ARCHITECTURE ON ICE: THE CHALLENGE OF BUILDING ON PERMAFROST

Overview:

Permafrost is the foundation of much of the Arctic and subarctic region. When building on permafrost, special construction techniques should be implemented.

Objectives:

The student will:

- explain why traditional winter camp dwellings did not cause permafrost degradation; and
- investigate the need for insulation when building on permafrost.

Targeted Alaska Grade Level Expectations:

Science

[9] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.

[10-11] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring, and communicating.

[10] SG3.1 The student demonstrates an understanding that scientific knowledge is ongoing and subject to change by using experimental or observational data to evaluate a hypothesis.

[9] SB2.1 The student demonstrates and understanding of how energy can be transformed, transferred, and conserved by applying the concepts of heat transfer (i.e., conduction, convection, radiation) to Alaskan dwellings.

Vocabulary:

convection – the transfer of heat energy through liquids and gases that move

freezing tube – part of a system of refrigeration that has been installed to remove heat from the ground

frost heave – the upward or outward movement of the ground surface (or objects on, or in the ground) caused by formation of ice in the ground

ice lens – a mostly horizontal, large layer of ice of any dimension

peat – partially carbonized vegetable tissue formed by partial decomposition of various plants

piling/pile – a long slender column usually of timber, steel, or reinforced concrete driven into the ground to carry a vertical load

prototype – an original model on which something is patented

thermal piling – a foundation pile on which natural convection or forced circulation cooling systems or devices have been installed to remove heat from the ground

thermosiphon – a passive heat transfer device installed to remove heat from the ground

Whole Picture:

Traditional Athabascan housing did little to permanently damage the ground upon which it was built, largely because most communities were semi-permanent. Housing was built to suit the season. In the spring, families traveled to fish camps. In the winter homes were built and insulated with available material. Because the homes were often dissembled in the spring, permafrost was not damaged.

Modern building on permafrost requires consideration of potential thawing. While permafrost can extend hundreds of feet deep, it is only the top section that concerns builders. This poses a problem, because permafrost usually does not begin until several feet below ground level. As long as it remains frozen, it is very strong and stable. If the frozen ground is subject to heat transfer, it will thaw. For this reason, structures built on

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top of permafrost can gradually sink; any heated areas will sink more rapidly. Over the years, this can cause the structure to buckle and even collapse.

There are several standard methods to determine presence of underlying permafrost. One method is to look at vegetation and geological patterns, however drilling into the soil gives better information. Digging a pit reveals the depth and character of the soil and any permafrost present, then the pit can be filled in with gravel afterward for a solid foundation. Digging is difficult if the permafrost is deep. In rodding, a 1/4 inch steel rod is driven into the soil until it can go no further, and then it is twisted. If it twists easily, it has hit a stone. If it springs back, it has hit wood or permafrost. If the rod is struck and gives off a dull clang it has contacted permafrost. A drilled core is the best way to analyze soil, yet it is the most expensive. Drilling can show a full log of the underlying soil, without committing to the pit.

There are three common ways to deal with permafrost. The first is to avoid it, but this is not always possible.

The most common way to preserve permafrost is by insulating the structures to be built on top of it. One way to do this is to build on pilings that allow air to circulate between the structure and the ground. Another way of preserving underlying permafrost is to raise the construction ground with gravel to the height of the foundations, or to dig down to permafrost and replace the soil with gravel. A modern way to preserve underlying permafrost is through refrigeration, using thermal pilings or freeze tubes. Such refrigeration works well with minimum maintenance so long as the climate and structure of the soil remains consistent.

In this lesson, students learn about the challenges of building on permafrost, consider the effect of traditional Athabascan winter camp buildings on permafrost and investigate the effects of various levels of heat and pressure on ice melt rate.

Materials:

- Large, flat cake pan, approximately 9x13 (two)
- Ceramic coffee cups with bottom rims that will make an indentation (eight)
- Hot water
- Ice water
- Rocks or gravel (enough to fill one cup)
- Sponge (two)
- Measuring cup
- Freezer access
- Chart paper
- Timer
- TEACHER INFORMATION SHEET: "Ice Melt Demonstration"
- STUDENT INFORMATION SHEET: "Architecture On Ice"
- STUDENT WORKSHEET: "Architecture On Ice"
- STUDENT INFORMATION SHEET: "Traditional Housing"
- STUDENT WORKSHEET: "Traditional Housing"
- VISUAL AID: "Architecture on Ice"

Activity Preparation:

NOTE: This lesson will take more than one day. Preparation is necessary a day prior to introducing the lesson. Students will make predictions one day then proceed with the lesson on the next. Predictions will take just 15 to 20 minutes.

1. One day prior, place about 1 inch of water in each of two large, flat cake pans and place them in the freezer. Fill one ceramic cup with water. Measure and note the amount of water in the cup then place it in the freezer, as well. Prepare ice cubes.

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2. Read TEACHER INFORMATION SHEET: "Ice Melt Demonstration."
3. Use chart paper to create two separate charts and a recording sheet for student hypotheses. On the hypothesis sheet write the following: "What happens to the rate of ice melt when differing amounts of heat are applied to the ice?" Underneath write HYPOTHESES. Half-way down write,

"What happens to the rate of ice melt when differing amounts of **pressure** are applied to the ice?" Underneath write HYPOTHESES. On a second sheet create "CHART 1 - Temperature" then on a third create "CHART 2 – Pressure." (See examples on the TEACHER INFORMATION SHEET: "Ice Melt Demonstration.") Leave room for notes within each chart section.

