area were lined with logs and the posts supporting the floor construction above were carried on logs laid to form raft footings. Concrete was placed under the furnaces only.

The exterior walls of the building were supported on short wood posts which in turn rested on surface foundations of 6- and 8-inch logs laid as a pad 5 feet in width. The present basement which extends under the entire building was constructed in two sections - the western section in 1948, and the eastern section in 1949. The building is now supported on the concrete basement wall.

Basement Details: (Fig. 5). The floor of the basement is 12 inches of unreinforced concrete placed over a rock fill. The concrete walls, 8 inches at the top and 16 inches at the base, are reinforced and are supported on a continuous concrete footing. The floor above is carried on 2- by 10-inch joists, 8- by 8-inch and 10- by 10-inch wood beams, and posts at 12-foot centres.

Sump pits in the floor, equipped with hand pumps, handle the drainage. The mechanical equipment in the basement includes warm air furnaces and water storage tanks.

Condition: The basement of this building is generally in good condition. The concrete floor is rough in a number of spots apparently due to the application of a new concrete topping which was too thin and has been breaking up and scaling off.

There are a few cracks in the floor but none are serious. One crack, along the middle third of the building about 3 feet from the south wall, suggests that this wall has undergone some settlement and caused the floor near it to tilt and crack. Movement of this south wall is reflected in the shimming which has been necessary under the floor joists at their point of support on the wall. Minor shimming was also necessary under beams at the top of posts. The basement was dry, although water stood in the sumps to within a few inches of the floor level.

Remarks: Father Biname reported that for several years after the building was constructed there was considerable seepage of water into the excavated space beneath the building. Initial seepage into the excavated area was removed by a siphon; later the incoming water was controlled by pumps.

Father Biname also stated that this seepage was accompanied by general settlement of the soil in the area beneath the building which led to considerable movement of the log surface foundations and a cave-in of the logs lining the walls of the excavated space. The building had to be re-levelled at frequent intervals during this period.

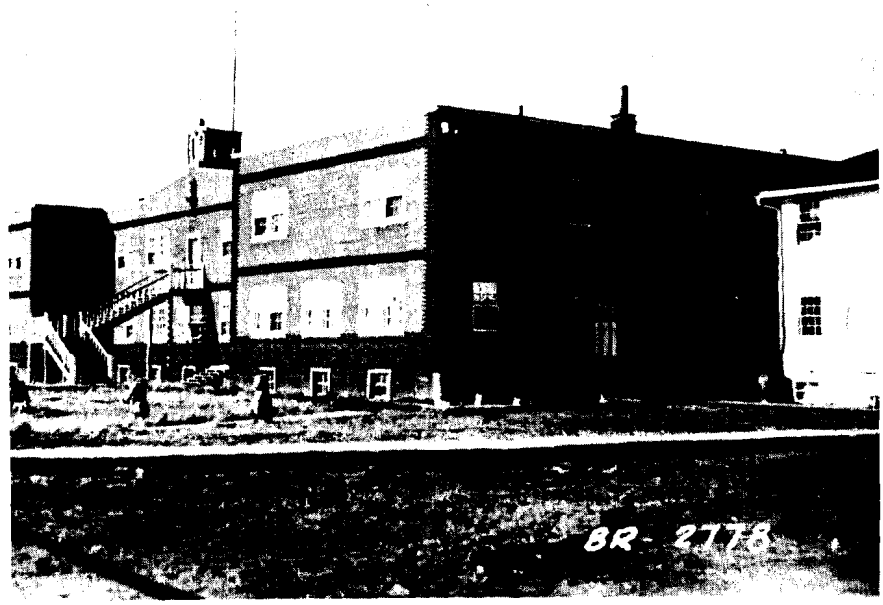


Figure 4 R.C. Mission School

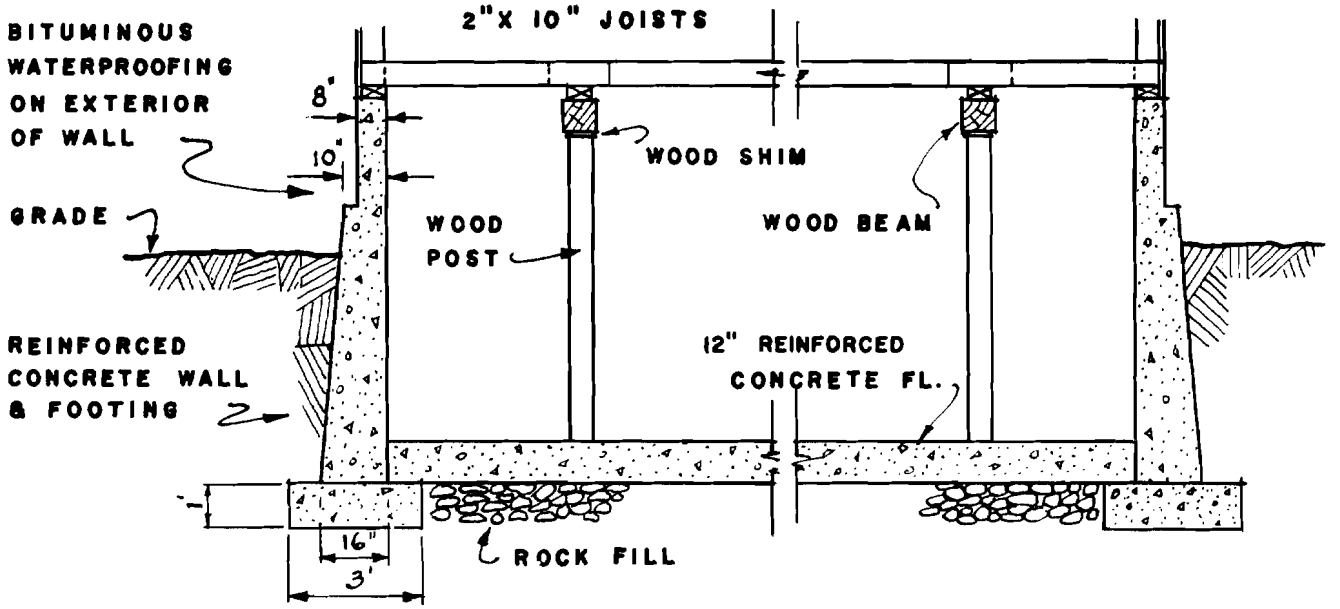


FIGURE 5 BASEMENT SECTION

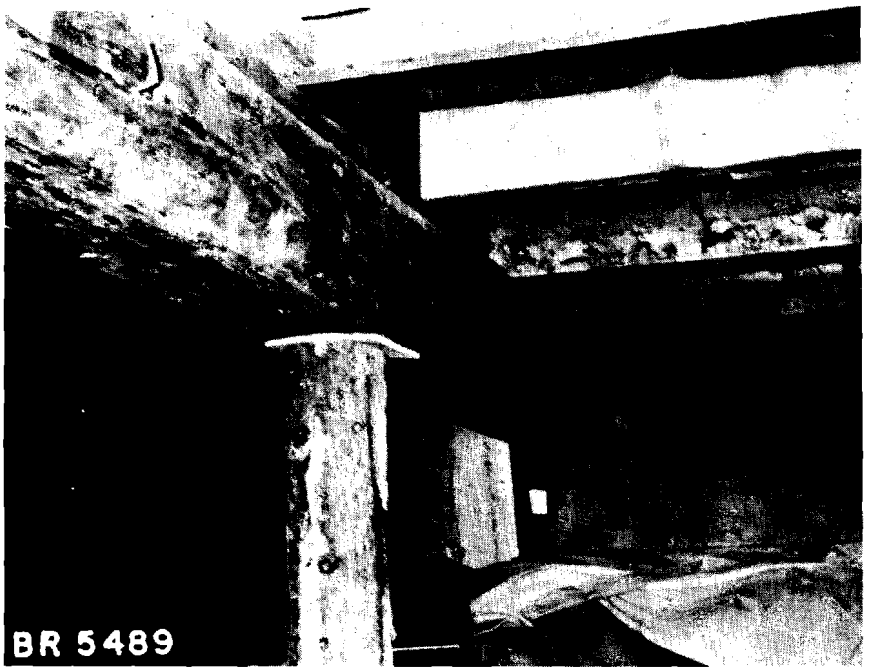


Figure 6 Basement Construction

R.C. MISSION SCHOOL

R.C. MISSION HOSPITAL (Fig. 7)

Location: Lot No. 8

Person Contacted: Father Biname

History: This frame building (35' x 80') was built in 1925 to serve as a school. When the present school was built in 1932 this building became a hospital. The original basement was a 20- by 20-foot excavation beneath the building to provide space for two warm air furnaces. The walls of this excavated area like those in the school, were lined with logs and the floor was concrete only under the furnaces. The building itself was supported on surface foundations of posts on log pads.

The basement was enlarged in 1950 to include the area under the whole building.

Basement Details: (Fig. 8). The existing basement has the same floor construction as the school - 12 inches of concrete on rock fill. The walls, however, are 6- by 6-inch timbers laid vertically, caulked, and finished on the outside with tarpaper, shiplap and pitch. There is mechanical equipment in the basement including two warm air furnaces and a boiler. Part of the basement has been partitioned off as living quarters.

Condition: The general condition of this basement is the same as that of the school. It was reasonably dry when examined. Father Biname reported that water was no longer a problem and the subsurface drainage is being handled satisfactorily by the sump pump.

Remarks: When construction of the present basement was started in 1950 it was found that the permafrost under the building had receded to a considerable depth. Observations taken at that time and reported in the field notes of D.B.R. staff members indicate that the permafrost had receded to a depth of more than 8 feet beneath the furnace.

