Wind-Diesel Power Systems Experiences and Applications

Parts of a presentation given at Winterwind 2008

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With help of
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Summit Station, Greenland

Photo Credit: Ian Baring-Gould

Main house with turbine in background

Photo Credit: Polar Services

Turbine after an ice fog event

Photo Credit: Polar Services

Main foundation plate buried in the snow

- National Science Foundation remote research station on the Greenland Ice Sheet
- Diesel fuel flown in, ~$38.0/l (Works out to ~$1/kWh)
- Aggressive efficiency and fuel use reduction program
- 80 & 120kW diesel engines
- **Testing 6kW turbine as the first step of a redesign**
- **Only ~2% annual energy comes from wind, up to 16% instantaneously**
- Packed snow/ice foundation
- Very low air density

Complications Regarding Wind Energy Development in Alaska Arctic

In addition to snow, ice, and cold temperatures, poor infrastructure, above ground utilities, and seasonal access hamper development activities

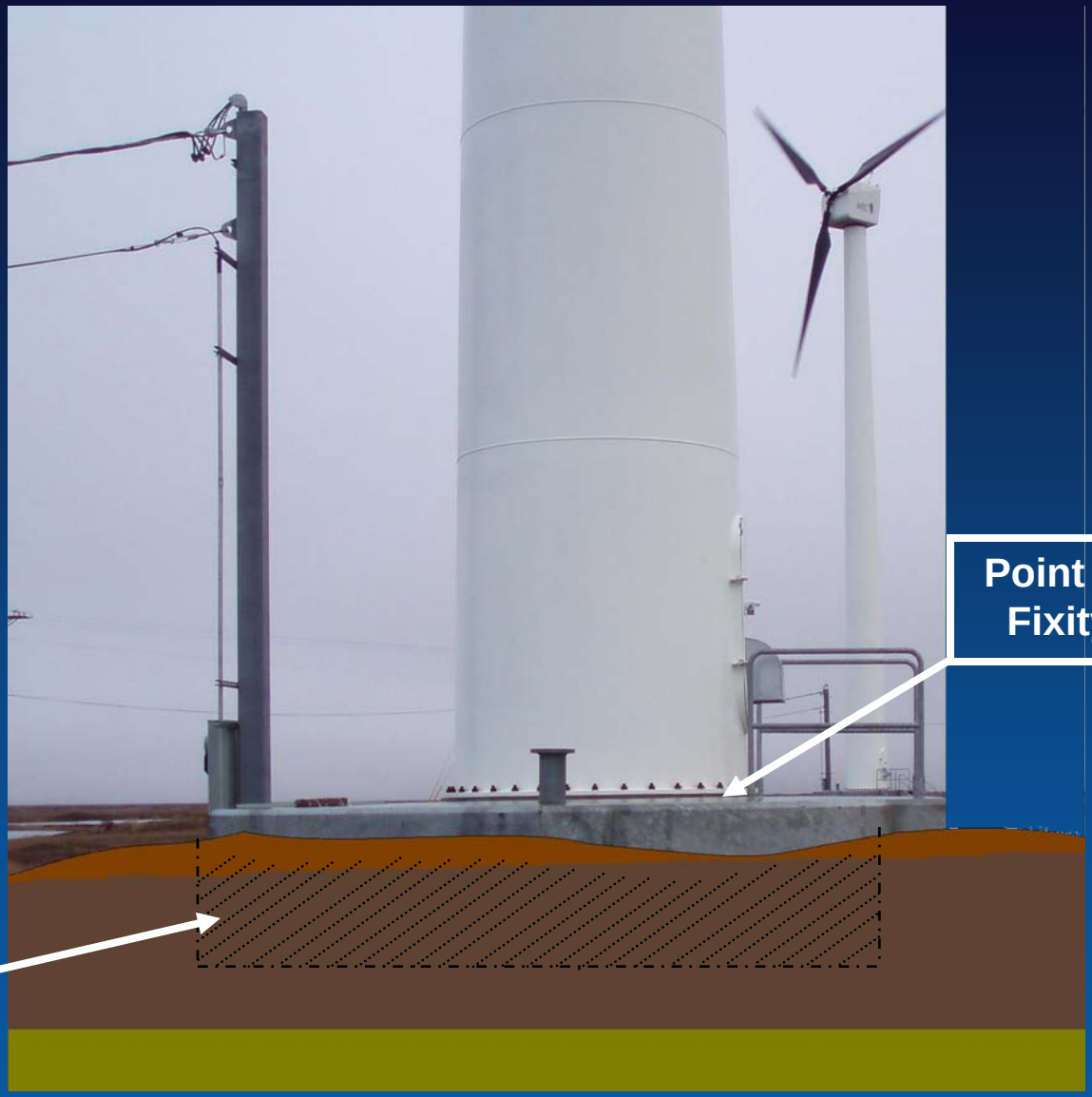
Access for specialty equipment required to place foundations and erect turbines is a challenge.