Activity Procedure:

Day One

1. Explain the next UNITE US lesson will discuss building structures on permafrost. The goal of engineers and builders is to keep the ground stable under infrastructure (roads, homes, commercial buildings, the pipeline, etc.). In the instance of permafrost, that means keeping it frozen. Roads are discussed in another lesson. For the purposes of this lesson, ask students to think about structures such as homes and other buildings.
2. Show students CHART 1 – Temperature and CHART 2 – Pressure. (See Activity Preparation) Show students the materials you will be working with:
   - cake pans with ice to represent permafrost ground
   - cups that represent structures built on the ground
   - sponges can be used to put insulation between the structure and the ground
   - gravel can be used to add weight to the structure
   - water in the cup can be heated or frozen to vary the temperature

   Ask students to think about a way to demonstrate the effects of heat and pressure on the ice using the available materials. Fill in the chart with student ideas. Remind them to think of a control for each. (An empty cup when considering pressure, a cup the same temperature as the ice for temperature.) Try and guide students to narrow the demonstration ideas so they can be done in the classroom. (See TEACHER INFORMATION SHEET: "Ice Melt Demonstration" for ideas and guidance.)
3. Ask the class to think about how fast the ice in the pan will melt under each of the cups. Note student prediction in the Prediction column of each chart. Ask students to think about which cup will melt the ice underneath the fastest, the slowest, etc. Ask students to explain why. Discuss the difference between "prediction" and "hypothesis." Ask students to formulate a hypothesis for both temperature and pressure. Write hypotheses on the chart paper labeled "HYPOTHESES." Hypotheses may include statements similar to:
   - If heat causes ice to melt faster than no heat, then a cup filled with hot water should transfer more heat and melt more ice when set on a pan filled with ice than a frozen cup set on the same pan.
   - If pressure causes ice to melt faster than no pressure then a cup filled with gravel should cause more ice to melt when set on a pan of ice than an empty cup set on the same pan.
   - If heat causes ice to melt faster than no heat then a cup filled with hot water but insulated from the ice by a sponge and set on a pan filled with ice should transfer no more heat and melt no more ice than an empty cup set on the same pan.

Day Two

1. Set up the demonstration as planned with student input. An example set up is recorded in TEACHER INFORMATION SHEET: "Ice Melt Demonstration."

NOTE: If student have science journals, have them draw the chart in their journal and write down the observations as they are noted on the board.

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2. While timing the demonstration, ask students the meaning of the word "foundation." Explain that the word foundation is used in many contexts, but that it always refers to an underpinning or strong basis. One context of the word foundation refers to buildings. Every building has some sort of foundation that connects it to the ground on which it stands. Ask students if they know the type of foundation upon which their houses stand. Ask if they know the type of foundation of buildings in the community. Ask if they can predict what might happen if the foundation of a building shifts. Ask students if they know of any structures in or around their community that have suffered damage from thawing permafrost.
3. Show VISUAL AID: "Architecture on Ice," page 1. The builders clearly didn't plan for the permafrost thaw and subsequent ground shift that would occur. Western settlers in the Arctic often used building techniques common to permafrost-free areas. After a few years, however, the issue became obvious. Show pages 2 through 3. Engineers are working toward solutions. Students will read about some of those solutions next. (Continue to display page 2 as students read. See next step.)
4. Divide students into pairs and hand out STUDENT INFORMATION SHEET: "Architecture On Ice" and STUDENT WORKSHEET: "Architecture On Ice." Ask students to read to find the answers to the worksheet. You may have to interrupt periodically to check on the demonstration. When students are finished, review the true/false questions and have students check for accuracy.
5. Complete the demonstrations; fill in the chart and discuss the observations. Did they confirm the hypotheses? Use the following questions as discussion starters, if necessary:
    a. What is the relationship of heat to the rate of ice melt?
    b. What is the relationship of pressure to the rate of ice melt?
    c. Were your predictions correct?
    d. What construction techniques could minimize heat transfer from a building to the permafrost?
    e. Is there a way to build a structure to minimize pressure?

    If students are completing a science journal entry, ask them to write a conclusion about how heat and pressure contributed to melting the ice.
6. Hand out the STUDENT INFORMATION SHEET: "Traditional Housing." Choose a reading strategy best suited for the class then read the material. (NOTE: The original pictures and text for A View from the Past can be found on the Alaska Native Knowledge Network site: http://www.ankn.uaf.edu/curriculum/athabascan/athabascans/aview_of_the_past.html.)
7. Hand out STUDENT WORKSHEET: "Traditional Housing," and allow students time to complete.

Ideas for Filming:

Students will complete a short film about permafrost for the final project associated with this UNITE US unit. Each lesson leading to the final project contains ideas about what students might film as they compile clips. Students are not limited to the list and are encouraged to use their imagination and creativity when filming.

Ask students to video the ice melting demonstration in the lesson.

Students should look for examples of building foundations in their communities that insulate permafrost. They might find buildings with gravel foundations, buildings on wood pilings or buildings on thermal pilings. If possible, students should film a structure in their community that has been damaged due to permafrost thaw. Students could film an interview with an Elder about how winter camps were once constructed. Students could film an interview with someone who has built a house in the community or participated in construction and ask how the site was selected and what was done to preserve permafrost.

Extension Idea:

Interview Elders about traditional housing in summer and winter. Compare interview results to get a picture of traditional housing in the community.

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Answers:

STUDENT WORKSHEET: Architecture on Ice

1. TRUE
2. TRUE
3. TRUE
4. FALSE
5. FALSE
6. TRUE
7. FALSE
8. FALSE
9. TRUE
10. TRUE

STUDENT WORKSHEET: Traditional Housing

Responses will vary, but should include references to lack of permanence of structures and to relatively small amount of heat generated and transferred.

ICE MELT DEMONSTRATION

Background:

The active layer above permafrost is a thin layer of ground that thaws every summer, allowing vegetation to grow. The active layer has insulating properties. Under the active layer lies permanently frozen ground. The active layer is vulnerable to environmental damage. A passing vehicle can tear up the insulating active layer allowing the frozen soil under it to thaw into scars that can remain for hundreds of years.

Underground, permafrost consists of frozen soils ranging from gravel to silt. Silty soil is made of fine, sedimentary particles that shed water, allowing water to migrate and accumulate in large bodies enclosed in the frozen silt. If the ice thaws, the ground will become a soupy mess.