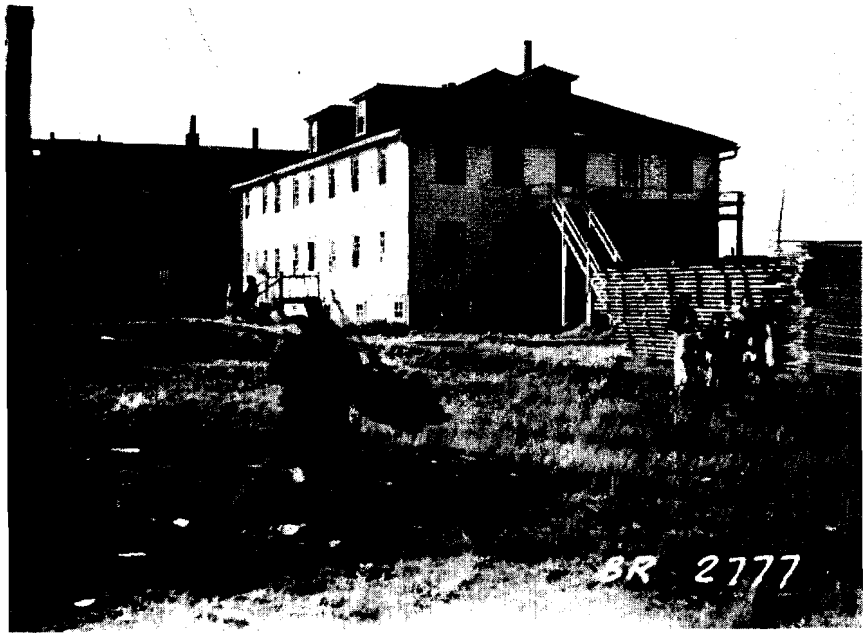


Figure 7 R.C. Mission Hospital

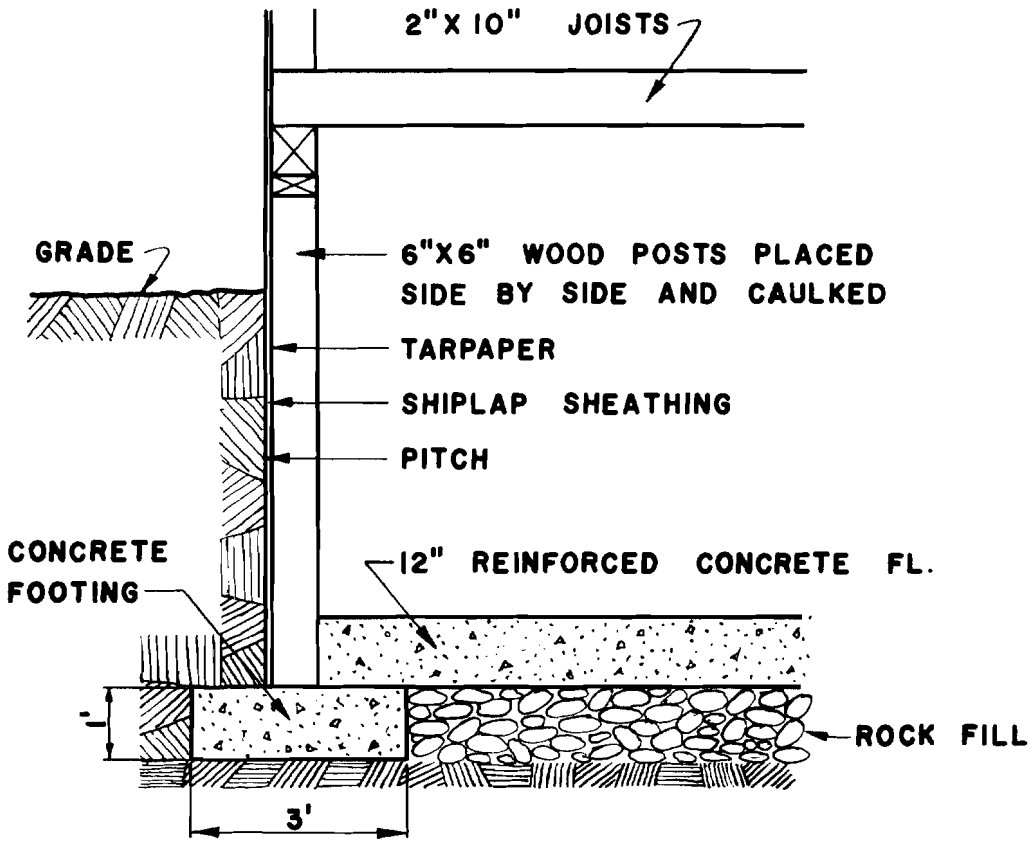


FIGURE 8 BASEMENT SECTION

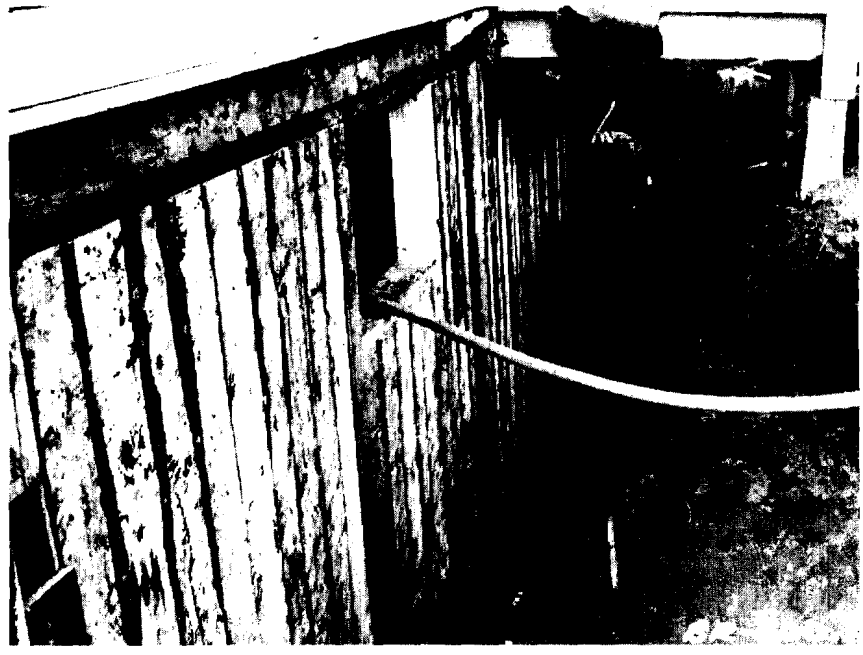


Figure 9 View of Hospital basement taken on August 11, 1950 during construction showing 6- by 6-in. post walls

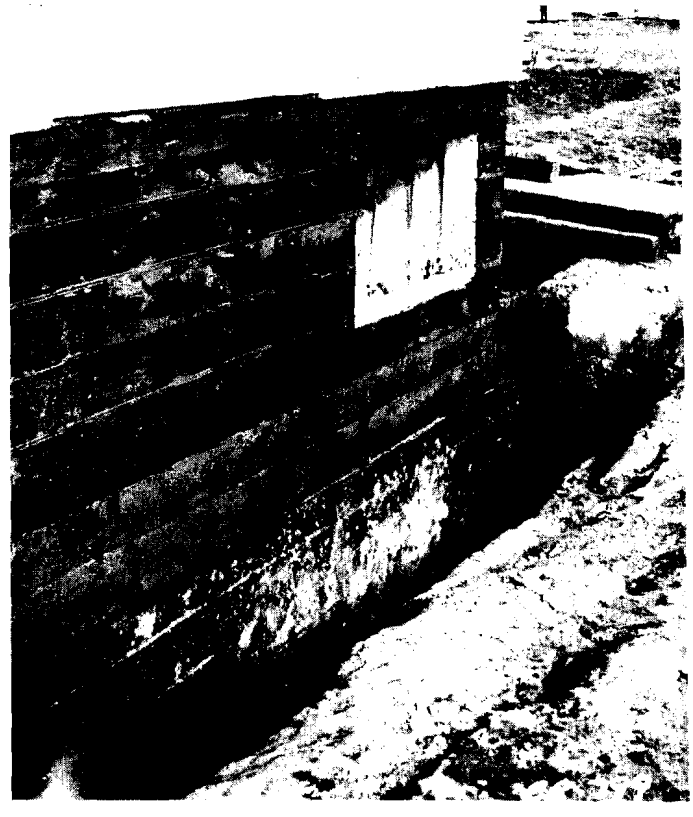


Figure 10 View of Hospital basement taken on August 11 1950 during construction showing complete section of wall with tarpaper, wood sheathing and pitch applied over the 6- by 6-in. posts

R.C. MISSION HOUSE (Fig. 11)

Location: Lot No. 9

Person Contacted: Father Biname

History: This frame building (30' x 40') and the existing basement area (15' x 30') were constructed in 1941.

The building itself is supported on 8- by 8-inch wood posts, which were placed on mud sills in a trench 3 feet deep. The trench was backfilled with sawdust as insulation.

Basement Details: (Fig. 12). The floor of the basement is reported to be of 4-inch thick concrete. Under the furnace a thicker concrete pad has been used. The walls are 2- by 4-inch studs lined with 1- by 6-inch boards on the inside to a height of 4 1/2 feet. Sawdust has been placed between the exterior foundation and the basement wall. The centre 10- by 10-inch beam is supported in the basement area by one post. A sump pit in the floor is pumped out at intervals with a hand pump.

Condition: The concrete floor was covered with a thin layer of dirt and sawdust and its condition was not easily determined. Parts of the floor that were examined were roughly finished and damp, indicating leakage or overflow from the sump, which was full and needed pumping.

The walls which were not load-bearing had pushed-in slightly due to pressure of the earth behind. A 3 1/4-inch shim has been placed at the top of the post in the basement area to raise the beam. Some movement of the posts at the perimeter of the building was also reported.

Remarks: Notes from an earlier survey of this basement indicate that in 1950 the post which supported the beam over the basement area, had settled 10 inches and cracked the concrete around it. To compensate for this movement, the building had been jacked up in 1950 and a 10-inch shim placed on top of the post. The area of cracked concrete had evidently been replaced.

Records indicate that the permafrost was 2 feet below the surface at the time of construction in 1941. By 1950 the permafrost had receded to a depth of 3 to 4 feet beneath the building.

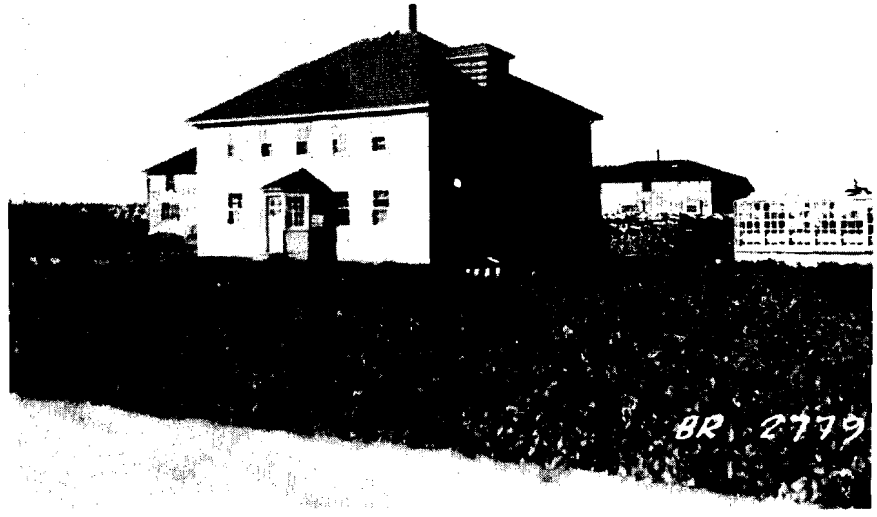


Figure 11 R.C. Mission House

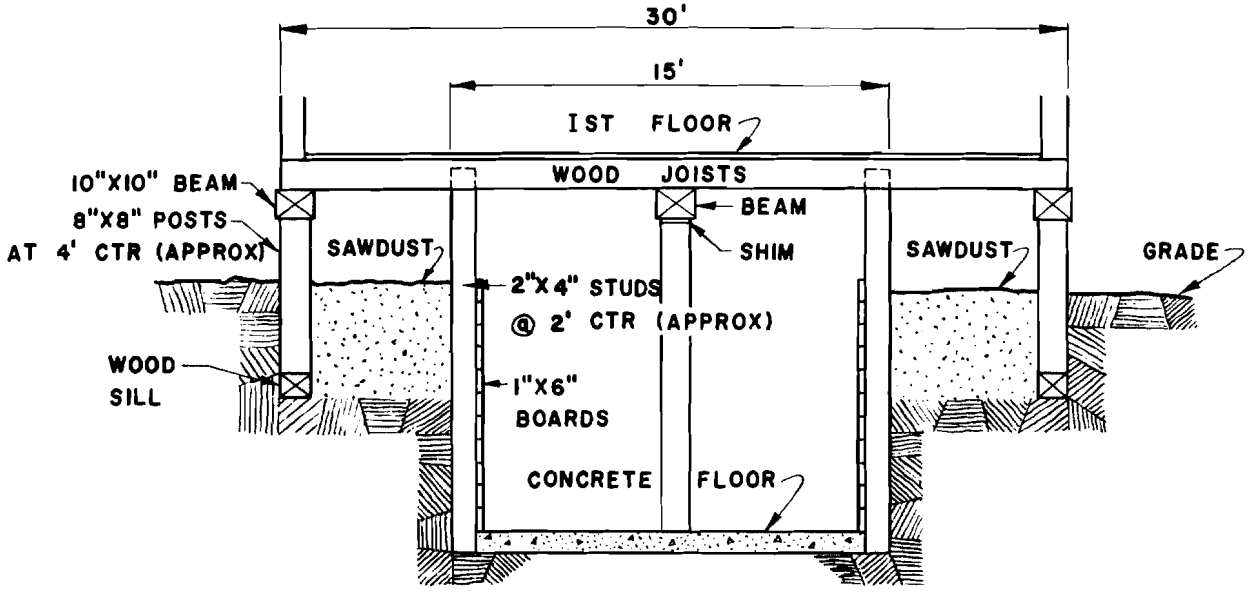


FIGURE 12 BASEMENT SECTION

H.B.C. MANAGER'S RESIDENCE (Fig. 13)

Location: Lot No. 12

Person Contacted: Mr. H. Figgures (Manager)

History: The present building (30' x 48') was constructed in 1949, with a basement under the west half of the building. This building replaced an earlier structure that had occupied this same area since 1928. The first building had an excavation under it approximately one-half the size of the basement of the present building.

