3 Challenges and Problems of Periglacial Environments

Although periglacial climates vary in their degree of severity, conditions are generally harsh, undoubtedly presenting a challenge for human occupation and development. Through history, the peoples inhabiting periglacial environments have adapted their cultures in remarkable ways to cope with the climate and to make the most of the limited resources. For instance, the traditional way of life of the Inuit (Eskimos) of Canada and Greenland was semi-nomadic and subsistence based, closely adapted to the environment and mainly dependent upon hunting and fishing. From the sea, whales, walrus and seals were important sources of food, skins and fuel; and on land they hunted many types of mammals including moose, caribou, musk ox and bear.

Establishing permanent settlements and developing industries, such as mining and oil extraction, has required major technical advances to be successful primarily because the presence of permafrost creates a unique set of problems for construction work and engineering. Permafrost underlies about 80% of Alaska and large tracts of northern land in Canada, Russia and Scandinavia, and the economic development of these areas has depended upon specially adapted buildings and infrastructure. Conventional construction techniques are unsuitable because they alter the thermal balance of the ground leading to permafrost thaw and ground subsidence. Problems are also caused when vegetation is cleared from the surface. This reduces the insulation of the permafrost, and in the summer this results in deepening of the active layer as heat is transferred down to the permafrost table more easily.

Ground subsidence is most severe in places where the permafrost is ice-rich, particularly in fine-grained sediments with a high porosity, so that deepening of the active layer causes a large volume of ground ice to melt relative to the original frozen volume of sediment. Even minor vegetation disturbances, for example by off-road vehicle tracks, can greatly increase melting of ground ice over the long term because tundra vegetation is very slow to re-establish itself. The effect of reduced insulation is exacerbated by structures, such as buildings or pipelines, that transmit additional heat to the ground. These effects speed up the development of a thermokarst landscape beyond the natural rate.

The damage caused by this form of ground subsidence can be seen in towns and villages built in permafrost areas before special engineering designs were developed. Historic buildings in the town of Dawson in the Yukon Territory of Canada, hub of the Klondike goldrush of the late 19th century, are tilted and fractured. Roads, railways and airstrips in many parts of the Arctic have also been damaged by ground subsidence. In Canada, Sachs Harbour airstrip on southern Banks Island has required constant maintenance and re-levelling since it was completed in 1962 because the underlying sediments are ice-rich and the area has experienced rapid development of thermokarst. Bridges are often damaged by frost heave because middle supporting piles are driven into unfrozen sediments beneath stream beds, whereas piles on either bank are driven into the active layer. Consequently, piles at the ends of the bridge are pushed upward due to seasonal frost heave, while piles in the middle remain stationary because of the absence of frost heave beneath the body of water.

In recent years many new methods of construction have been employed to protect permafrost and to prevent subsidence. While largely successful, these methods are initially more expensive than conventional construction, adding to the cost of living in permafrost areas, and continual maintenance of the structures is often necessary. Houses and other small buildings are now often elevated above the ground on piles driven into the permafrost. A gap about 1 m high beneath the base of the building and the ground surface allows air to circulate and remove heat that would otherwise be conducted into the ground. Larger structures are built on **aggregate pads**, which are layers of coarse sand and gravel, typically 1–2 m thick, that substitute for the insulating effect of vegetation and also reduce transfer of heat from the building into the ground. Aggregate pads are also used beneath roads, railway tracks and airstrips. The thickness of the pads must be carefully calculated to maintain the thermal balance of the ground at its natural state. If too thin, insulation may not be strong enough to prevent thaw of permafrost causing subsidence, whereas if too thick, increased insulation may result in elevation of the permafrost table and upward heaving of the ground.

Another challenge in permafrost areas is the provision of water and energy supplies and waste disposal. Telephone and electricity cables and water pipes cannot be buried underground because of the stresses and damage that would be caused by freezing and thawing in the active layer. Telephone and transmission poles require continual maintenance because of frost heave. In relatively large settlements of a few thousand people or more (such as Inuvik in northern Canada) **utilidors** are used to carry the water supply, heating pipes and sewers between buildings. Utilidors are insulated box conduits made of concrete, wood or metal that are elevated above the ground (Figure 27). In smaller settlements where it is uneconomical to set up a utilidor system, water supply and waste disposal are provided by truck.

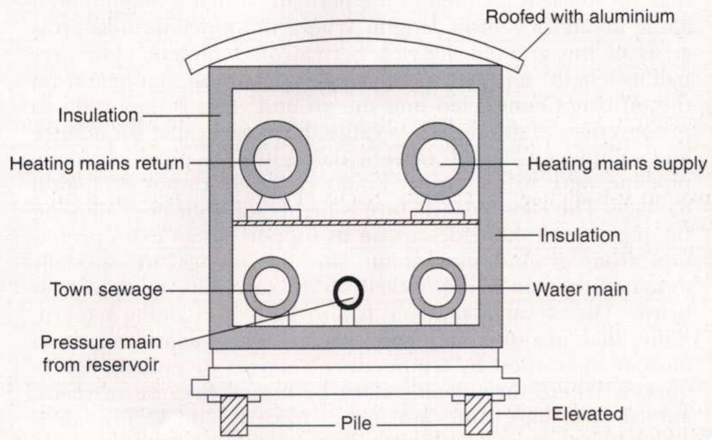

Figure 27 Cross-section of a utilidor. *Source*: Money (1980).

Glacial and Periglacial Environments, David Anderson, Hodder & Stoughton, 2004