It is easy to imagine how construction disasters can be caused by such a thaw. Homes, buildings, roads, train tracks – even the Jenpeg Dam in Canada – have been affected by the unpredictable behavior of permafrost.

Scientists and builders continue to study the problem. Important in all solutions is a basic principle: Keep the heat from transferring to the permafrost! Insulation is key. Small, lightweight structures may need only airspace between the floor and the soil surface. This is accomplished by raising the building on stilts. Larger structures require the support of insulated pilings driven deep into the permafrost.

Permafrost was an important consideration when engineers designed the Trans-Alaska Pipeline.

Preparation:

One day prior:

- Place about 1 inch of water in each of two large, flat cake pans and place them in the freezer.
- Fill one ceramic cup with water. Measure and note the amount of water in the cup then place it in the freezer.
- Prepare or purchase ice cubes.
- Prepare chart paper. One sheet create "CHART 1 - Temperature" then on a second create "CHART 2 – Pressure" (see page two).
- Prepare a piece of chart paper to record hypotheses. Write the following: "What happens to the rate of ice melt when differing amounts of heat and pressure are applied to the ice?" Underneath write HYPOTHESES.

Materials

- 2 large, flat cake pans, each with an inch of ice (previously frozen)
- 8 ceramic coffee cups
- Hot water
- Ice water
- Gravel or rocks to fill one cup
- 2 sponge for insulation
- Freezer access
- Timer
- Chart paper

ICE MELT DEMONSTRATION

Demonstration Guide:

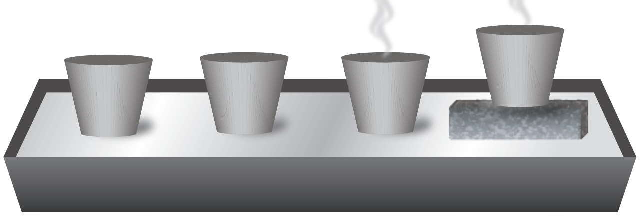
Use the ideas below to help students explore the effects of both temperature and pressure on frozen ground. Set up two demonstrations – one for temperature and one for pressure (mass).

Set up:

- Place the pre-frozen cup on the ice.
- Place the sponge on the ice.
- Fill two cups with very hot water (the same quantity used in the frozen cup) then place one directly on the ice; place the second on top of the sponge.
- Fill one cup with ice water and place on the ice (the same quantity used in other cups).

*** Place the cups so they do not touch each other.**

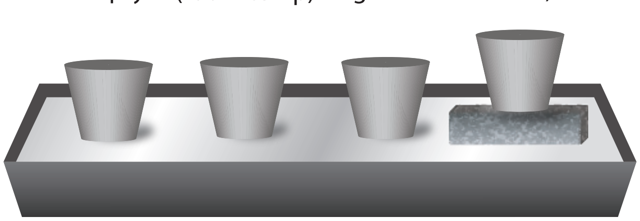
Temperature



1. Every five minutes, remove the cups that originally had hot water and refill them with hot water.
2. After 15 minutes remove all four cups from the pan. Feel the surface of the ice. Make observations on the chart.
3. Continue to refill the hot water and make observations as time permits.

The frozen cup serves as a **control** in the demonstration. It can be compared with the cups with materials that change the temperature.

Pressure (mass)



Set up:

- Place the empty cup on the ice.
- Place the cup with room temperature water on the ice.
- Fill one cup with rocks or gravel and place on the ice.
- If student want a 4th cup, consider filling it with gravel and figuring a way to distribute the weight.

*** Place the cups so they do not touch each other.**

The empty cup serves as the **control** in the demonstration. It can be compared with the cups with materials that change the weight.

ICE MELT DEMONSTRATION

Use the following chart layout to record predictions and observations on the board or on chart paper.

Chart 1: Temperature

Description	Prediction	Observation
CUP 1: ____________		
CUP 2: ____________		
CUP 3: ____________		
CUP 4: ____________		

Chart 2: Pressure

Description	Prediction	Observation
CUP 1: ____________		
CUP 2: ____________		
CUP 3: ____________		
CUP 4: ____________		

Construction Problems

Construction on frozen ground is difficult and challenging. Huge layers of ice can form underground and thicken over time. The process leads to expansion and can make the ground move, known as frost heaving. Not only do frost heave lift up the ground, they raise everything built above.

Heated buildings radiate heat to the ground. The heat can thaw the permafrost underneath the building. Once the permafrost thaws, it sinks, damaging the building it supports.

Pictured on the right is the Old Richardson Roadhouse near Black Rapids during the late 1940's. Note how the heated portion of the building has settled uniformly into the ground without even damaging the chimney, while the unheated porch has remained at the original ground level and has been torn loose.

Photo courtesy of CRREL, the U.S. Army corps of Engineers, printed in the July 20, 1984 edition of the Alaska Science Forum, Coping with the Permafrost Foundation.

Building Solutions

Permafrost is an excellent foundation for building – as long as it remains frozen! Removing insulating ground cover and building a heated road or building is a sure way to cause underlying permafrost to thaw and lose its rigidity. Modern engineers work hard to keep the permafrost stable and frozen. To do so they have to figure out how to keep heat from reaching the ground.

Elevate the Structure

- raise the structure using pilings made of materials that limit heat transfer
- elevate to allow natural air circulation beneath the structure and to minimize heat transfer

Insulate the Ground

- a gravel pad, usually from 4-to-6-feet deep, insulates the active layer
- insulate the floor to reduce heat transfer from the structure

The Cold Climate Housing Research Center in Fairbanks, Alaska is developing new technology that will aid builders. New types of insulation, such as soy foam, are designed to protect the permafrost from thaw and may even allow homes to sit directly on the ground without pilings.

COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF ALASKA FAIRBANKS

HCM-00754

PERMAFROST
A Building Problem in Alaska

by
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The following 4 pages are an excerpt from the publication above, released by the University of Alaska Fairbanks Cooperative Extension Service.