Photo Credits: Alaska Village Electric Cooperative

Foundations in permafrost are a challenge

- They must not settle, tilt or be uplifted
- Pile foundations (six to eight piles) may extend 1/3 to 2/3 the height of the tower into the ground

Wind towers on land in most of the world are built with a ‘point of fixity’ at the base of the tower where it typically rests on a massive concrete foundation.



The tower foundation is elevated to allow cold air to pass over the ground to keep it frozen and to avoid heaving of the tower base.

In order to be properly secured in permafrost, wind turbines may require pilings in the ground which are 1/3 to 2/3 of the height of the tower.

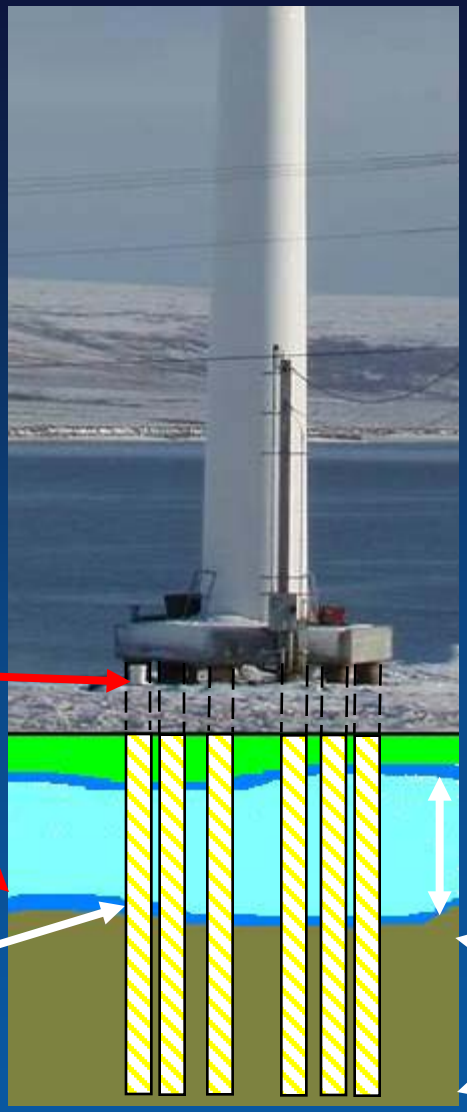
Frozen ground at surface in March

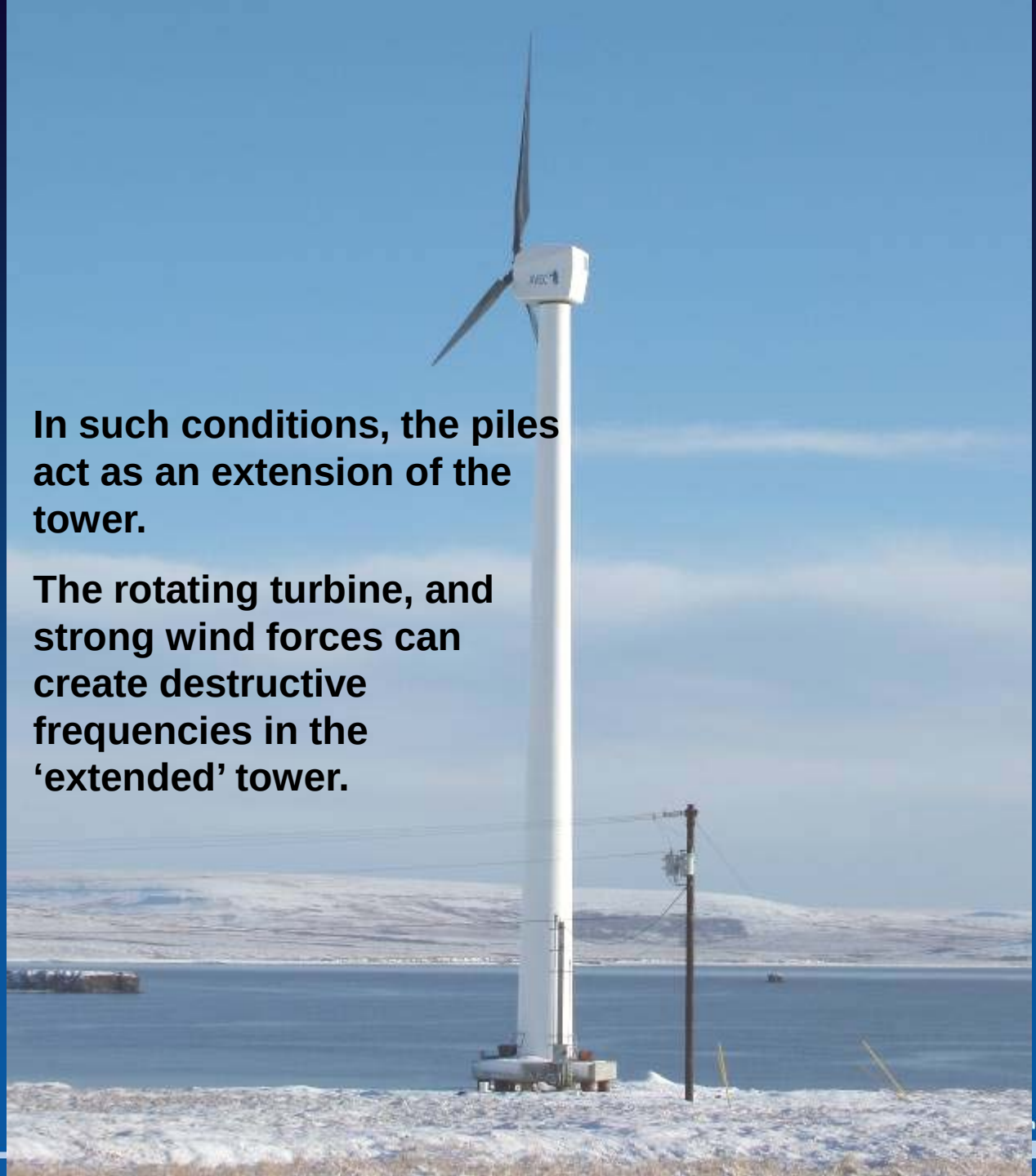
Frost line in September/October after seasonal thaw

0.5 to 5 m

One problem with Alaska permafrost conditions is that the point of fixity may be below the ground surface and may vary throughout the year as the frost line of the active layer migrates.

When the active layer is thawed, there is minimal to no lateral support to the piling near the base of the tower.