Basement Details: (Fig.14). The basement walls are constructed of 4- by 4-inch posts at 3-foot centres finished on the outside with 2- by 10-inch planks covered with roofing paper. They are reported to be carried on a concrete footing 2 feet wide and 10 inches deep. The floor, said to be 4-inch thick concrete, is laid on a 4-inch insulating layer of sawdust. The basement is equipped with an oil-fired warm air furnace and a sump with automatic pump.

Condition: The floor of this basement showed a few minor cracks but its general condition was good. There was some evidence of dampness (Fig. 16); it was reported, that enough leakage had occurred on a number of occasions to necessitate care in the storage of food supplies in the basement. A groove, several feet in length, had been cut into the concrete floor presumably to obtain better drainage to the sump.

The wood walls of the basement had pushed-in several inches due to earth pressure and it had been necessary to erect 6- by 6-inch posts behind the 4- by 4-inch posts to brace them against movement.

Remarks: The portion of the building over the unexcavated area is supported on 10- by 10-inch concrete posts on 2 ft. by 2 ft. by 1 ft. concrete pads approximately 10 feet apart. The tenants reported differential movement of the structure above grade, which resulted in doors and windows sticking and partitions separating from adjacent walls and ceilings.

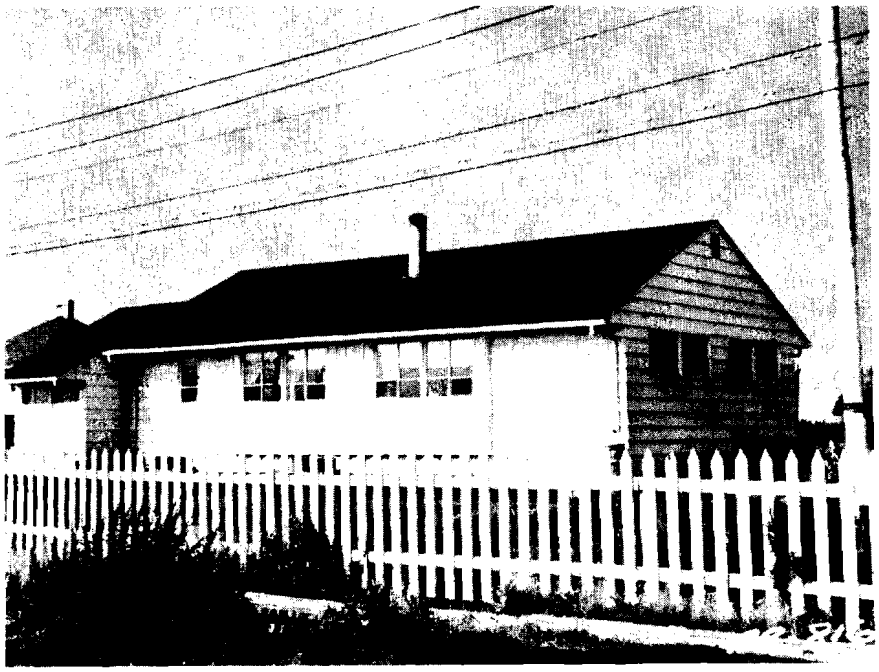


Figure 13 H.B.C. Manager's Residence

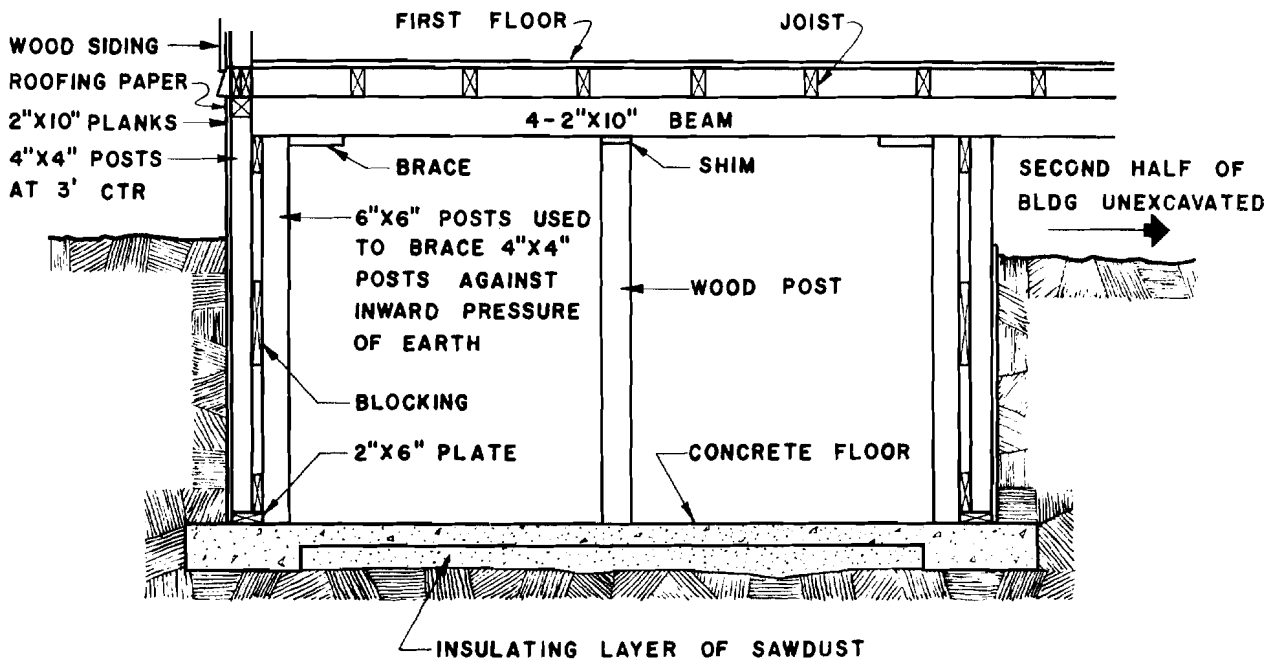


FIGURE 14 BASEMENT SECTION

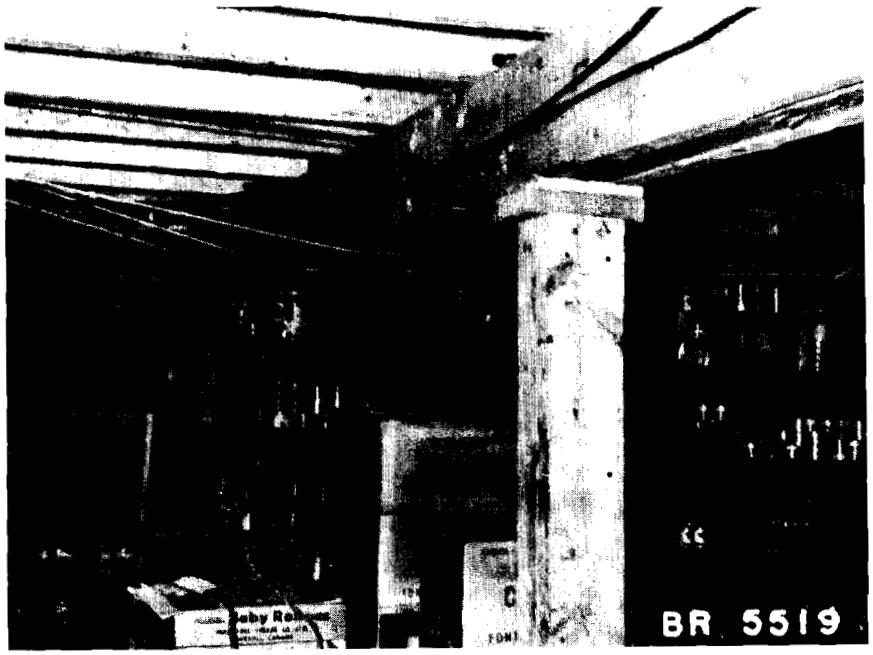


Figure 15 Basement Construction

Figure 16 Water on Basement Floor

H.B.C. MANAGER'S RESIDENCE

D.N.D.-R.C.C.S. - 1 1/2-STOREY DWELLING (Fig. 17)

Location: Lot No. 17

Persons Contacted: Warrant Officer II Dave Allison

History: This frame building (22' x 28') and the existing partial basement (10' x 16') were completed in 1948.

The outer walls of the building are supported on 10- by 10-inch mud sills placed directly on the ground surface around the perimeter of the building. The floor construction is raised a few feet off the ground by short insulated stud walls which are sheathed on the inside with 1- by 6-inch boards.

Basement Details: (Fig. 18). The basement is of concrete with stub walls 10 inches thick and 4 1/2 feet high, and a floor reported to be 10 inches thick.

The basement is separate from the rest of the building except for the structural support afforded the two 6- by 6-inch wood posts under the main girder. The basement has a sump in the southeast corner, equipped with an automatic pump and a forced warm air oil-fired furnace.

Condition: The structural condition of the concrete in the basement walls and floor is satisfactory. There are no obvious cracks.

The building itself, however, has been subjected to considerable movement and to compensate for this, three jacks have been installed in the basement in the following locations under the main girder.

(a) One long jack on the concrete floor between the two wood posts.

(b) One short jack on top of the concrete wall at the east end of the basement (Fig. 19).

(c) One short jack on the soil between the concrete wall and the exterior wall at the west end of the main girder (Fig. 20).

The ground between the basement wall and the outer wall has settled and there is evidence of movement of the mud sills. This is particularly noticeable at the east and west walls of the building where the mud sills have twisted in, allowing the walls above to settle and lean-in at the bottom.

There was no free water in the basement at the time of the survey, but a groove had been cut into the concrete floor to obtain better drainage to the sump.

Remarks: It was reported that the installation of a long jack between the two posts in the basement had been necessary during the first winter of operation. During that period, the posts separated from the main girder due to frost heaving under the mud sills or settlement of the basement structure. Differential movement of the building and the basement reportedly became more severe each year until in the autumn of 1953, it was necessary to provide two additional jacks (Fig. 18) to raise the building back to its original level. In March 1954, serious leakage developed through the concrete floor around one of the wood posts; the water entered the basement in spurts as though under pressure.

To remedy this condition, the floor was rebuilt with drain tile under the floor, leading to a sump.

