Screenings
from the Soil Research Lab

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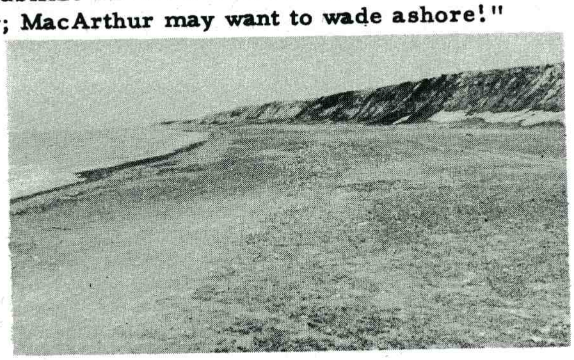
MECHANICAL STABILIZATION OF AN ARCTIC BEACH

Problem:

To stabilize a beach in the neighborhood of Pt. Barrow, Alaska, for wheeled vehicular traffic.

Historical:

In 1910 Admiral Peary, back from the North Pole, said "Great Scott!" Scott being a polar explorer too. "Great Scott! We don't know how to stabilize an Arctic beach! We must act immediately; MacArthur may want to wade ashore!"



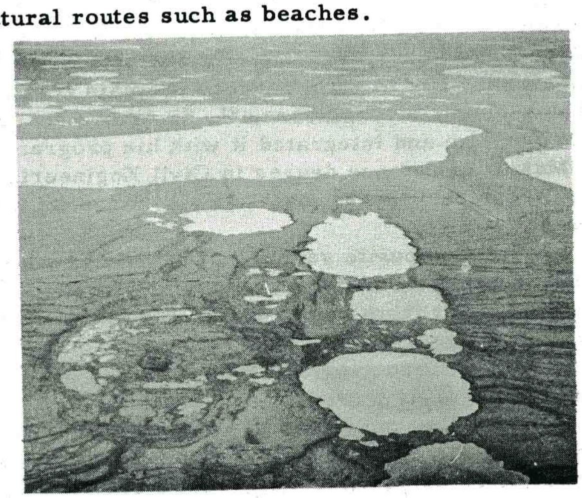
The beach near Pt. Barrow. Land to the right, sea to the left. Since most activities are directed from the beach, it would be a good place for a road.

So a directive was issued and marked "Expedite!" and sent to Washington, D.C. Unfortunately Washington was indisposed at the time and the directive slipped by Martha and ended up in the files. It was pulled out and remarked "Expedite!" in 1926, 1929, and 1937, then went back in the files.

Then in 1954 a couple of Iowa State College engineers were discussing a world problem when one of them said "Gad, this coffee's terrible! Let's go to Alaska!" The other took a gulp and cried, "Check; when do we go?" They wired the Office of Naval Research, asked about the Arctic Beach, and in the summer of 1954 left for Alaska. The Iowa State College research team consisted of three men, Dr. D.T. Davidson, Dept. of Civil Engineering; Dr. C. J. Roy, head of the Dept. of Geology, and an obscure employee named Handy.

Perspective:

Northern Alaska is a broad, flat area of Arctic coastal plain isolated from the atmosphere's central heating plant by high mountains to the south. Even though the annual precipitation is very low, of the order of 10 inches, the extremely poor drainage causes very wet conditions in the summer. Drainage is inhibited by permafrost, or permanently frozen ground, below a depth of about 1 to 3 feet. The plain is dotted with lakes, and the "dry land" in between is tundra -- mainly grass, peat, and water. Because of this, large scale summer land travel is practically impossible except over natural routes such as beaches.



The Arctic Coastal Plain. Lakes, permafrost, and not many trees. Land travel is practicable only during cold weather. The Lakes shown have gone through several stages of development. Often they are square or rectangular in shape and are parallel to each other.

The beach at Point Barrow is made up of highly rounded coarse sand, and for walking or truck travel the beach is literally unbearable. The sand has very low bearing capacity, and one finds that each step is up out of a hole. A short walk convinces one of the utility of soil stabilization, and a short ride in a jeep convinces one even more. A jeep grinds forward in four-wheel low.

Approach:

Because of the remoteness of the Arctic areas the most desirable method for stabilization would be to use locally available materials. An abbreviated materials survey was conducted by the field party, and samples were shipped back to Iowa State College.

