Kangerlussuaq Airport: Establishing a borehole database in support of future operational and maintenance decisions

Foged, Niels Nielsen; Ingeman-Nielsen, Thomas

Published in:
Proceedings of the conference AIC2018

Publication date:
2018

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):
Foged, N., & Ingeman-Nielsen, T. (2018). Kangerlussuaq Airport: Establishing a borehole database in support of future operational and maintenance decisions. In Proceedings of the conference AIC2018 : Transportation Infrastructure Engineering in Cold Regions (pp. 74-75). B Y G D T U. Rapport, No. R-388

Kangerlussuaq Airport: Establishing a borehole database in support of future operational and maintenance decisions

Thomas Ingeman-Nielsen[1*], Niels Foged[1]

[1] ARTEK, Department of Civil Engineering, Technical University of Denmark
[*] Speaker, e-mail: tin@byg.dtu.dk

Motivation

Greenland is in the process of reorganizing the transportation infrastructure network with the construction of several new airports capable of accommodating trans-Atlantic flights. As part of the changes induced, difficult decisions have to be made regarding the future operation and maintenance of existing airport facilities. Here we discus the geotechnical setting of Kangerlussuaq Airport (67.01°N, 51.69°W) which is currently the main airport hub of Greenland. It was established at a remote and uninhabited site by the U.S. Army Air Forces in October 1941, as an alternative runway to the base at Narsarsuaq and was used as hub and refueling station for transatlantic flights during World War II. Its location was based on the very favourable climatic conditions resulting in high operational regularity.

Background

The airport and its supporting settlement are situated in the rather complex geological setting of a glaciomarine delta in the valley system east of the head of the Kangerlussuaq fjord. Due to its inland location and proximity to the ice sheet, the airport experiences a stable dry subarctic climate with a mean annual air temperature of -3.3°C (2004–2014). Extreme winter temperatures range down to approximately -45°C and summer temperatures up to 25°C. The area has continuous permafrost, the thickness of which has been estimated at 130 m at the airport location (van Tatenhove and Olesen, 1994).

A gravel runway was first constructed in 1941 on the typically coarse grained river plateau; it was strengthened and paved in 1952, and finally expanded (both width and length) to its current size in 1957-58. No excavation and replacement was done during the two first phases of the construction, but for the third phase, excavation and replacement was performed to 3.3 m b.g.s. for the longitudinal extension. The area of the original runway was not reconstructed; the pavement was merely widened to the north. The westernmost part of the new runway extended onto a lower plateau of marine fine-grained sediments affected by deep erosional scars, and a thick embankment was constructed to support the runway (USACE, 1958).

Approach

Based on available blue prints, reports and borehole logs, information about a total of 147 boreholes and test pits in the airport area has been digitized and collected in a database. It comprises information about soil types, water contents, thaw depths and classification of ground ice occurrences, as well as technical information such as drilling date (or year where the date is not available). The information cover investigations conducted from 1952 to 2016 and span different drilling and sampling technologies and both US and Danish site investigation and classification practices – nevertheless, the information has been attempted standardized in a common and intercomparative format. All boreholes and test pits have been georeferenced and their locations are assumed accurate to within 2 m, see figure 1. The collection of the information in a database, allows users to extract statistical information about the occurrence of e.g. soil types, thaw depths or ice content classifications, and link this information to specific areas within the airport. It therefore constitutes a solid factual basis for future operational and maintenance decisions.

Discussion

Based on information from the borehole database, we conclude that the eastern part of the runway is constructed on a river plateau of mainly sand and gravel deposits. Around station 70+00 (2030 m from east end of runway) the depositional environment changes and encountered sediments consist mainly of silt and clay on the lower marine terrace.

Information from 42 holes is available along the runway, 31 of which are located on the river plateau. Most holes on the river plateau (27 of them) contain layers of peat or silt (organic and/or inorganic), the combined observed thickness of which has a median of 0.7 m (maximum 1.4 m) across the area. These materials represent the original surficial eolian deposits and vegetation on which the 1942 runway was constructed. Some holes (7) are not deep enough to observe the lower boundary of these deposits, and thus the maximum thickness may be larger than indicated. All boreholes on the river plateau include coarse-grained (sand and gravel) layers, and the deeper boreholes available show only coarser grained materials