ENGINEERING DESIGN CONSIDERATIONS

The same factors that determine the local occurrence of permafrost must be taken into account when designing buildings for permafrost areas.

Temperature change
Permafrost is an excellent foundation as long as it remains frozen; it is very sensitive to temperature changes. Changes to the ground surface, like removing the ground cover, will change the temperature of the ground causing the permafrost to thaw and possibly lose its rigidity. A building radically changes the way heat moves in and out of the soil; constructing a building on a permafrost site will affect the permafrost. Buildings are normally heated in the winter, adding heat to the soil. A building also shades the soil in the summer, preventing exposure to the sun. So, the soil is warm in the winter when it should be cold, and cold in the summer when it should be warm. Make every attempt to keep the soil beneath the building frozen and the permafrost stable. The strategy for alleviating the engineering risks of building on permafrost sites, is to build the structure on piles or an elevated foundation taking special care to insulate the ground and prevent thawing. (Publications about building construction on permafrost are available from the Alaska Cooperative Extension. Please see References.)

Drainage
Permafrost, because it is frozen, is nearly impermeable to moisture. Water that occurs above the permafrost table (the top of the permanently frozen layer), and the active zone on top of this layer is extremely difficult to drain. So in spite of low rainfall (in the interior of Alaska for example), poor drainage becomes extremely noticeable. When flying over a permafrost area, the ground surface appears very wet because a thin layer of water is trapped and unable to drain through the underlying permafrost zone. Permafrost consequently limits ground water recharge into the subsurface areas below the permafrost.

Type of soil
Soil type is an important consideration when selecting a building site. Solid rock, gravel, and sand normally contain very little ice at freezing temperatures or below. Thawing therefore does not result in as much settling with coarse soils as with fine grain materials. Ice in coarse grained soils occurs in a number of forms: coatings or films on small particles, stones or boulders, or as ice in soil pores.

Fine grain soils–such as silt, clay or peat–typically have high ice content. They are susceptible to settling when permafrost melts. These soils are also susceptible to heaving which occurs when moisture moves to a freezing layer in the soil and moves (heaves) the soil above the freezing zone vertically. (As long as the water in this soil remains frozen, the ice binds material of considerable strength.) Frozen permafrost makes a good foundation as long as it remains frozen. However, when thawed, these soils can change into a soft slurry with very little strength for supporting a building and foundation failure can result.

Geologic Quadrangle maps are available for some areas of Alaska that describe terrain features like elevation, contours, soil classifications, drainage and permeability of soil, permafrost and susceptibility of soil to frost action, bearing strength of soil, slope stability and suggested use of soils. The USDA Soil Conservation Service is also helpful when seeking information regarding soils.

Ground Ice
The riparian soils in Alaskan river valleys are nearly always a friable (soft) silt. These soils are commonly some of the worst soils for frost action and heaving. This type of soil combines good water retention characteristics with a high hydraulic conductivity, factors that are necessary for ice lenses to develop. In permafrost areas large masses of clear subterranean ice form. When these ice lenses melt, they often leave large holes in the surface of the ground. Thawing subterranean ice created a spectacular hole at a golf course near Fairbanks–a 15 foot deep golf trap.

METHODS OF DETERMINING THE DEPTH AND PRESENCE OF PERMAFROST

Determining the conditions of permafrost at a site is made by measuring the depth of the active layer down to the permafrost. There are four methods of locating the depth to permafrost.

Rodding is commonly used as a quick guide for determining depth to permafrost or the thickness of the active layer. A ¼- to ½-inch sharpened steel rod is driven with a heavy hammer until it will go no further. The rod is then turned by a wrench. If the rod turns easily, it probably hit a stone. If back spring occurs, the rod has probably penetrated wood or permafrost. The sound of the rod may indicate whether it struck a stone, wood or ice. A sharp clang indicates a stone, a dull clang indicates ice, and a dead thud indicates wood.

Auger boring is usually more conclusive in determining the depth to permafrost. Auger boring can also supply information on ground water levels and types of soils.

Digging a pit requires more labor, but is a fairly reliable method of determining the active layer depth and allows the character of the permafrost and the soil to be studied.

Machine coring is the most positive method of determining the depth of the active layer, the thickness of the permafrost, and the characteristics of the frozen and unfrozen soil. Machine coring is the recommended method to use before constructing all commercial and industrial buildings on permafrost. If you have any doubts about soil characteristics, machine core before constructing a home. The cost of boring is minor compared to the cost of repairing foundations that may settle because of thawing permafrost.

FOUNDATION SELECTION

After general site conditions are evaluated, a more detailed investigation is normally required at the specific construction site. Alternatives can be selected when you are sure there is permafrost present.

Perennial freezing can be ignored on well-drained, coarse-grained river sand and gravel or bedrock, because they have few associated problems. In a continuous permafrost zone, particularly with fine grained soils with high ice content, every effort must be made to preserve frozen conditions. In the discontinuous zone, it may be necessary to remove frozen material that is susceptible to frost action. (A good discussion of permafrost removal and treatment is given in the Foundation Chapter of the Alaska Residential Building Manual 2007. See References.)

For some types of structures, in either continuous or discontinuous zones, it may not be possible to prevent thawing without special design considerations. Permafrost may need to be preserved through a combination of insulation and ventilation techniques.

A gravel pad, 4-to-6-foot deep, can be used to insulate the active layer. The building can be set on mud sills or other suitable foundation that allows free circulation of air beneath the structure floor. The floor must be insulated to reduce heat transfer from the structure. Some settling must be anticipated and taken into account in the design of the foundation.

Wood piles anchored in the permafrost are considered the most stable foundation for arctic building. The piles should be well embedded in the permafrost and the structure raised above the ground to permit natural air circulation beneath the structure and to minimize heat flow from the structure to the frozen ground.