Figure 17 D.N.D.-R.C.C.S. 1 1/2 Storey Dwelling

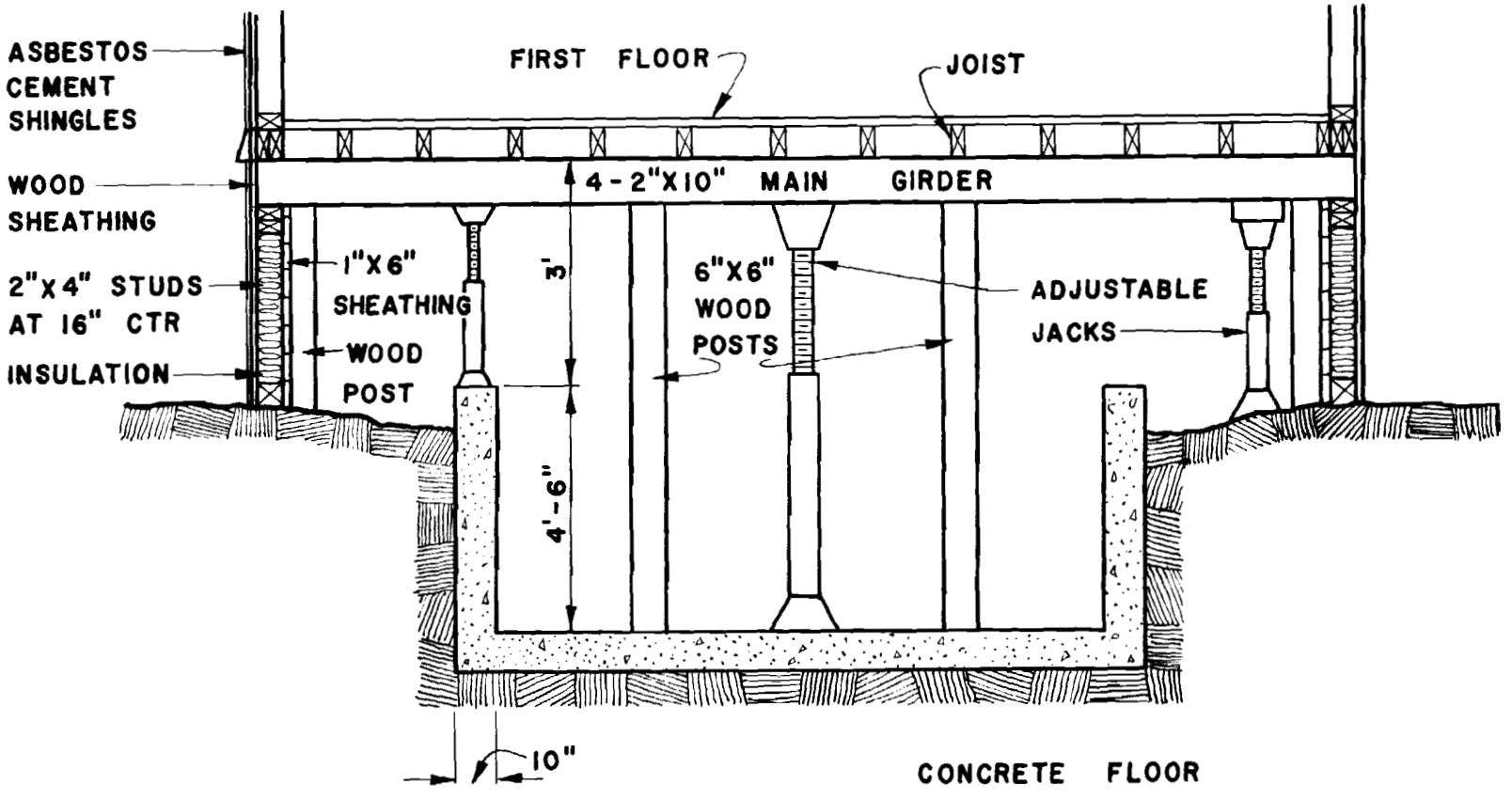


FIGURE 18 BASEMENT SECTION

D.N.D. - R.C.C.S. 1 1/2 STOREY DWELLING

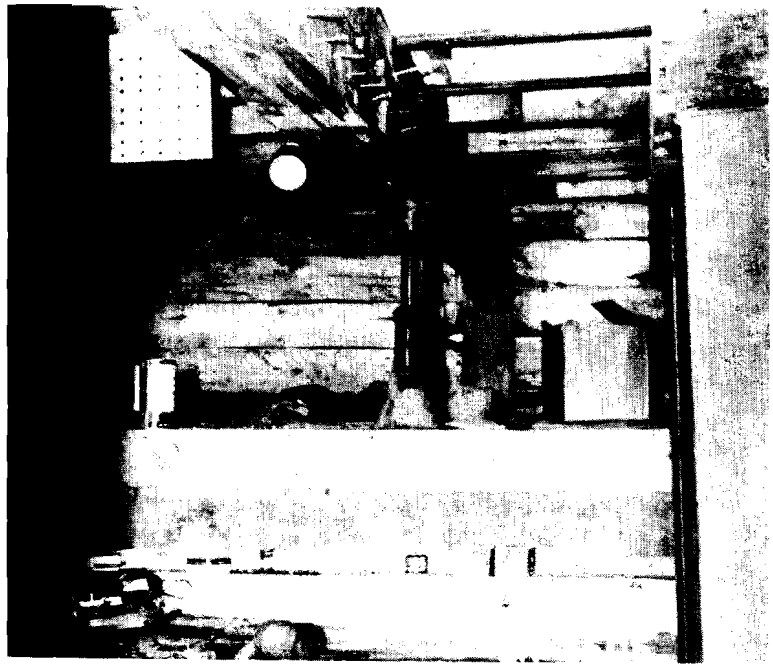


Figure 19 Jack on Basement Concrete Wall

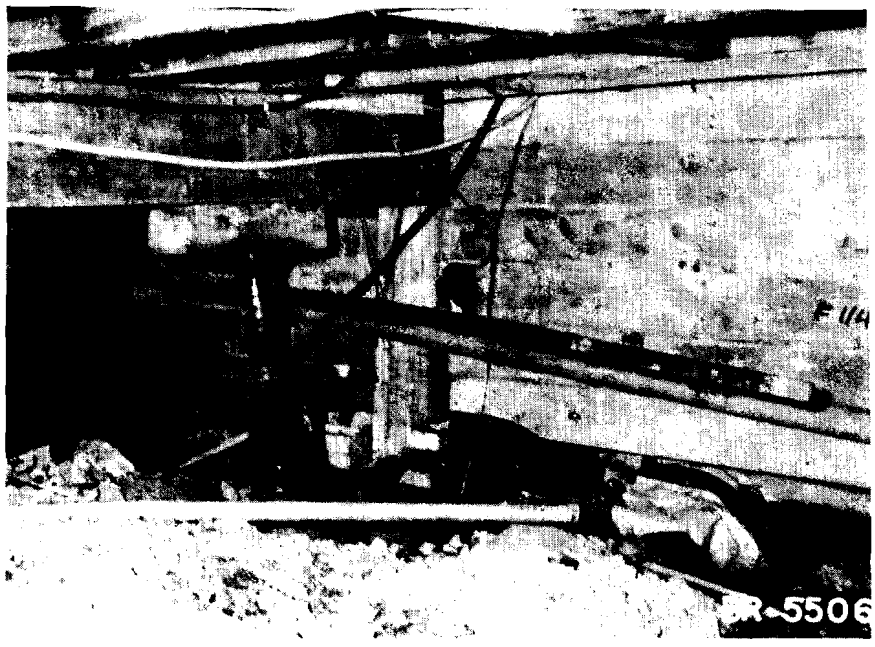


Figure 20 Jack on Unexcavated Area

D.N.D.-R.C.C.S. 1 1/2 STOREY DWELLING

R.C.M.P. INSPECTOR'S RESIDENCE (Fig. 21)

Location: Lot No. 26

Persons Contacted: R.C.M.P. Constable

History: This wood frame building (28' x 28') with full-size concrete basement was built in 1950.

Basement Details: The basement under this building is a conventional one with 10-inch thick concrete walls, concrete footings, and a 6-inch thick concrete floor. There is a 26- by 28-inch wood-lined sump pit in the floor equipped with automatic pump. An oil-fired warm air furnace and a concrete water storage tank are also located in the basement.

Condition: Walls - There are no obvious cracks in the concrete basement walls apart from a narrow crack at location (1) in Fig. 22, which extends diagonally up the wall.

There is no evidence of leakage through the wall itself but there is an extensive area of dampness at location (2) in Fig. 22 (junction of the floor and the wall), where the wall is damp to an average height of 1 foot in the corner. The damp area extends up the wall to a height of 2 1/2 feet (Fig. 23).

The concrete in the walls is honeycombed in several places. Floor - The concrete floor is badly cracked (Fig. 22). The cracks vary in length but average between 1/32- and 1/16-inch in width.

At location (3) in Fig. 22, crazing has occurred over a large area; the top 1/2- to 3/4-inch layer of concrete has begun to separate from the base concrete and is flaking off in large pieces (Fig. 24). Water has accumulated beneath this spalled area and bubbles up through the cracks when the concrete is walked on. A similar condition is developing at location (4) in Fig. 22; the top 1/2 inch of concrete has begun to separate from the base and free water has accumulated under it.

The floor is generally damp, pitted, and rough. Two small pools of free water about 1/8- to 1/4-inch deep were noticed where the floor was not properly graded to drain to the sump. Considerable leakage into the basement, particularly through the junction of the floor and wall, which often resulted in free water covering the whole area, was reported. Drainage to the sump was poor and grooves had been cut into the concrete floor to improve this situation.

Remarks: A field survey in 1950 during the construction of this building, indicated that the soil was primarily silt with a 6-inch layer of grey clay about 4 1/2 feet from the surface. Permafrost was encountered at 2 1/2 feet and massive ice was found at the northwest corner of the excavation at a depth of 4 feet.