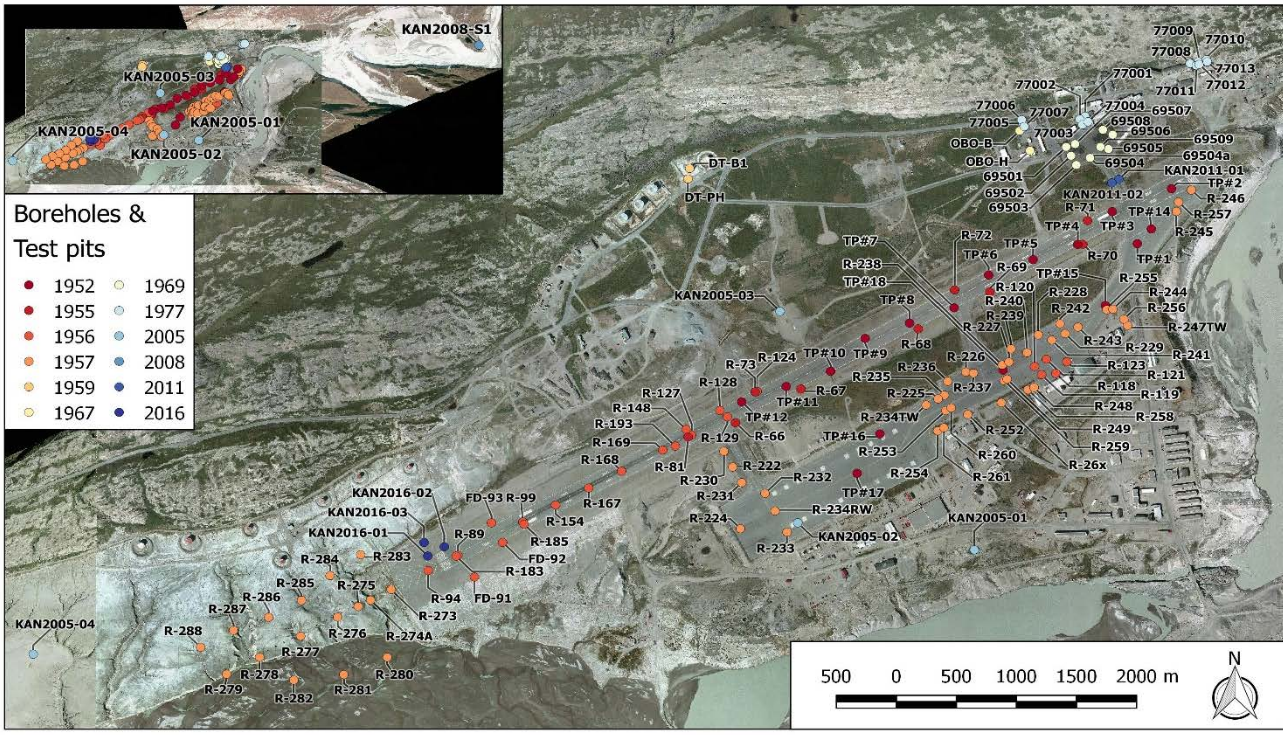

Figure 1. Map of Kangerlussuaq airport with indication of available boreholes and test pits. The color coding represents the year the investigations were conducted.

below the layer of surficial deposits. For the coarse grained deposits the content of fines (grain sizes <0.02mm) where measured is typically low, with an average of 4.7% and standard deviation of 3.5% (N=60). Eight boreholes extend into the permafrost and all available frost classifications indicate poorly or well bonded samples with no segregation ice (NW or NP). The risk of settlements related to permafrost thaw on this part of the runway (stations -6+50 to 70+00) is therefore limited.

Past station 70+00, the embankment rests on marine fine grained deposits of silt and clays of low plasticity (CL and ML). The fines content (grain size <0.02 mm) of available samples average 62% with a standard deviation of 13% (N=63). Much of the materials encountered have been classified as rich on segregationally ice, mainly in the form of regular and irregular lenses and veins (II and IS). In this part, the thermal regime in the ice rich sediments is protected by the thick embankment on which the runway is constructed.

Conclusions

The analysis of boreholes along the runway documents that the eastern part (until st. 70+00 or 2150 m) is located on a river plateau consisting of mainly coarse grained material with low ice content. Surficial organic and silty deposits are present in the subgrade of the oldest parts of the runway, but these deposits are typically of limited thickness. Assuming an active layer thickness of approx. 4 m below paved surfaces (Jørgensen & Ingeman-Nielsen, 2007) all observed occurrences are located in the active layer, and therefore do not constitute a risk related to permafrost thaw, but rather a risk of seasonal frost heave if the pavement is not properly maintained and the construction kept well drained. This is consistent with the fact that no significant thaw deformations have been reported for the western part of the runway.
Severe settlements on the western part of the runway (from st. 78+00) are ongoing, and reported as early as 1971. Based on available borehole and test pit information, these deformations are related to processes in the embankment construction, rather than thaw of the ice-rich natural permafrost subgrade.
Especially the southern taxiways and aprons have been severely affected by thaw settlements, due to the fact that very limited excavation and replacement was conducted during construction.

References

[1] Jørgensen, A. S., & Ingeman-nielsen, T. (2007). The Impact of Light-Colored Pavements on Active Layer Dynamics Revealed by Ground-Penetrating Radar Monitoring. In Proceedings of the Ninth International Conference on Permafrost (pp. 865–868).

[2] van Tatenhove, F. G. M., & Olesen, O. B. (1994). Ground temperature and related permafrost characteristics in west Greenland. Permafrost and Periglacial Processes, 5(4), 199–215. DOI: 10.1002/ppp.3430050402

[3] USACE (1958): BW-8 Sondrestromfjord – Airfield Paving – Runway Extension – Subsurface Exploration. U.S. Army Corps of Engineers (USACE). Drawing no. AW 86-04-02 sheet 8A [Technical drawing]