Piles are driven in place with a pile driver. However, the permafrost must be melted with a steam jet. The piles can be set in an augured hole filled with slurry and allowed to refreeze. Autumn and early winter are the best time to set piles for the next construction season. Piles should set undisturbed for a year until firmly frozen and anchored in place by the permafrost. Sometimes piles are fitted with refrigeration coils to hasten the freezing process. The tops of the piles are cut off 4 to 5 feet above ground allowing free air circulation beneath the structure floor.

Thermal piles or freezing tubes can be used to increase the depth, stability and amount of permafrost and for stabilization during warm weather. These devices are filled with a non-freezing liquid and use heat convection, drawing heat from the earth during subzero weather and convecting it to the atmosphere. The power for the convection cycle comes from the warmer soil temperatures in the ground.

Building foundations should be designed with a uniform weight distribution. Lightly-loaded, improperly anchored piles may be pushed out of permafrost by the active layer and heaving action. Piles should be fitted with a slip-fit casing that will minimize the surface friction on the piles. In lightly loaded structures–houses for example–the number of rows of piles and beams should be balanced for uniform load distribution and to minimize uneven floor movement. An improperly designed structure may be costly to realign once it has settled. Foundations should be designed for easy access to realignment and adjustment areas in the event minor dimensional changes occur.

PROFESSIONAL SERVICES AND ADVICE

Individuals considering building construction in Alaska should consult with architects, engineers, and contractors who are thoroughly experienced with Arctic building problems.

NAME: ______________________________

ARCHITECTURE ON ICE

Directions: Read STUDENT INFORMATION SHEET: "Architecture On Ice." Determine whether each statement below is true or false.

1. TRUE FALSE Frost heaves are caused by ice pushing up the ground over it.

2. TRUE FALSE Removing vegetation can cause permafrost to thaw.

3. TRUE FALSE Keeping permafrost stable is a challenge for engineers.

4. TRUE FALSE Gravel and coarse-grained soil are bad for building when permafrost is present.

5. TRUE FALSE River valleys are good places to build when permafrost is present.

6. TRUE FALSE Rodding is a way to check for permafrost at a building site.

7. TRUE FALSE Digging a pit at a building site will give the best information about permafrost presence.

8. TRUE FALSE Machine coring is always worth the money it takes to do it.

9. TRUE FALSE Pilings made of wood are usually very stable for use as a foundation when building on permafrost.

10. TRUE FALSE New types of buildings being developed will better protect permafrost than older building types.

Traditional Housing


Archives, University of Alaska Fairbanks

Traditionally, housing was built to suit the season and tasks of the people.

During the spring and summer many families traveled to fish camps like this one along the Tanana River.

Summer camps consisted of tents or other semi-permanent dwellings and did not pose a potential danger to permafrost.

Winter camps, however, were set up during the coldest months of the year and interiors had to be warm.

Winter camp was made up of several households, and although the exact house plan and building materials varied from area to area, the winter houses of many Athabascan groups were similar. They were semi-subterranean structures made of a wood frame covered by birch or spruce bark, which was then covered by moss, and topped with dirt. All that was visible of the houses from ground level were mounds of snow with smoke curling out of the centers. The semi-subterranean house plan used by most Alaskan Native groups in winter is excellent for retaining heat, because there is little surface area through which heat can escape, and cold winds cannot penetrate the structure. In addition, the many layers of insulation used on Interior Athabascan winter houses kept the inside quite warm.

Chief Robert Charlie Talks About Building a Sod House

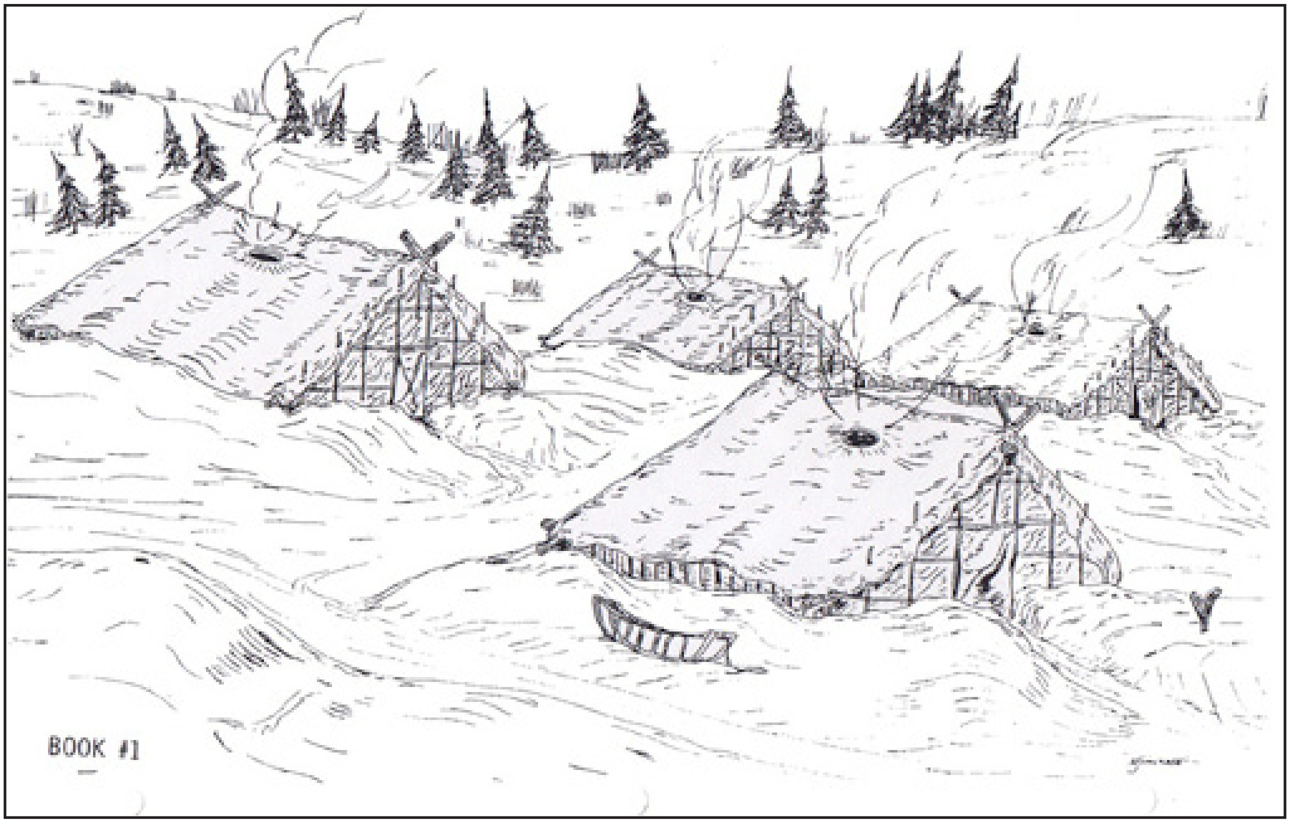
"Let us go back to the ancestral times of Athabascan People when there was no such building material as is available nowadays. To build a sod house, say a 15′ by 15′ round structure, you must first gather your materials. Athabascans always carried hand-made tools with them when moving in small groups, for cutting and digging. In this case tools were made of bones or obsidian."