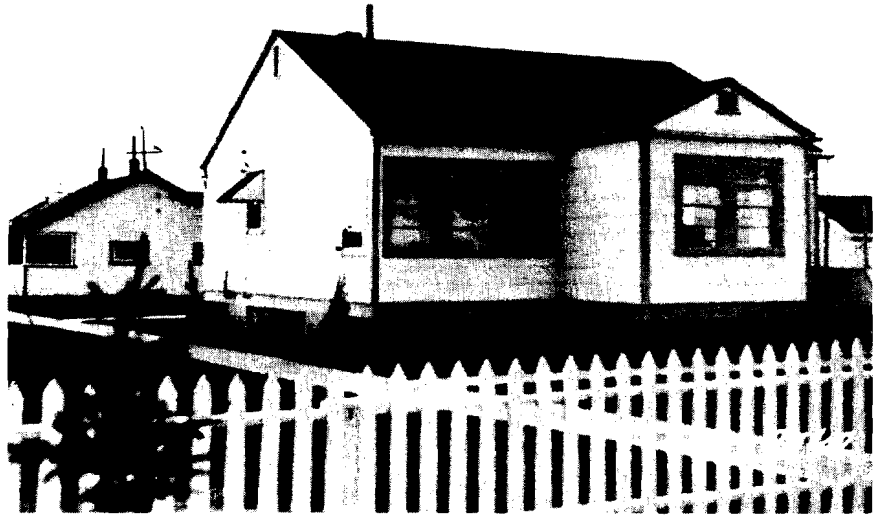


Figure 21 R.C.M.P Inspector's Residence

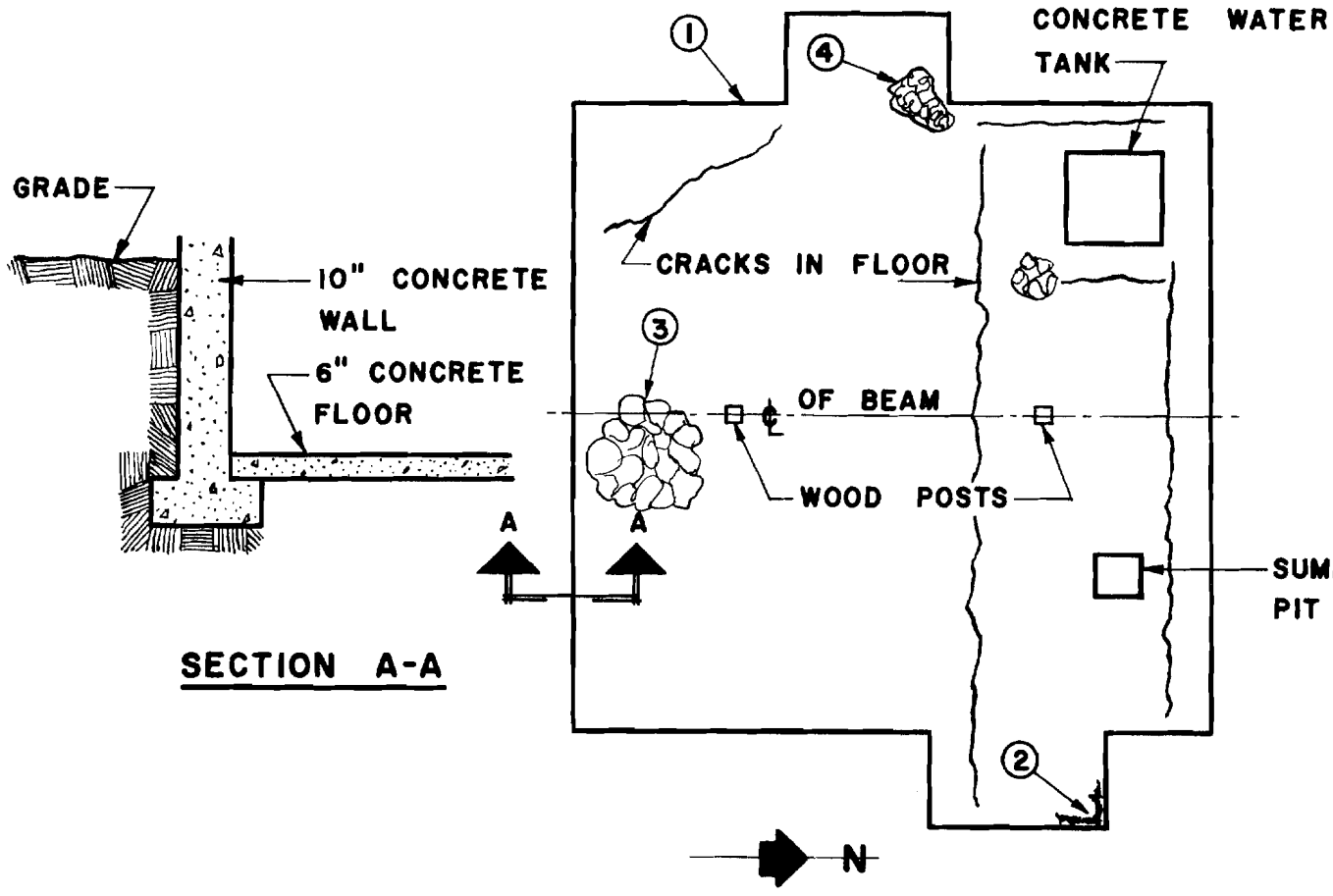


FIGURE 22 BASEMENT PLAN

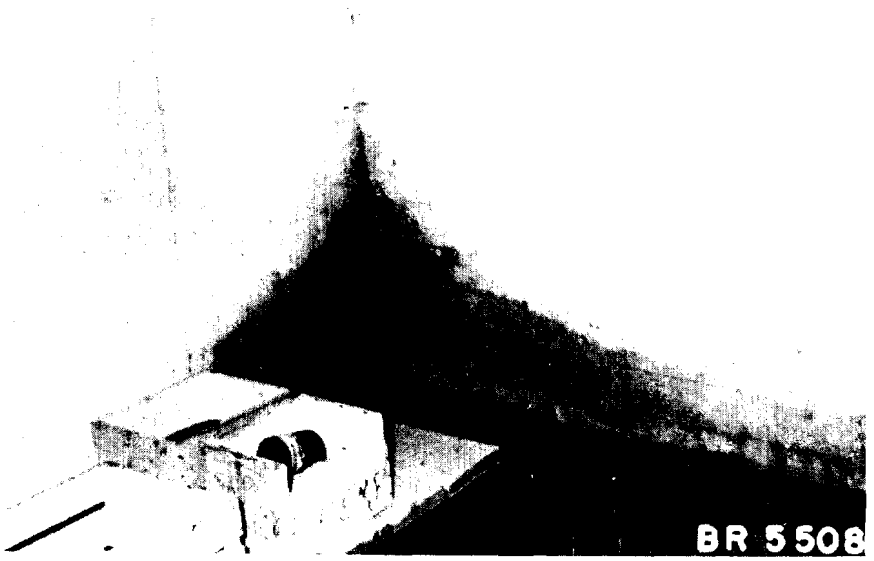


Figure 23 Leakage at Junction of Basement Wall and Floor (location (2) on basement plan, Fig. 22)

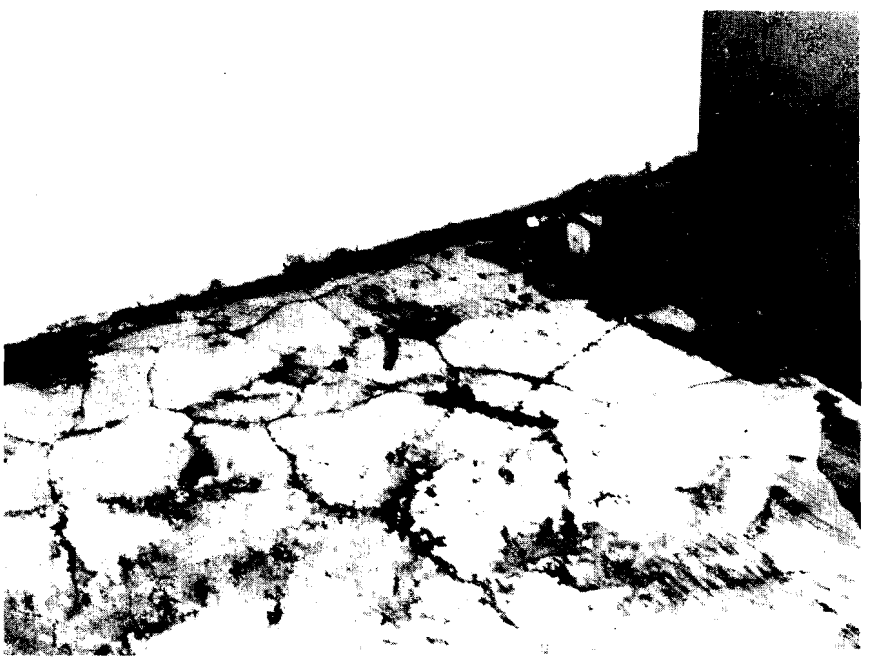


Figure 24 Section of Concrete Basement Floor (location (3) on basement plan, Fig. 22)

R.C.M.P. INSPECTOR'S RESIDENCE

NORTHERN AFFAIRS AND NATIONAL RESOURCES - SUB-DISTRICT ADMINISTRATOR'S RESIDENCE (Fig. 25)

Location: Lot No. 27B

Persons Contacted: Mr. Burton, Sub-District Administrator, NA and NR, Mr. J. Cooper, NA and NR

History: This two-storey frame building (23' x 26') was built in 1948 with a full-size conventional concrete basement.

Basement Details: This is a conventional concrete basement with 10-inch thick walls. The footings are reported to be 18 inches wide and 8 inches deep, and the floor 4 inches thick. There are reported to be 8 inches of gravel fill under the floor.

The basement is equipped with a sump pit and automatic pump, a concrete water tank, and an oil-fired warm air furnace. The central beam is supported on two round steel columns (Fig. 27).

Condition: Walls - The basement walls, especially the north and east walls, are cracked in a number of places. Photographs of typical cracks taken at locations (1) and (2) in Fig. 26 are shown in Figs. 28, 29 and 30. In general, the cracks are vertical and run the full height of the wall. Some diagonal cracking has occurred at the junction of an opening, such as a window or door. The cracks range in width from 1/16 to 5/8 inch and are of varying depths. The crack at location (2) is especially bad and has penetrated through the wall (Figs. 29 and 30), indicating that the two ends of the wall have undergone settlement.
Floor - Some cracking has occurred in the concrete floor at locations shown in Fig. 26, but these cracks are not large and this floor is in better condition than are most other floors in the area.

The basement was dry when examined and there was no evidence of leakage through the walls or floor. It was reported that all subsurface water could be handled satisfactorily by sump pump in floor.

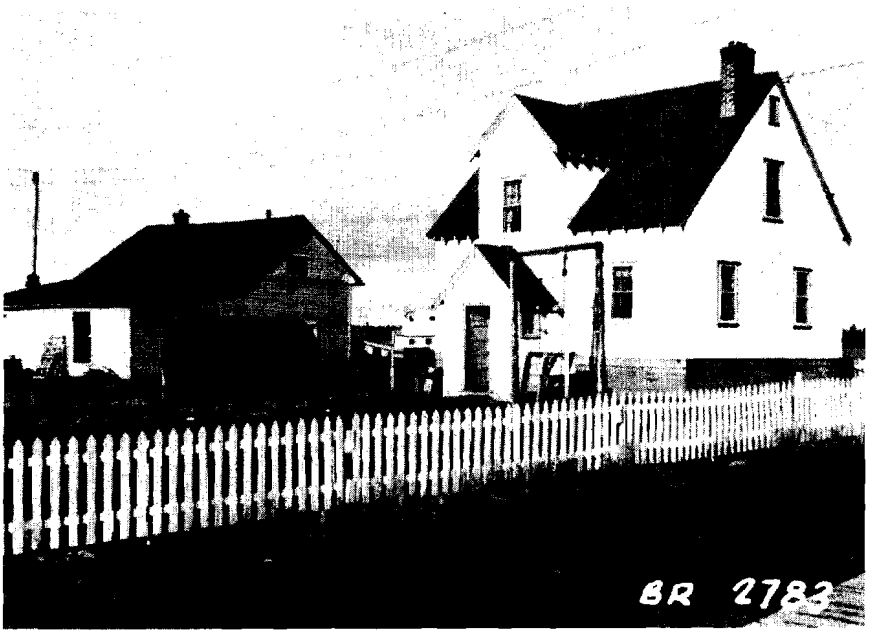
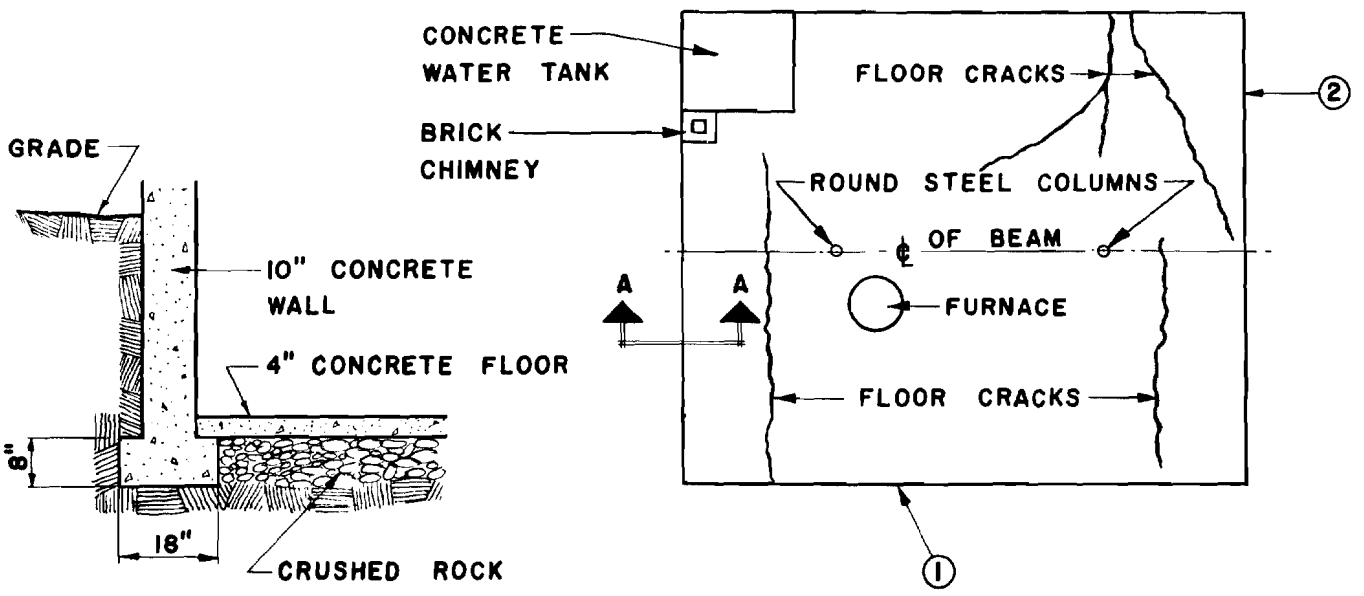