Method:

As always, the most appealing method for doing the laboratory work was to turn it over to someone else. A research study such as this

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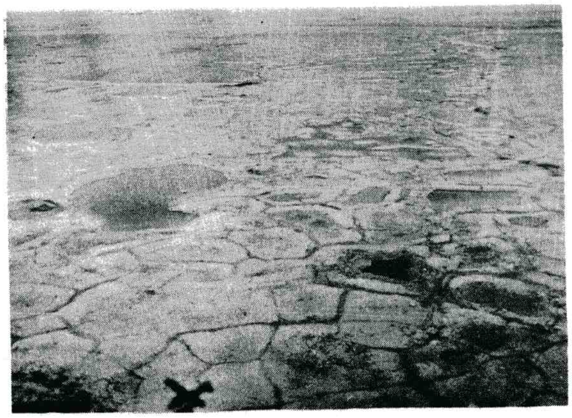

Ice-wedge polygons on the Arctic Plain -- severe cold causes the ground to crack; surface water running into the cracks freezes to ice which does not allow the cracks to close. Successive cycles cause squeezing up of the enclosed ground and thickening of the ice wedges. Areas lower in the middle with water in them are known as low-centered polygons. Shadow of the small seaplane for scale.

constitutes a satisfactory problem for a graduate student, and each graduate student must write a thesis in order to get a degree. Captain Ira J. Ward, Corps of Engineers, U. S. Army, accepted the problem and integrated it with his program for a Master of Science degree in Civil Engineering.

Samples turned over to Capt. Ward included the following:

1. Composite sample of gravelly beach sand representing the material to be stabilized.
2. Silt from an old beach ridge located inland on the tundra.
3. Coarse gravel carried onto the beach by ice the previous winter.

These were studied and analyzed by Iowa Engineering Experiment Station personnel to measure such things as particle size, roundness, mineralogic composition and physical properties, and the data were kept in reserve for later engineering interpretations. Meanwhile various mixtures of the three materials were prepared and evaluated for stability by means of the California Bearing Ratio (C.B.R.). The C.B.R. measures stability under load, and results are expressed relative to the stability of rolled (i.e., compacted) stone.

Results:

The best mixes proved to have close to "ideal" particle size gradings given by Talbot curves. This theoretical grading scheme considers the mix an agregate of interlocking coarse particles. The voids are then filled by the next size finer, and the then remaining voids are filled with the next size finer, and so on down to clay size material. In this way grain contact area and supposedly friction are at a maximum, although now there is disagreement on this. The same theory is used in the design of various concrete mixes. In concrete the ultimate binder is portland cement or asphalt, whereas in mechanical stabilization it is clay. Clay has peculiar sticky or cohesive properties which, while not permanently water stable, can give a strength which is very satisfactory. A bituminous surfacing can be added to the road if dryness must be preserved.

The best mix gave a C. B. R. of 31 percent, or about a tenfold increase over the C.B.R. of the natural beach material, which as they say about Marilyn, ain't bad. The best mix consists of 60 percent beach sand by weight, 30 percent tundra silt, and 10 percent ice-rafted gravel. Omission of the ice-rafted gravel reduced the C.B.R. about 4 percent. In all cases the C.B.R.'s were higher after soaking in water. Data indicate that alternate wetting and drving would increase the C.B.R.

A current answer to the road problem in the Arctic is the Weasel, a tough suffering track vehicle originally designed for the invasion of Normandy. On this occasion a Weasel successfully carried its passengers 14 trouble-free miles before it broke a track. Drs. Roy and Davidson have a look. Everybody but the Weasel walked back. (It had to be carried.) The location is south of Pt. Barrow only a few hundred yards from where Will Rogers and Wiley Post had more serious problems in 1935.

Evaluation:

A C.B.R. of 30 would be satisfactory for a light traffic road or for a heavy traffic road only if a base course of stronger material were laid on top of it. Stability of the beach sand mix is not as high as expected.

Discussion:

The mix has an ideal gradation, and departures from the ideal were found to give a weaker mix. The intriguing thing is that even with the best gradation possible the mix insists on having rather low stability. Further study gave two possible explanations for this; both have to do with unique properties of the materials:

(1) The sand and gravel consist of highly rounded chert particles, chert being a very hard, siliceous rock often called "flint." The average sphericity was 0.7 and 0.8 for the two materials, a value of 1.0 indicating a collection of perfect

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