"Laying the foundation is digging dirt two or three feet deep for a 15′ x 15′ family-sized house. The wall frame is spruce or willow eight to 10 feet long and three inches in diameter at the trunk. The poles would be four to six inches apart all the way around. The house is built like a tepee, seven to eight feet high with a hole in the upper center so the smoke can go out. Around the frame they wrap birch bark or dried and oiled caribou hide. Once the hide is up they would put dirt and moss on the outer part of the walls. They put extra dirt around the skirt of the sod house. The door would be of bear hide with full fur."

"Once the sod house is completed, there is no draft coming in and it makes it very comfortable. The fire in the center makes for a bright light and is used for cooking."

Alaska Native Knowledge Network

A View of the Past



Written by
Patricia H. Partnow

Illustrated by
Michael D. Jimerson

For the Athabascan Indians of Interior Alaska
Social Studies Unit, May 1975

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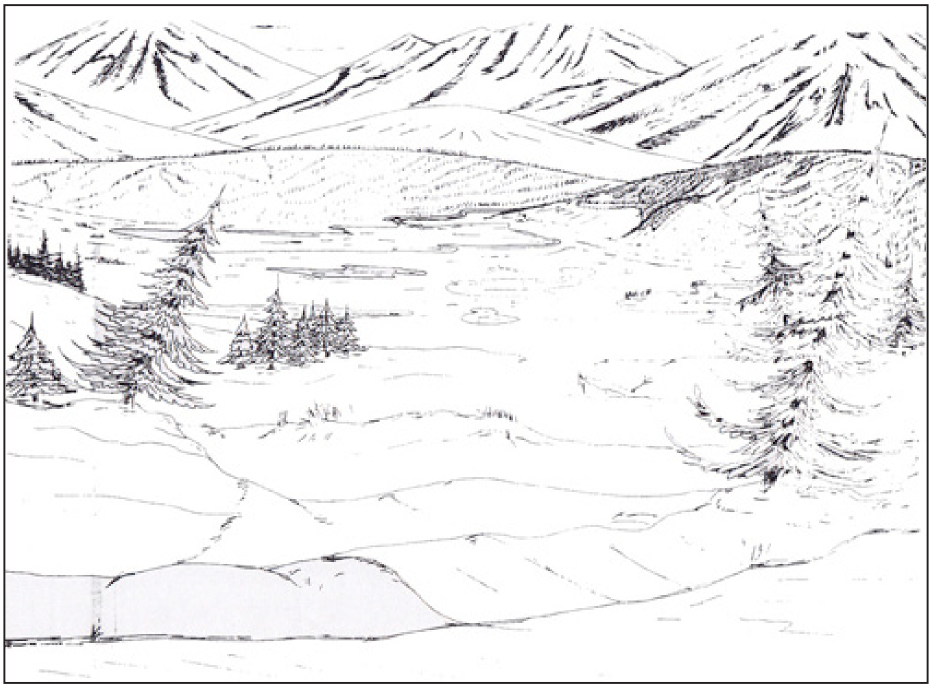
5-75-500

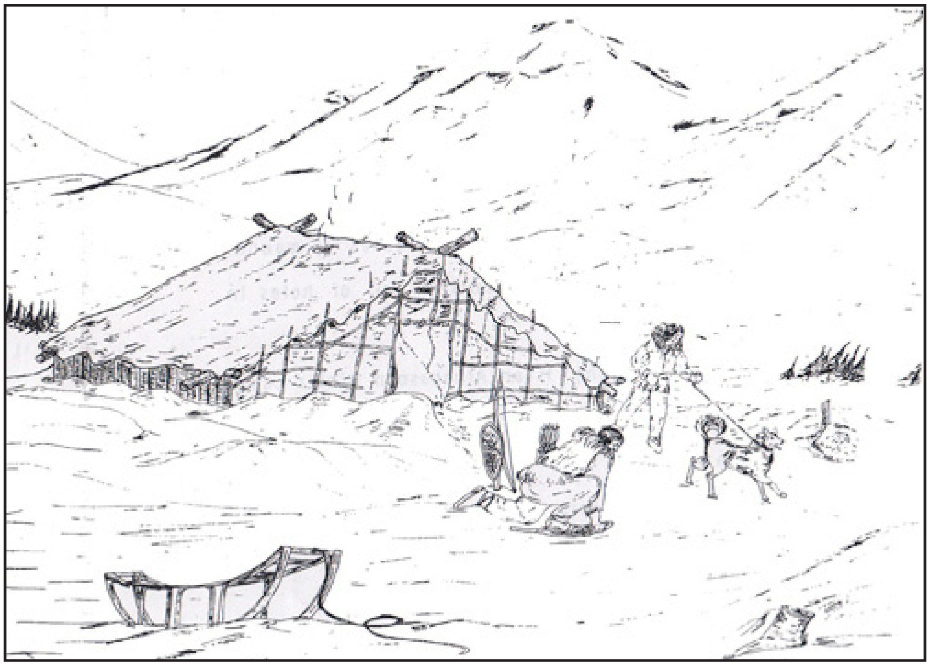
TRADITIONAL HOUSING



It's a cold, still morning in November two hundred years ago. In the interior of what is now known as Alaska, the rivers and lakes have been frozen for several weeks. Snow covers the ground and clings to the short branches of the spruce trees.