Figure 25 Sub-district Administrator's Residence, NA and NR



SECTION A-A

FIGURE 26 BASEMENT PLAN

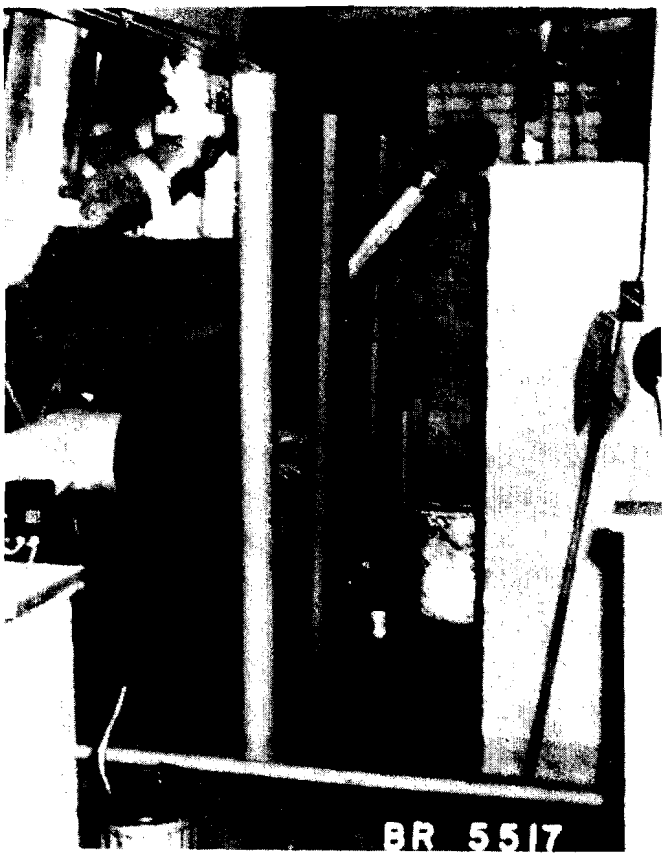


Figure 27 Basement Construction

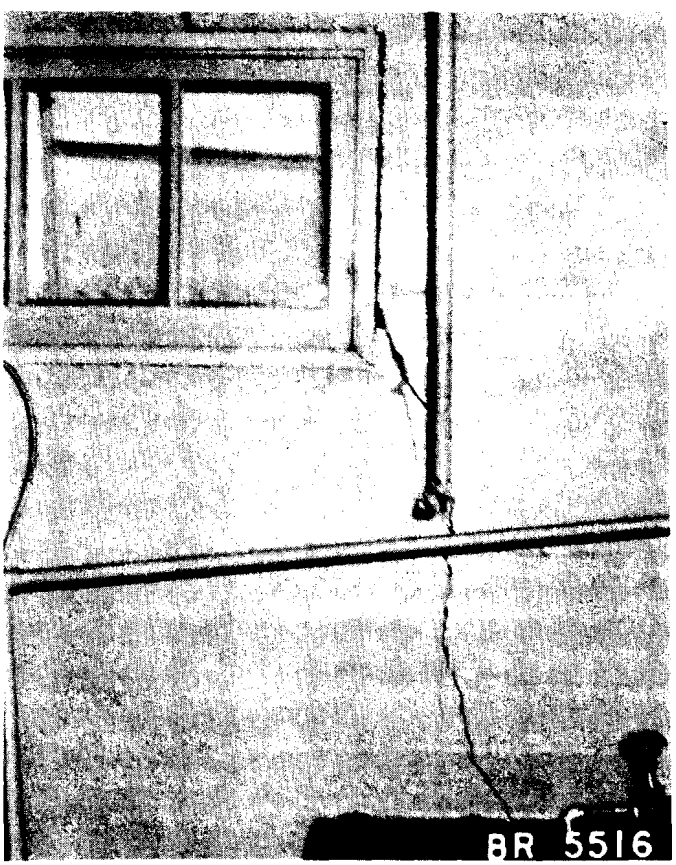


Figure 28 Crack in East Wall of Basement (location (1) on basement plan, Fig.26)

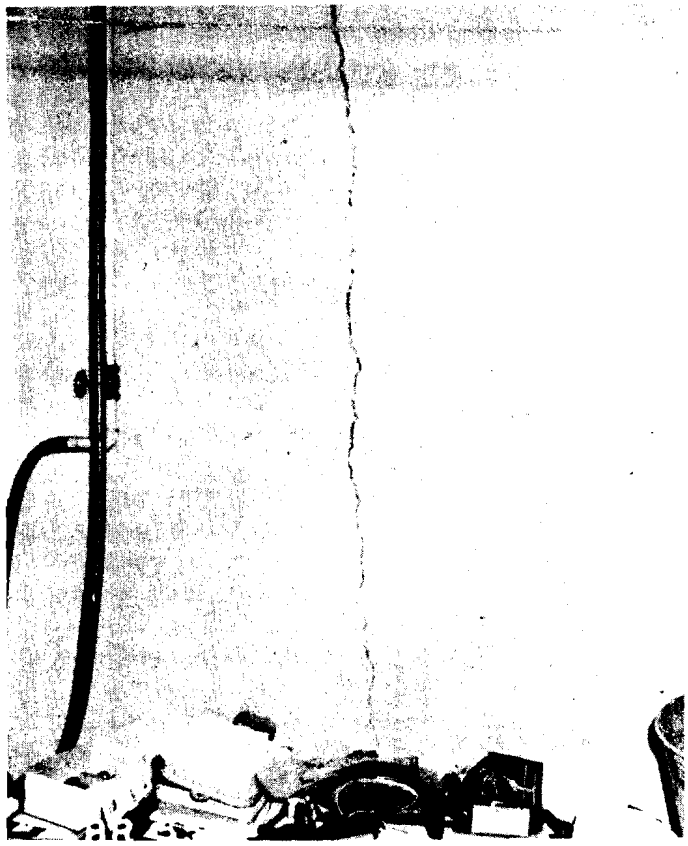


Figure 29 Interior view of Wall Crack at location (2) on basement plan

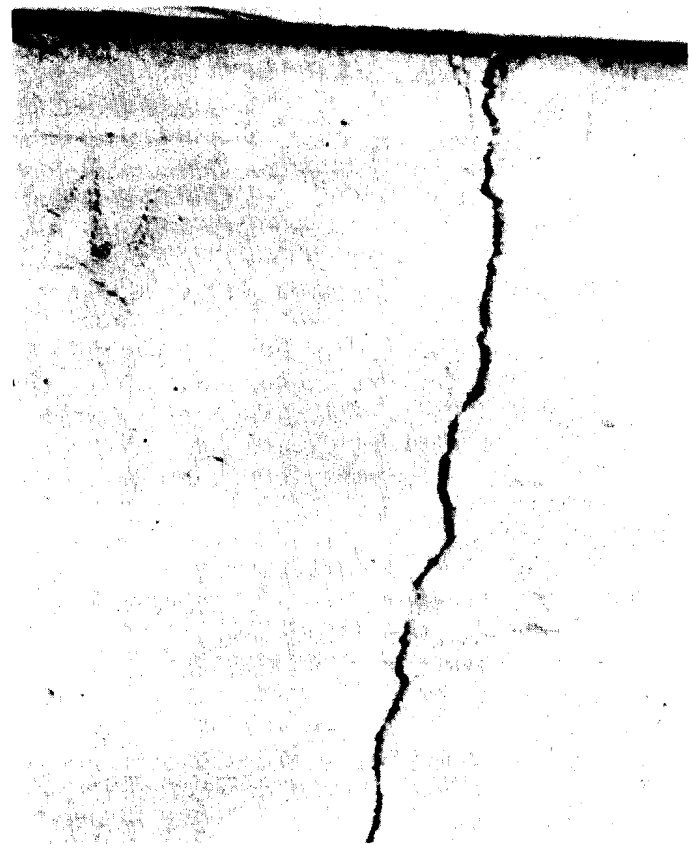


Figure 30 Exterior view of Wall Crack at location (2) on basement plan (upper portion of crack)

ANGLICAN MISSION SCHOOL (Fig. 31)

Location: Lot No. 32

Persons Contacted: Archdeacon Webster, Mr. Jim Edwards and Mr. Fred Willis, Anglican Mission staff

History: This wood frame structure (73' x 130') was built in 1935 with only a small 20-foot square excavation beneath it to provide space for storage. The exterior walls of the building are supported on 6- by 10-inch wood sills resting on 3-foot high wood posts with log pads as footings on the ground surface (Fig. 33).

The excavated area has been gradually enlarged during the years and it now includes the area shown hatched in Fig. 32.

Basement Details: The walls of the excavated area are lined with boards up to the height of the earth. These boards are fastened to log posts spaced 4 to 5 feet apart (Fig. 36). Much of the area is used for storage of supplies and equipment. The exposed earth floor under these items has been covered with logs and planks. The remainder of the area consists largely of walkways and has been covered with planks laid over wood sills. Some of the earth floor has been left exposed.

The main beams supporting the first floor joists are supported in turn by log posts with wood pads as footings (Fig. 34).

There is a sump with automatic pump in the northeast section of the basement. When surveyed, the water in it was about 1 foot below the surrounding floor level. There are no heating units in the basement.

Condition: Dampness is obvious in this excavated area; the exposed earth is damp to the touch and the wood sills supporting the floor planks are in varying stages of decay.

There are nearly 100 log posts supporting the first floor construction, many of which have had to be shimmed at the top under the beams. One of the Mission staff reported that the building has had to be jacked-up every spring and additional shimming installed. In some cases, the shims indicate settlement of 10 to 12 inches (Fig. 35). Settlement has been especially severe next to the water storage tanks. Settlement has also occurred on the exterior of the building. In order to level the building, shims have been placed at the top of the posts (Fig. 33).

Remarks: It was suggested that the wet condition of this excavated area has been aggravated by overflow from the water storage tanks.

