

Title: FORMATION OF ICE PLUG OBSTRUCTIONS IN THE DRAINAGE SYSTEM
OF AN AIRFIELD NEAR THE SOUTHERN PERMAFROST BOUNDARY, by
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FORMATION OF ICE PLUG OBSTRUCTIONS IN THE DRAINAGE
SYSTEM OF AN AIRFIELD NEAR THE SOUTHERN PERMAFROST BOUNDARY

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This paper writes up data obtained in 1942 and 1943 at an airfield located near the southern permafrost boundary.

Until it was put into operation, a considerable part of the landing strip, mainly in the southern and southeastern parts, was covered by hillocks of goosefoot. In external appearance, these hillocks resembled graves (hence the name "mogilniki") crowded close together, and in places several hillocks were all merged into one. These hillocks ~~were~~^{were} from 0.5 to 1.5 meters high and from 2 to 7 meters wide. Troughs and depressions between the hillocks were covered with sedge and moss or peat in the form of high mounds which were normally saturated with water.

The hillocks were composed generally of dusty loam with seams of peat; the depressions between them were composed of peat up to 1.0 meters thick on top and the same clays as in the hillocks below.

In addition to these clays, dusty deposits of a yellow and dark brown color with high clastic material content were scattered on the airfield; clastic material predominated in the depths, the clays acting as filler.

In the spring of 1941 (when the drainage system was being installed), the depth of the upper permafrost surface on the airfield fluctuated from 1.8 to 2.0 meters in the southern and southeastern (unused section) and from 3.5 to 4.0 meters in the northern and northwestern (previously used) part of the field.

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The collector pipes on the strip were laid 1.5 to 2.5 meters deep. The inspection pits of the entire drainage system were not heated in the fall of 1941; therefore during the winter of 1941-42 ice plug-like obstructions formed in two places in collector 1, which has a cross section of 0.6 x 0.6 meters, in the northwestern part of the airfield and in collector RD-2 in the southeastern part.

As seen in Figure 1, ice formed in collector 1 mainly near the inspection pits and near the temporary shack for construction work. Below inspection pit 2, ice froze in beads and one layer gradually covered another until a thickness of 0.4 meter was reached. Near inspection pit 1, ice filled the entire collector pipe.

As was found in the summer of 1942, an ice plug obstruction formed solidly in a collector about 12 meters long. In inspection pit 2 of the collector, the ice reached 0.28 meter on the high side, 0.2 meter on the bottom of the pit, and 0.15 meter on the low side. There was a fill of 0.35-0.37 meter on the pit roof.

The formation of ice in the collector near the shack can be explained partially by its low fill (namely, 0.85 meter) but mainly by the fact that a hard-rolled vehicular road passes through the fill of the collector some 12 meters above the shack. This road contributes to more intensive freezing of the ground.

An ice plug obstruction formed in inspection pit 1, apparently when water trickled in with a temperature close to 0°C. The water immediately froze because of the rapid penetration of cold air through the roof of the inspection pit, due to the low soil fill and complete absence of heat. In addition, the water flowing out of the collector into the inspection pit also froze.

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The formation of ice plugs in the collector pipe can be explained by the fact that the ground around the collector and the collector itself was frozen and therefore the water flowing through the pipe at a temperature close to 0° quickly froze. Contributing also to the rapid freezing of the water flowing through the collector was the fact that the gutters on the concrete runways were not covered for the winter. Therefore, the cold air going through them which was forcefully drawn in by the shack, rapidly cooled the water flowing through the collector pipe. Another contributing factor, which became evident when the collector was opened up in June 1942, was that it was filled not only with pebbles and gravel but also with local soil (yellow-brown sandy loam with boulders) and mainly stones.

During the winter of 1941-42, ice plugs formed in the southeastern part of the strip in the collector of a taxi strip, which started from inspection pit 75 of collector 3 and continued to pit 60 of the collector RD-2, a distance of 295 meters (see Figure 2). The ice plugs at these points first were revealed in the spring of 1942, when puddles of water started to appear on the surface of the collector. In addition, a small lake, about 75 meters long and 15-20 meters wide, was created each time after a rain in the place where the taxi lane crossed the collector in the lowest eastern part. It disappeared a day or two after its appearance mainly because of runoff along the base of the RD-2 fill towards the east and partially because of evaporation.

The collector was first opened and the ice-plug obstruction removed from it in the section between inspection pit 75 and the taxi lane on 25 June 1942 and the removal was completed 24 August 1942. Pits 75, 62 and "a" were opened first (the latter, size 0.30 x 0.30 meter, was probably intended as a gutter). It turned out that the last two pits, 62 and "a", were full of water. When the collector was opened by trenches, it was found that the

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permafrost in this area (29 June 1942) reached a depth of 1.1 meters and the fill over the collector was just ballast. The soils here were composed of thick dusty sandy loams blue-gray in color with interlayers of peat (hillocky goosefoot with the vegetative cover removed).

Opening the collector was quite labor-consuming and was interrupted for long periods. The sides of the trenches thawed and caved in; therefore the same section of the collector would often have to be opened several times.

The collector was made easier to open by the fortunate construction of its covers. These were made from separate semi-circular joists 12 to 13 centimeters wide and 22 to 23 centimeters long laid cross-wise across the pipe. When the section of the collector between inspection pit 75 and the taxi strip was opened up by trenches, an ice plug was found in the pipe which filled the entire pipe solid over a distance of 40 meters.

The upper and lower surfaces of a piece of ice taken from the collector were rough; the ice seemed transparent, but was cloudy whenever mineral soil particles were found in addition to air bubbles, and its structure was lamellar.