In a clearing, set back from the river a bit, are four snow-covered houses – mounds of white with smoke curling out of holes in the tops.

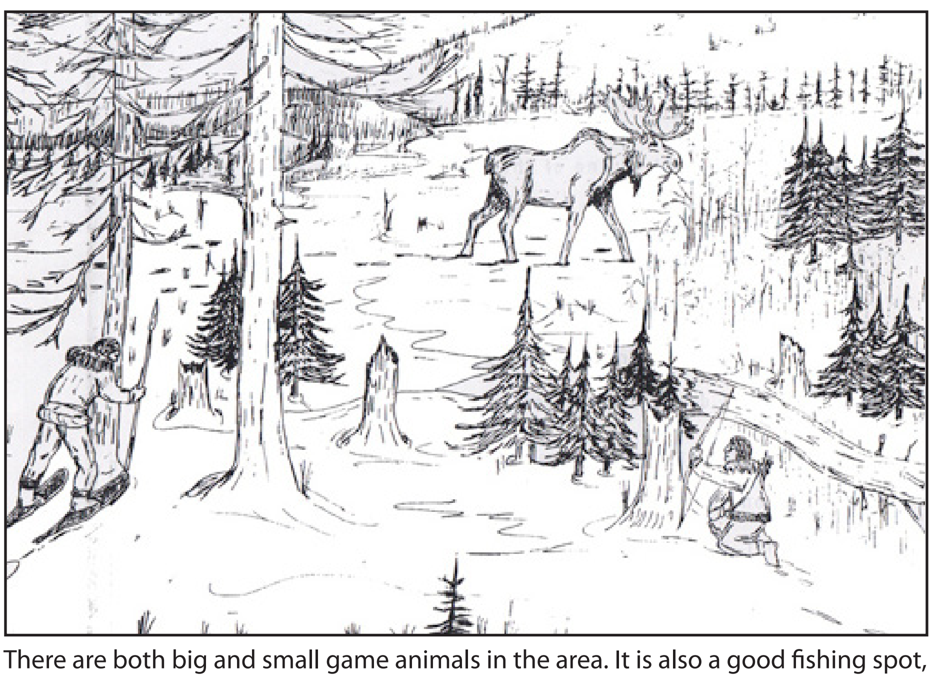
This camp is an Athabascan winter camp. Relatives and good friends, all members of the same band, have decided to stay at the same camp this winter and have built their moss-covered houses close together.



Two men come out of one of the houses carrying bows, arrows, and sinew snares. Laughing and talking to each other, they put on long snowshoes, untie a barking dog, and set off with it across the frozen river and into the forest on the other bank.

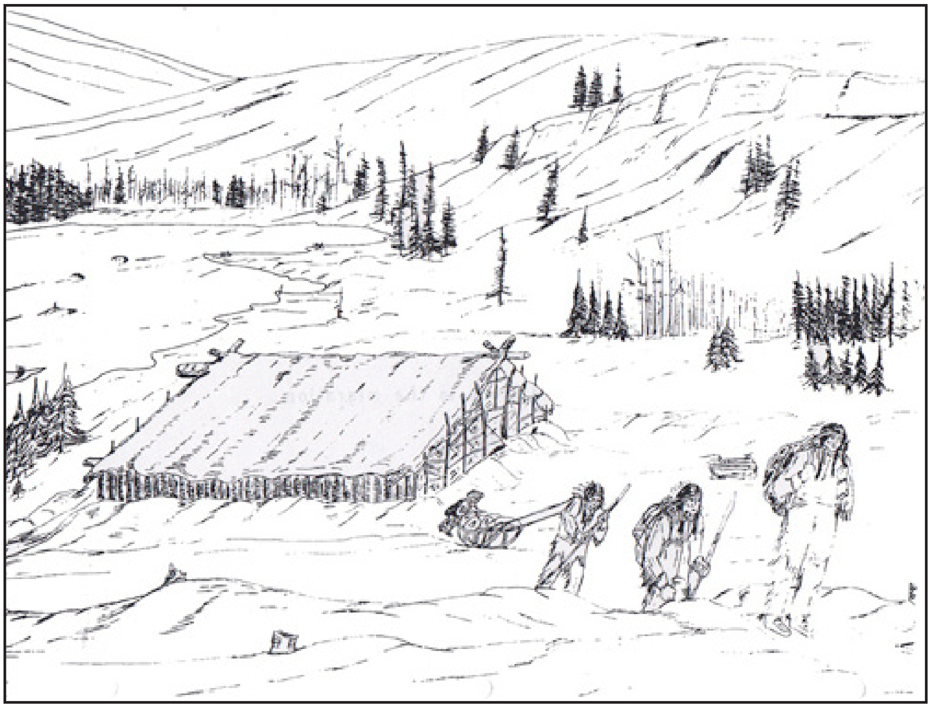
A woman, bundled in a caribou-skin parka, follows them out of the house and walks down to the river to get water.

A third man walks downriver a bit and checks his fish net under the ice. Soon the ice will be too thick for netting and it will be time to jig. But for now the winter run of whitefish is still filling the nets.



There are both big and small game animals in the area. It is also a good fishing spot, and close to the migration route of a herd of caribou.