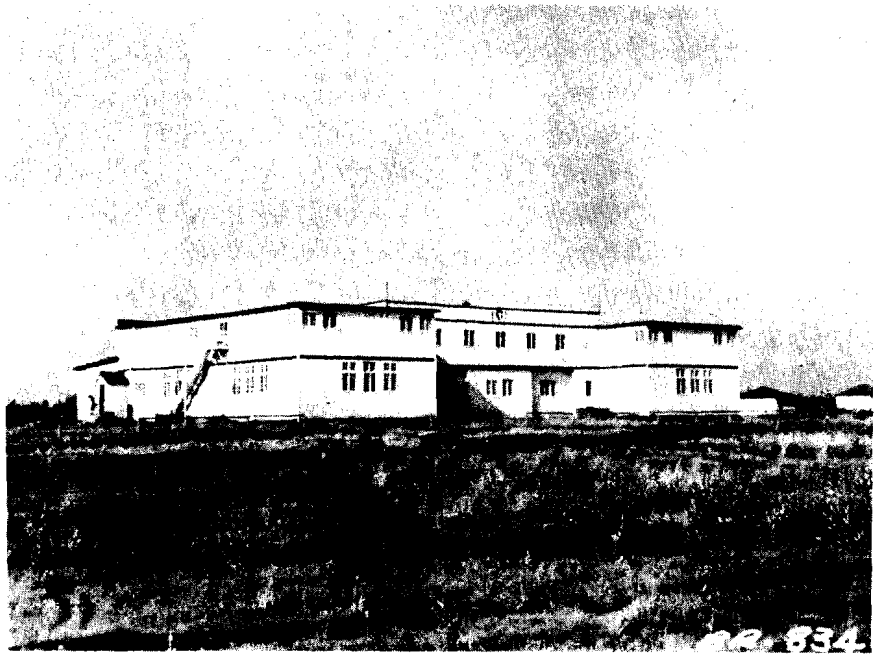


Figure 31 Anglican Mission School

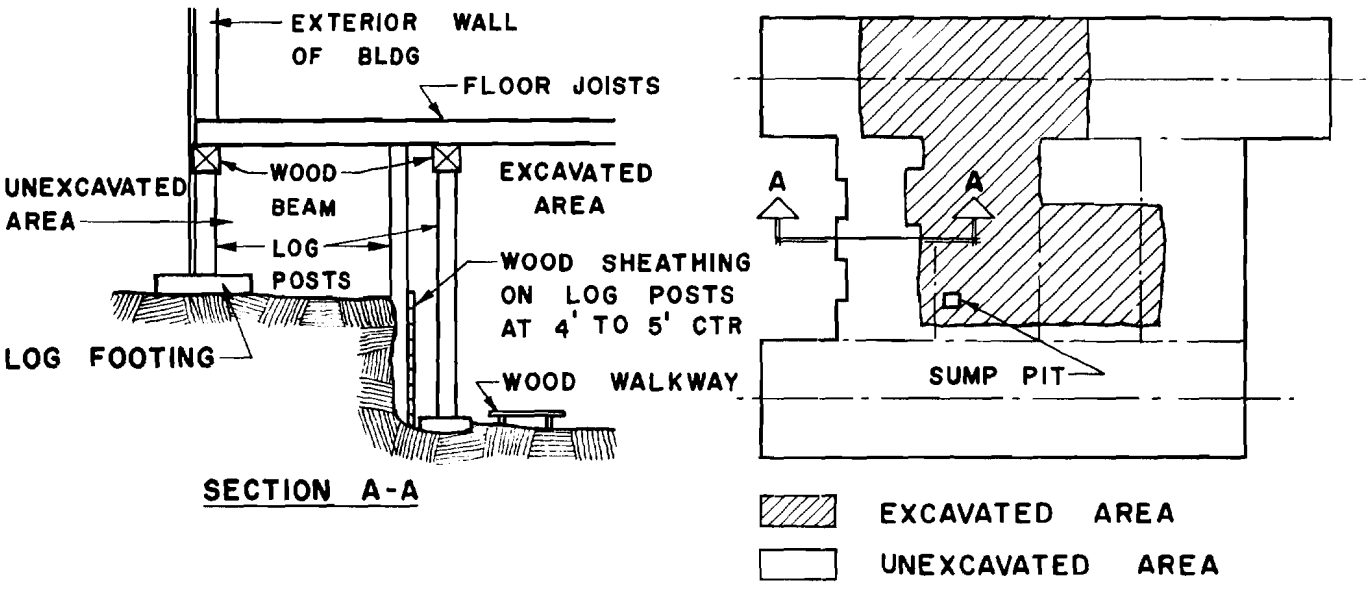


FIGURE 32 BASEMENT PLAN

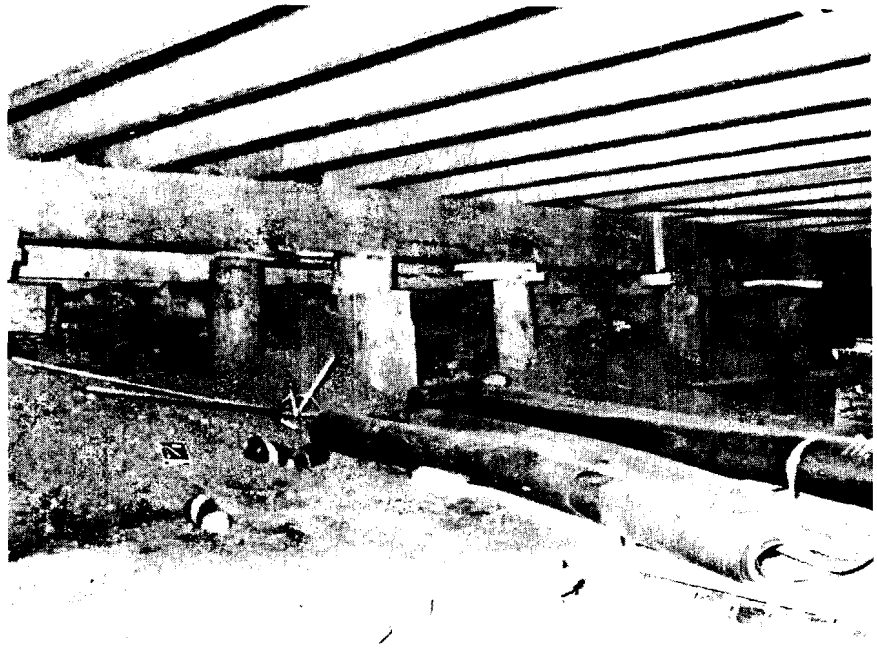


Figure 33 Surface Foundations under Exterior Wall of Building (showing unexcavated area next to basement space)

Figure 34 Basement Posts

ANGLICAN MISSION SCHOOL

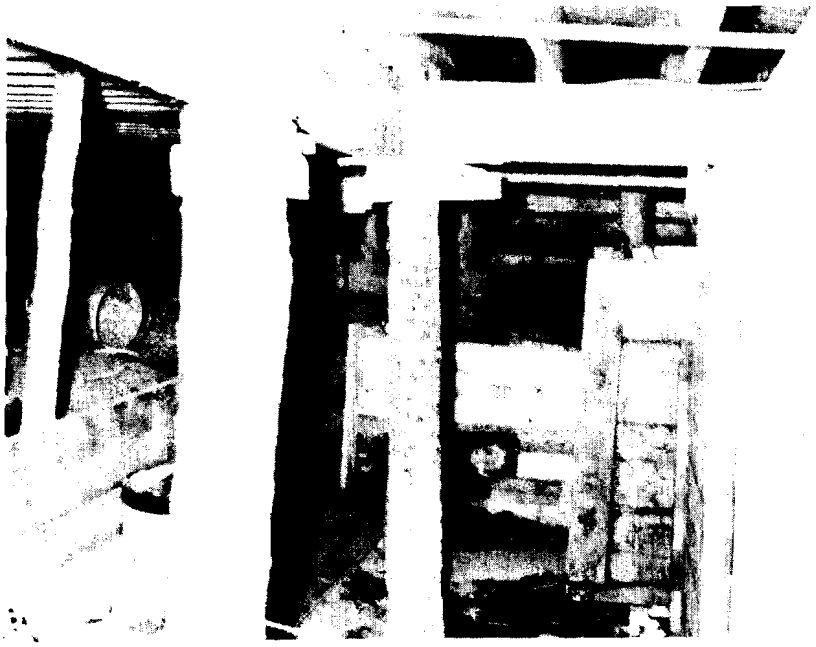


Figure 35 Shimmed Posts in Basement

Figure 36 Basement Wall Construction (typical of partial basements)

ANGLICAN MISSION SCHOOL

D.N.D.-R.C.N. - COMMANDING OFFICER'S RESIDENCE

Location: Lot No. 39

Persons Contacted: Mr. Wilkinson (Officer in Charge) and Mr. Cooey

History: This wood frame building (21' x 30') was built in 1935 by the Hudson's Bay Company. It was sold to the Navy in 1952 and in 1953 it was moved to its present location at the Navel Station and erected over a newly constructed basement foundation.

Basement Details: (Fig. 37). Some construction details of this basement were obscure but it is believed that the basement was constructed as shown in Fig. 37.

The floor consists of 2- by 8-inch joists at 16-inch centres placed on a 4-inch thick gravel layer covered by wood flooring and 8 inches of concrete.

The walls are concrete 8 inches thick at the top and are believed to slope to a greater thickness at the base.

The two wood posts supporting the first floor construction have been carried down into the permafrost to 4 feet below the level of the basement floor. The posts are supported at this depth on a raft footing of 8- by 8-inch logs.

The concrete in the floor and walls of the basement has been reinforced with both wire mesh and steel bars.

The basement is equipped with an oil-fired warm air furnace, a sump with automatic pump, and a concrete water storage tank.

Condition: No cracks were seen in the walls although one-half the wall area was hidden behind stored cartons of supplies.

The floor was roughly finished and some cracking had occurred between the two wood posts and between one post and the exterior wall. There was evidence of free water on the floor, either from leakage or overflow of the water storage tank (Fig. 38).

It was reported that the sump was seldom dry.

Remarks: When the excavation was made for the basement, permafrost was found within 18 inches of the ground surface.

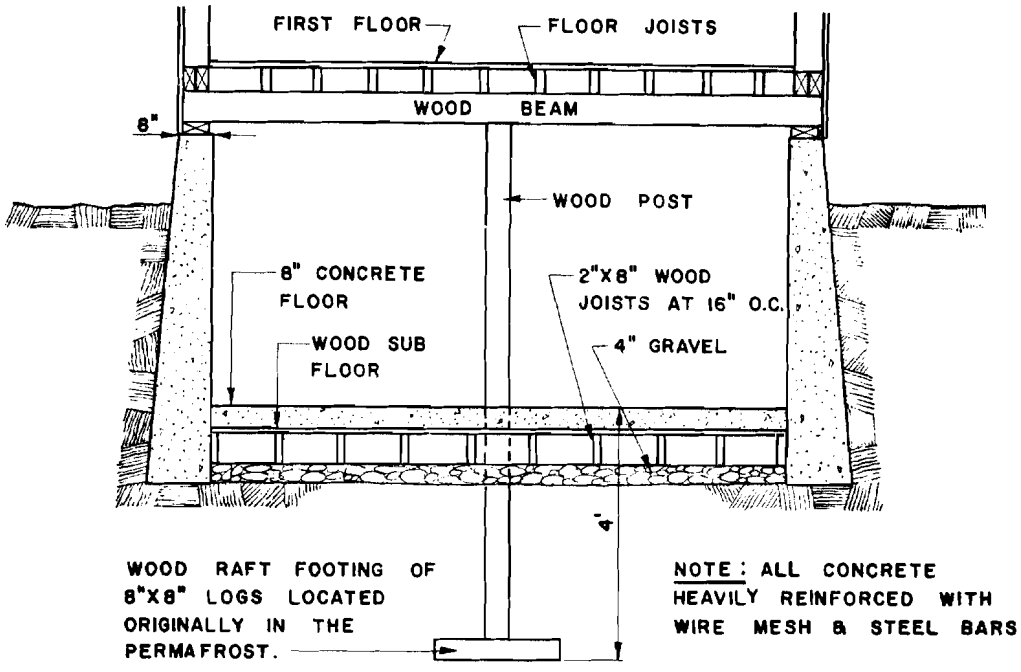


FIGURE 37 BASEMENT PLAN

Figure 38 Basement Floor and Wood Post

PART C

SUMMARY OF FINDINGS

The Basements in Aklavik

Of the more than three hundred buildings in Aklavik, only seventeen have basements. These differ widely in construction and condition. Only six of these seventeen buildings have full basements. Four of these appear to be the conventional type; the walls and floors are concrete and the walls are the supporting foundation of the buildings. These four are the basements under: the R.C. Mission School; the R.C.N. Commanding Officer's residence; the R.C.M.P. Inspector's residence; and the residence of the Sub-District Administrator of the Department of Northern Affairs and National Resources.

The two last-mentioned basements have 10-inch concrete walls and 4- to 6-inch concrete floors. No special precautions were taken against the problems of permafrost in their design and construction; both basements show signs of failure. The R.C.M.P. basement has severe cracks in the concrete floor with a resultant moisture problem (Fig. 24). The N.A. and N.R. basement has badly cracked walls due to settlement caused by thawing of the permafrost (Figs. 29 and 30).

The condition of the other two basements is much better. There is some evidence of moisture in the R.C.N. basement; some cracks appear in the floors of both the R.C.N. building and the R.C. Mission School. There is, however, no real evidence of failure in these buildings.

In the R.C.N. building, some precautions against possible permafrost problems were taken during construction of the basement floor (Fig. 37). To reduce heat loss downward to the permanently frozen ground, the concrete floor was separated from the permafrost by a layer of gravel, 2- by 8-inch joists, and a rough wood flooring. The posts supporting the first floor beam were put down through the basement floor a distance of 4 feet into the permafrost. In addition, the concrete walls were heavily reinforced and battered on the outside to resist frost heaving. The R.C.N. building has been in use in its present location only since 1953 and it may be too early to evaluate its performance.

The R.C. Mission school basement is of extra heavy construction; the walls are 16 inches thick at the base and the floor is 12 inches thick, all of reinforced concrete. An important feature of this construction, however, and one likely to be very

significant in determining the performance of the building, is the fact that the present basement was not built until 16 years after the building was erected. During these 16 years, heat loss downward from the building caused the permafrost beneath to thaw gradually and this created many problems of building maintenance and drainage. When the existing concrete basement was built, the permafrost had already retreated several feet below its original level, thus considerably reducing future problems with the permanently frozen ground.

The remaining two full-size basements are the R.C. Mission Hospital and the D.N.D.- R.C.C.S. dwelling on Lot 16. The former has a concrete floor and wood walls; the latter is of all-wood construction. The R.C. hospital basement, like that of the school, was built many years after the building was first occupied when the permafrost had receded thus minimizing the problems. The R.C.C.S. basement is in the poorest condition of all the full-size basements. The wood walls have been pushed-in by earth pressure, and settlement of the basement has caused movement in the structure above grade. Infiltration of moisture is a major problem and the wood in the floor is decaying and disintegrating because of its wet condition (Fig. 39).