When the work ended (24 August 1942), the ground in this section had thawed to 1.7-1.8 meters; the permafrost was no deeper than 2.0 meters at this spot in the fall of 1941 and 1942. Consequently, the collector, which was laid at a depth of 2.25 meters, entered the permafrost layer and apparently froze through in the fall of 1941 from below.

The ice plug described possibly formed in the fall of 1941 in the section from inspection pit 75 to pit 61 and above, in the direction of pit 60; formation of an ice plug in the last section was favored by the 23 centimeter small cobblestone fill over the wooden covers of inspection pit 60, which helped to cool it rapidly. However, we can assume that an

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ice plug formed only in the section between pit 75 and the taxi strip in the fall of 1941. In the section between the strip and pit 61 and above (towards pit 60), ice plugs may have formed in the spring of 1942; after thawing in RD-2 reached 0.60 meter, atmospheric water from the rains during this period started to flow from the gutters into the collector pipe. Since the ground around the collector was frozen at this time, the water, standing motionless in the collector pipe, could gradually freeze solid in the pipe.

The ice plug in the collector pipe in the section between the pits "a" and No 62 thawed on 24 August 1942 because these pits were opened on 25 June 1942 and warm air flowed into the collector pipe through them. The ice plug in the section between pits 61 and 60 also thawed in the fall of 1942. Only the plug in the section between pits 62 and 61 could not be thawed or removed. As a result, a great deal of water formed in the collector pipe and in the ballast fill over it, pumping of which continued to 5 December 1942.

In the spring of 1943, inspection pits 62 and 61 were open and the ice plug thawed by the middle of summer in the section.

Thus, for normal operation of the entire drainage network the whole year around on airfields similar to the one described, the following conditions are necessary:

1. When airfields are constructed on unused sections of hillocky goosefoot, the drainage should be laid no deeper than two-thirds the depth of the active layer.
2. All inspection pits of the system should be heated in the fall; wooden flooring should be installed in them and they should be filled with heat insulating material such as loose peat or manure up to 0.5 meter.

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3. All gutters of concrete runways should be tightly closed in the fall with wooden or cast iron covers to prevent freezing of the system in the winter and influx of water from an early spring snow thaw.

4. The shacks of collectors should be heated not only in the winter period from the time the frosts start until the flow of water stops, but also in the spring, from the approach of thaws to the end of the first spring frosts.

5. After all collectors stop operating, the first two or three inspection pits, counting from the shacks, must be opened in order to make sure that there are no ice plugs present.

6. If ice plugs have formed in the collectors, it is necessary to:
- a) thaw small ice plugs with steam or warm spring air, opening for this purpose the inspection pits between which the ice plugs have formed.
 - b) punch out large ice plugs, opening small sections of fill over the collector pipes for this purpose.

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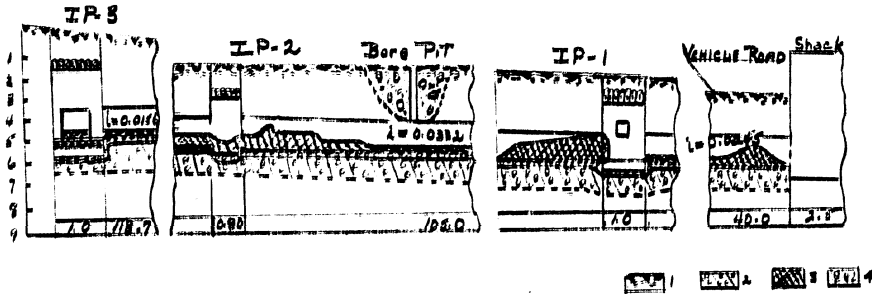


Figure 1. Diagram of Longitudinal Profile of Collector 1. 1- Soil Fill, 2- Rock Rubble with Clayey Soil, 3- Ice on January 1942, 4- Gravel-Pebble Fill (p. 70 Text).

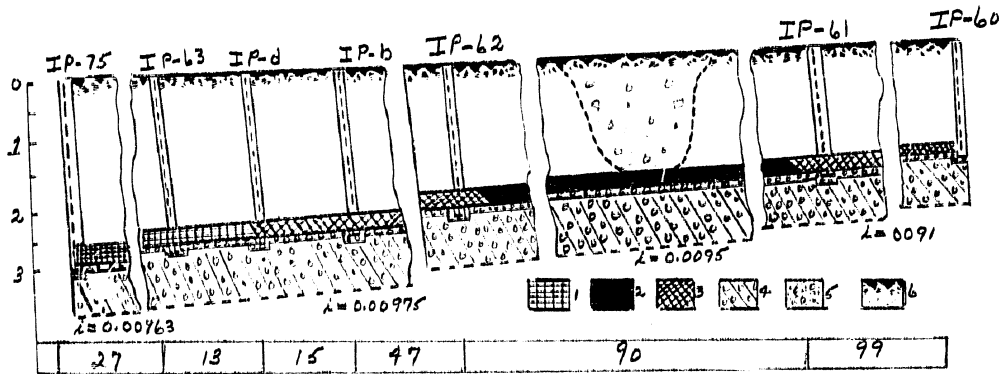


Figure 2. Diagram of Longitudinal Profile of Collector for Taxi Strip 2. 1- Ice Plug Removed During the Summer of 1942; 2- Ice Plug Left for the Winter of 1942-1943; 3- Ice Plug Which Thawed Out in the Summer of 1942; 4- Clayey Soil with Rock Rubble; 5- Gravel-Pebble Fill; 6- Soil Fill (p. 71 Text)

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