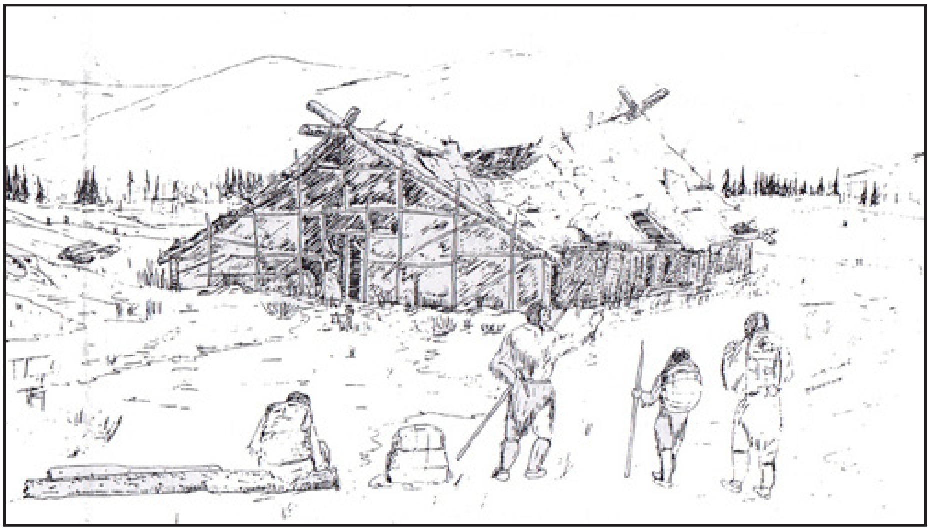
TRADITIONAL HOUSING



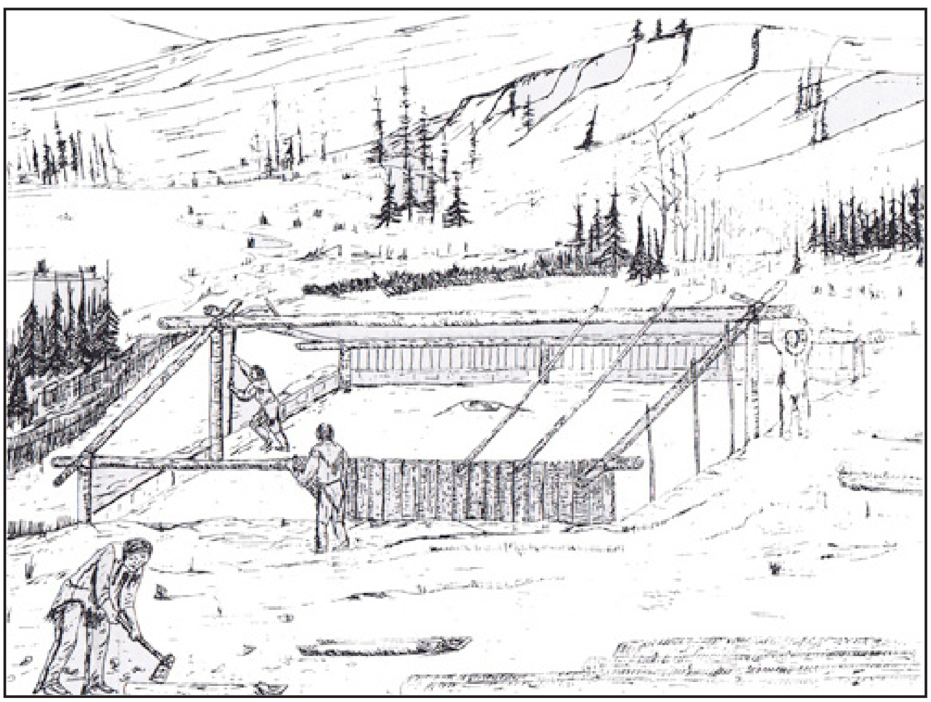
Each of the houses in this winter camp is home for two families. In one household, the two families decided to live together because the wives are sisters and their husbands get along with each other. In another, a married daughter and her husband are sharing a house with her parents. And in still another, the two men are hunting partners and good friends, and so decided to share a house.

These Athabascans will hunt and fish for awhile, but later on this winter they will break camp and split up. Each household will go to its own pond or lake to trap beavers, or will travel to a favorite hunting spot. When they move out of their winter camp, they will carry their tents, tools, clothes, and weapons with them. They'll leave only the houses themselves, still covered with snow.

TRADITIONAL HOUSING



As spring comes and the snow melts at this winter camp, the moss and dirt that cover the houses will become wet and heavy. Water will drip through the planks on the roof, onto the dirt floor inside. By summer, the poles that held the roofs up will fall down under the weight of the soggy roof.



When the people return next fall they will be glad to see their friends and relatives again. They will see that the old houses have fallen down, and will start the work of building new ones. They will by busy with the houses, with fishing and hunting and getting ready for the winter. It is a good time of year!

NAME: ______________________________

TRADITIONAL HOUSING

Directions: Consider what you have learned about building on permafrost. In a paragraph or two, explain why traditional Athabascan winter houses did not thaw permafrost below them like housing structures today.

ARCHITECTURE ON ICE

Construction on permafrost can be tricky business. This damaged building in Dawson City, Canada, shows what can happen when the warm interior of a building causes the permafrost underneath to thaw. Photo courtesy of the National Snow and Ice Data Center.

ARCHITECTURE ON ICE

Buildings like these in Barrow are built using pilings to keep permafrost from thawing.

Top: Ilisagvik College Building, photo by Frank Kelley (PolarTREC 2007), Courtesy of ARCUS

Bottom: Barrow Arctic Science Center, photo by Frank Kelley (PolarTREC 2007), Courtesy of ARCUS

ARCHITECTURE ON ICE

This prototype home was built in Anaktuvuk Pass in 2009. The Cold Climate Housing Research Center at the University of Alaska Fairbanks is monitoring several aspects of performance in the Anaktuvuk Pass prototype home including thermal performance, ventilation, and energy use.