The remaining eleven basements differ widely in size and details of construction. With the exception of the Hudson's Bay Co. building, however, they all have one thing in common. Their walls do not support the weight of the building but only serve to enclose space and retain the earth in the surrounding unexcavated area (Fig. 36). They differ in this way from the full-size basements.

Many of these partial basements consist of little more than an excavation in the ground beneath the building large enough to provide space for a heating unit or food storage. The sides of these basements are usually lined with boards, some only to mid-height; the floors are covered by wood planking or a roughly finished concrete slab. The types of construction range from the primitive details of the Anglican school basement (Figs. 34, 35, and 36) and the Anglican Cathedral basement (Fig. 40), to the more carefully finished basement under the R.C.C.S. station (Fig. 41).

In general, these partial basements have not performed well. There is much evidence of leakage resulting in conditions that seriously limit their usefulness as basement areas. In nearly every case, settlement of the building has also occurred, and some adjustment of the exterior walls of the building has been necessary (Figs. 33 and 35). In some of the basements, such as those under the Anglican hospital, the Anglican school principal's residence,

and the N.A. and N.R. dwelling on Lot 13, the problems of leakage and settlement have diminished with time and the lowering of the permafrost table. This process has, however, taken many years during which difficulties have been experienced and the usefulness of these underground spaces has been severely curtailed.

A contributing factor to the difficulties with basements at Aklavik is that many of them are constructed with wood as the main material in walls and floor. In the north, wood offers many advantages as a construction material above grade, but it is not suitable for basement construction. Wood walls are not made watertight readily nor do they normally have sufficient strength to resist inward pressure of the soil; wood itself is subject to decay and disintegration when exposed to soil under wet conditions (Fig. 39).

Even when concrete is used, however, difficulties arise and poor performance results, as evidenced by the condition of the R.C.C.S. 1 1/2-storey dwelling on Lot 17, the R.C.M.P. Inspector's residence, and the N.A. and N.R. Sub-District Administrator's residence. In each of these cases failure has occurred either because of leakage, or movement of the structure caused by thawing of the permafrost.

Two exceptions to the generally poor performance of the basements at Aklavik are the basements under the R.C. Mission school, and the R.C. hospital. These basements appear to have performed well and are reported to provide serviceable space below grade. It is significant, however, that both these basements were constructed after the buildings had been in use for many years and the permafrost had retreated some distance below its original level.

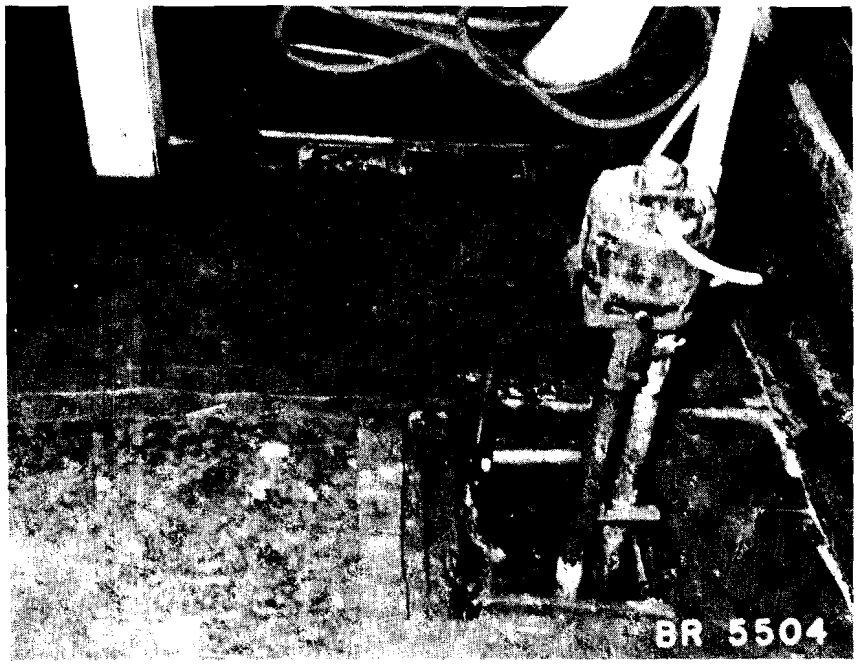


Figure 39 Basement of R.C.C.S. Dwelling on Lot 16 showing Decay of Wood Floor

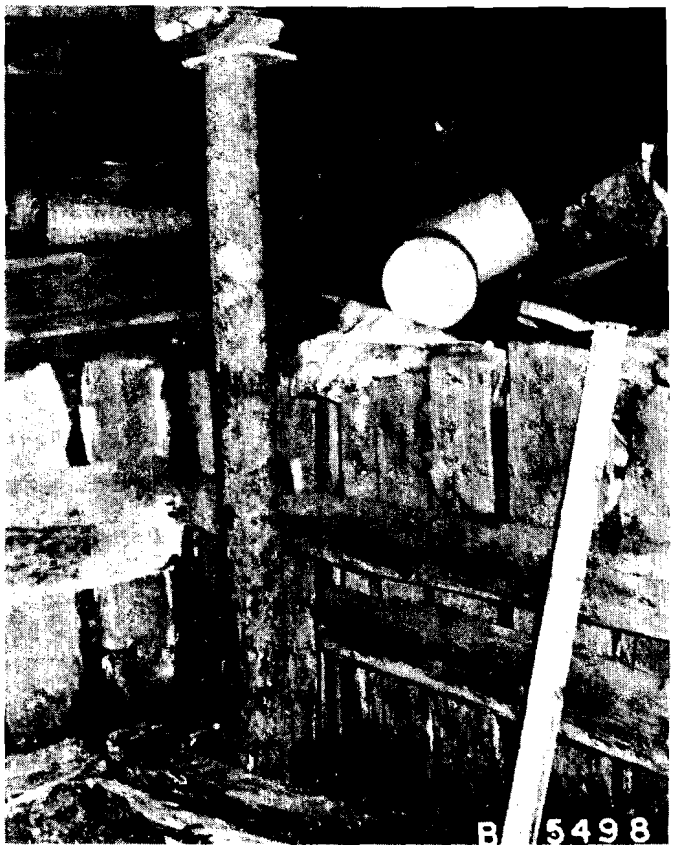


Figure 40 Partial Basement of Anglican Cathedral showing Walls lined to mid-height with rough wood slabs

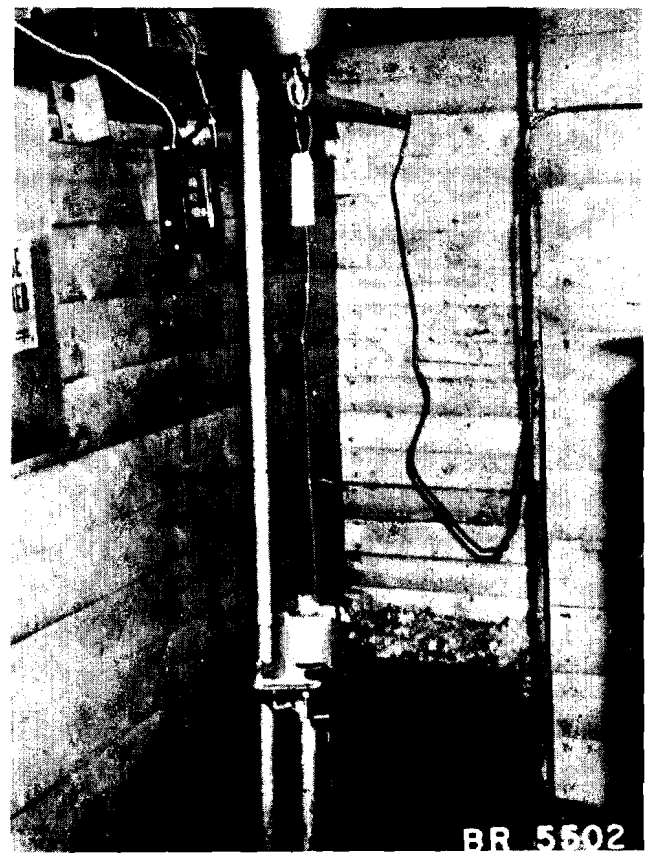


Figure 41 Partial Basement of R.C.C.S. Station showing Walls lined to full height with wood sheathing

Comments on Basement Construction in Permafrost Areas

Although complete details were not available on all performance aspects of the seventeen basements in Aklavik, the information that was obtained and recorded in this report gives some indication of the problems that arise when basements are constructed in permafrost areas.

Probably the greatest single difficulty introduced by basement construction is that of preventing the permafrost from melting and thus causing differential settlement of both the basement and the building. There was considerable evidence that such settlement had occurred in nearly every building examined in Aklavik. In the few buildings where settlement was not a serious problem, such as in the R.C. school and hospital, permafrost conditions had been significantly changed by construction in the area, which had taken place several years before the present basements were built.

Attempts to control movement by isolating the basement from the building or insulating the basement against the surrounding permafrost have not been successful. The first method was tried with several of the partial basements in Aklavik including the R.C.C.S. married quarters on Lot 17. Complete separation of basement from building was not achieved in this structure because of the necessity to support the first floor beam by posts bearing on the basement floor. Movement of this building occurred because heat losses from the basement caused the permafrost to recede gradually beneath the surface foundations of the structure.

The insulation technique was attempted in the R.C. Mission house on Lot 9, where some sawdust was placed between the basement wall and the perimeter of the building. This technique did not prevent the thawing of the permafrost nor movement of the posts supporting the exterior walls of this building. In general, the use of insulation in conjunction with basement walls and floors to preserve the permafrost in its frozen condition, is likely to be of little value, regardless of the type of insulating material used. Insulation cannot prevent heat flow; it can only retard it. The most that can be expected of the insulation is that it will extend the useful life of the building a few extra years by reducing the heat flow to the permafrost, and thus slowing up the thawing process. There is every indication that failure will still result during the expected life of the building.

The second major problem with basement construction in permafrost is that of drainage. Normal methods of removing surface and subsurface water can not be readily practiced in permafrost areas. The problem is complicated further when the permafrost table beneath a structure tends to be depressed because of heat loss downward from the building. In a basement, this effect becomes more pronounced, and gradually a bowl-shaped surface depression is formed under the structure. Because the surrounding permafrost is impermeable this depression acts as a reservoir into which will flow much of the local drainage water. This accumulation of water tends to thaw the permafrost further, but its most serious feature is the problem it poses of maintaining a dry basement. There was much evidence of the seriousness of the water problem in the basements at Aklavik.

In conclusion, it is obvious that there are a number of problems to be solved before satisfactory performance can be expected of basements in permafrost. The magnitude of these problems will vary with local factors such as the type of soil and permafrost conditions. No design should be prepared without a full knowledge of field conditions based on site studies.

The only type of basement construction that would appear to have any hope of success in areas where melting permafrost causes settlement would be one in which the building was supported independently of the basement, and the necessary supports were placed at such a depth in the permafrost that they would remain below the level of the frozen ground during the life of the structure. The actual depth required for these supports would probably vary with the number of local factors and each building, but it would seem to require the use of steamed-in piles. The problems of drainage and of maintaining a dry basement would still remain, along with the additional problem of limiting movement of the basement itself, where this is a prerequisite because of furnace installations or other mechanical service connections. The problems are such that the cost of any suitable construction would probably be very high - so high that it may often prove more economical, and certainly less troublesome, to avoid basements altogether and provide equivalent enclosed space above grade.

Acknowledgments

The writer wishes to acknowledge the assistance given him by the many people in the Aklavik area connected with the Missions, the Hudson's Bay Company, and the various government departments, who were contacted during this survey. The names of several of these persons appear in the chart on pages 4 and 5, but special mention should be made of Mr. W. Burton, Sub-District Administrator, Department of N.A. and N.R., Father Biname, Roman Catholic Mission, Archdeacon Webster, Anglican Mission, and Mr. H. Figgures of the Hudson's Bay Company.