Permafrost Symposium 2023 Reflections

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I would like to share some of my observations and thoughts regarding the Permafrost and Infrastructure Symposium held in August 2023. The symposium started in Utqiagvik (formerly Barrow), Alaska and ended in Fairbanks, Alaska. The beginning days were spent at the BARC, owned and operated by UIC, the local corporation. Holding the initial presentations there provided unique opportunities to interact with UIC employees, many of whom grew up and live in Utqiagvik. The workshop was attended by people from a wide variety of backgrounds, including various levels of local and national government agencies, engineers, scientists, and academics, all who were connected to the Arctic. Because of the diversity of the attendees, there were numerous opportunities during discussions, presentations, breakouts, and free time to discuss a variety of topics related to permafrost and infrastructure. While many of my conversations on a day-to-day basis are primarily focused on science and engineering, it was a lot of fun to talk about permafrost and infrastructure to a wider audience.

During the Utqiagvik portion of the symposium I had the opportunity to present on the topic of designing piles in permafrost. While this topic can be a graduate school course, I tried to focus on the relevant and broad issues related to piles in permafrost for infrastructure and do it in 15 minutes. Key topics of my presentation related to the widespread use of piles throughout the Arctic for infrastructure development, simple design concepts for piles in permafrost, and some final thoughts on climate impacts to permafrost and the challenges related to pile stability in thawing permafrost.

Pile supported infrastructure can be seen across the Arctic. Their use includes support of buildings, tanks, bridges, pipelines, transmission and communications towers, and more. Pile foundations tend to be an economical and low impact option for constructing in the Arctic. As an example, traditional concrete supported structures are far and few between in villages in northern and western Alaska. Concrete costs, while typically around $150 per cubic yard in places like Anchorage and Fairbanks, can be at least an order of magnitude higher in rural Alaska. This is primarily due to mobilization and shipping costs, but also related to the short construction windows available for building with this construction material. In contrast, pile construction can happen any time of year, and is preferred in the winter due to better access to sites where access could impact tundra during the summer.

There are a variety of pile options that are used in the Arctic, but the most common type of pile tends to be the adfreeze pile. This type of pile is constructed by drilling a hole in the ground slightly deeper and larger than the pile and setting the pile in the hole. The anulus of the hole is typically filled with a sand-water slurry and allowed to freeze back, locking the pile in place. The pile capacity to transfer the load is directly affected by the ground temperature, ice content, and salinity. All of these are critical information to gather during the pile design process. Numerous design considerations tend to complicate the design as a specific site, but the general concept is fairly straightforward. One other topic that was discussed during the presentation was related to frost heave effects on piles. This occurs when the near-surface soil freezes seasonally and expands vertically. When the ground around the pile freezes and moves vertically it can

grab onto the pile and apply forces in the upward direction. If the pile is not embedded deeply enough to resist that upwards force it will also move (heave) upwards.

Lastly, I discussed some of the engineering concerns related to permafrost degradation and pile capacity. As mentioned previously, temperature and ice content are a couple very important aspects of pile design. Decreases in temperature result in decreases in pile capacity. Simply put, a pile that was designed to support 1,000 pounds in 1990, when the permafrost temperature was 25°F, will not be able to support the same load when the permafrost temperature rises to 28°F. This poses a challenge to infrastructure in the Arctic in two ways. The first is that older infrastructure will very likely require some type of retrofit for continued use into the future. Given that historically, we have had an easier time funding new capital expenses, this will be a funding challenge at a minimum. The second issue is that there is no real solid direction to guide engineers for what permafrost temperatures may be in the future. Engineers are challenged because deeper piles result in larger project costs and the decision regarding how deep is deep enough ends up not being only an engineering decision.

During the portion of the symposium that was in Utqiagvik I was able to participate in a field trip to Wainwright, Alaska. The group traveled by fixed wing aircraft to the village, and we toured the town. While I have been involved in several infrastructure projects in Wainwright, it was my first time to visit. We toured several critical pieces of infrastructure including the water and wastewater treatment plants, the landfill, a new rock revetment to protect the shoreline, ice cellars, and several new houses that had unique foundation systems. At lunch we met with several residents and discussed life in Wainwright and some stories of the past. It was a great experience and one that left an impression in me, especially seeing some of the work that I have helped with over the past few years.

After several days in Utqiagvik, the group traveled over to Prudhoe Bay to spend a couple days in the oil fields on the North Slope of Alaska before heading down the Dalton Highway to Fairbanks. This was another new opportunity for me, as I have not had the opportunity to visit Prudhoe Bay, while again having worked on numerous projects in the area. It was very interesting stopping at the trial pipeline burry site and looking at the attempts to burry pipe and rehabilitate the ground above the pipe. That coupled with the discussions related to rehabilitation permafrost caused by drill pads at Prudhoe Bay and fiberoptic line installation damage along the Dalton Highway, were very interesting and supported concerns I have shared over the years related to the sensitivity of permafrost to construction damage.

The trip down the Dalton Highway was another excellent showcase of engineering challenges, especially as we traveled from the more continuous and cold permafrost in the north to the warmer and more discontinuous permafrost in the central portion of the state. The warmer permafrost presents additional challenges as it degrades and loses stability achieved in its frozen state. And again, it was very interesting to discuss these topics with a wider audience consisting of professionals with different backgrounds. I think a new appreciation for the challenges related to constructing roads in cold regions was well conveyed by the Alaska Department of Transportation and Public Facilities representatives as our guides along the way.

The symposium was wrapped up with a couple of activities in the Fairbanks area. I was lucky enough to get to go into the USACE CRREL permafrost tunnel, which I have visited before, but

it always offers something to learn from each visit. We also had a closing discussion at the University of Alaska Fairbanks. It was fun to hear about the learnings and take-aways from the other participants. For me, one of the take-aways is the importance of sharing permafrost engineering principles in, hopefully, easier to digest bites for a wider audience. I have attempted to capture some of the piles in permafrost concepts above with that in mind. This will be especially important in the future, given the growing interest and importance of the Arctic to the global economy.