CASE STUDY: THE TRANS ALASKA PIPELINE

Since the 1970s increasing effort has been made to exploit oil and natural gas in Arctic regions of Alaska, Canada and Russia. This too has its unique challenges relating to exploration, drilling and transport in a periglacial environment. For example, oil extracted from the Prudhoe Bay oilfields in Alaska must be transported 1290 km (800 miles) to the ice-free port of Valdez before it can be loaded onto tankers and shipped to market. This is achieved by the Trans Alaska Pipeline, which was completed in 1977 and is a remarkable feat of engineering. It is very important for the United States oil industry, delivering 17% of its domestic oil production. It took approximately 6 years to design and about 3 years to build, employing about 70 000 people over the duration of construction and costing around US$8 billion in total. This was far in excess of the original cost estimate, largely because of unforeseen difficulties in building the structure across extensive areas of permafrost. The pipeline has a maximum daily throughput of some 1.4 million barrels, and the oil flowing through the pipeline is at a temperature of 65°C.

The Trans Alaska Pipeline has a number of design features that are specially adapted to the permafrost that is encountered along about 75% of its length. Where the pipeline must cross areas of fine-grained, ice-rich permafrost sediment (just over half its length) it is elevated above the ground so that heat from the oil is not conducted into the ground. This is important to prevent thaw of ground-ice because this would cause subsidence and solifluction of soil, thereby damaging the pipeline. If the pipeline were to rupture it would cause enormous ecological damage. The elevated structure is highly sophisticated, allowing the pipeline to shift sideways on its supports as an extra protection from ground movement, and the pilings are specially designed to resist being 'jacked up' by successive years of frost heave. The elevated pipeline is also built in a zigzag pattern, rather than in a straight line, so that it is able to adjust to ground movements caused by temperature changes or even by earthquakes. Where the pipeline must be buried because of roads, animal crossings and avalanche hazards, thick insulation coatings are used, and in the most sensitive permafrost areas refrigeration pipes are installed around the main pipeline to keep the ground frozen.

In areas free of permafrost, or where the permafrost sediment is coarse grained (free draining and less susceptible to subsidence on thawing), the pipeline is buried underground using cheaper, conventional methods. Designing the pipeline in the most cost-effective way demanded careful study of the different soil and sediment types along its length, and their degree of susceptibility to ground subsidence and frost heave. Only about 6.5 km of buried pipeline required the most expensive design including below-ground refrigeration.

The Trans Alaska Pipeline