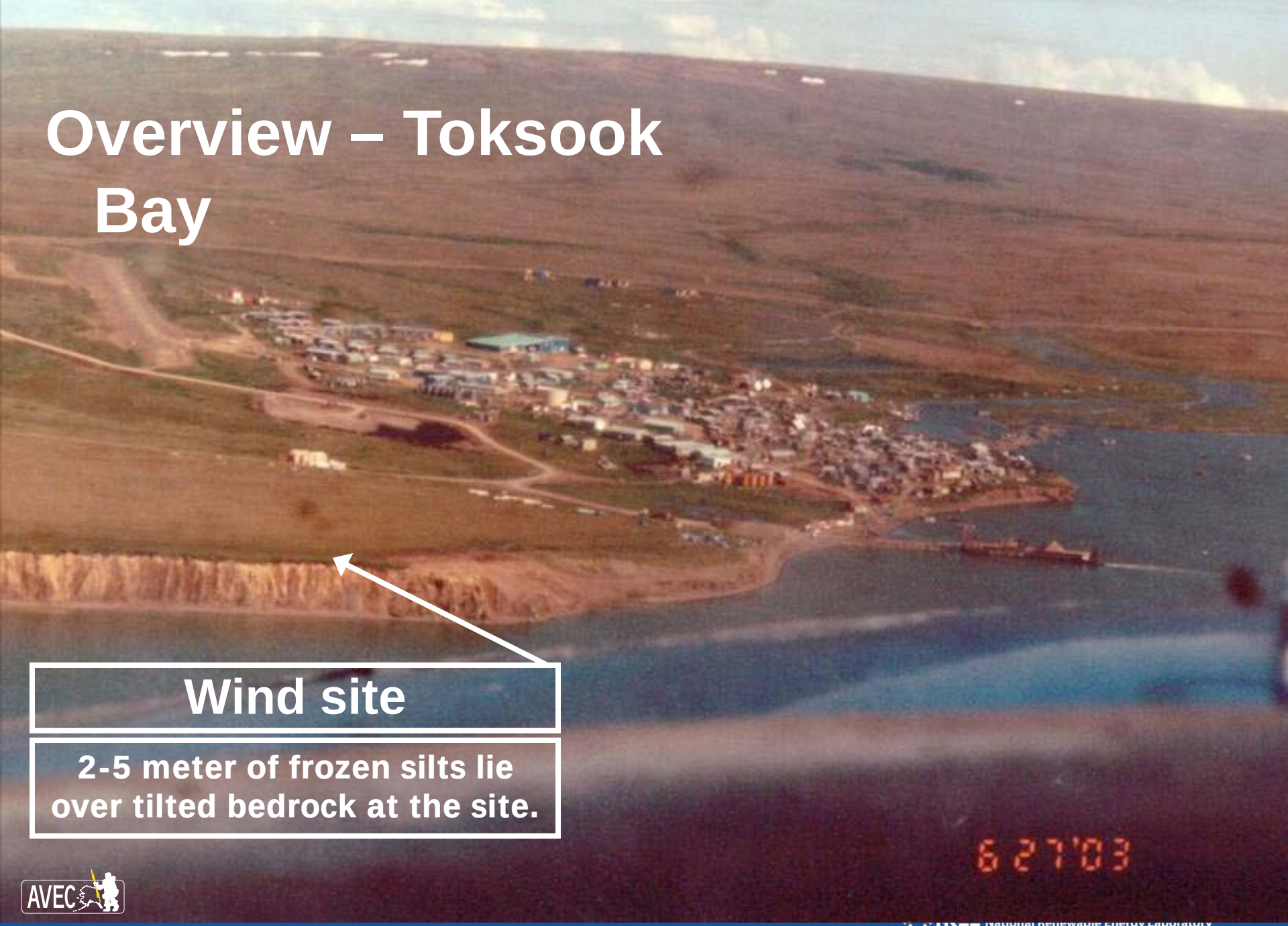


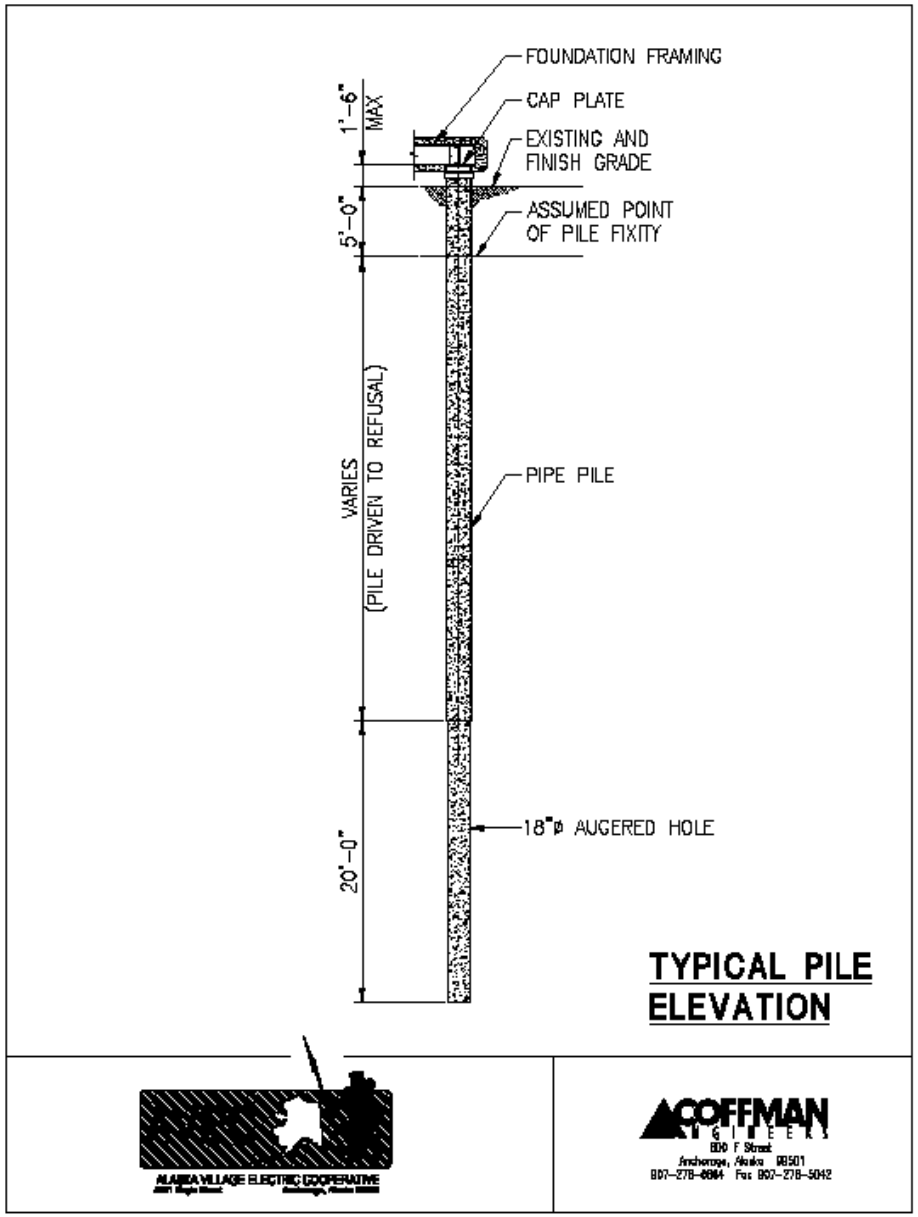


In such conditions, the piles act as an extension of the tower.

The rotating turbine, and strong wind forces can create destructive frequencies in the ‘extended’ tower.

Overview – Toksook Bay




FOUNDATION FRAMING
CAP PLATE
EXISTING AND FINISH GRADE
ASSUMED POINT OF PILE FIXITY
PIPE PILE
18"Ø AUGERED HOLE
1'-6" MAX
5'-0"
VARIES (PILE DRIVEN TO REFUSAL)
20'-0"
TYPICAL PILE ELEVATION
ALASKA VILLAGE ELECTRIC COOPERATIVE
COFFMAN ENGINEERS
800 F Street
Anchorage, Alaska 99501
907-278-6664 Fax 907-278-5042

- Holes pre-drilled
- Piles driven to refusal
- Piles later cut

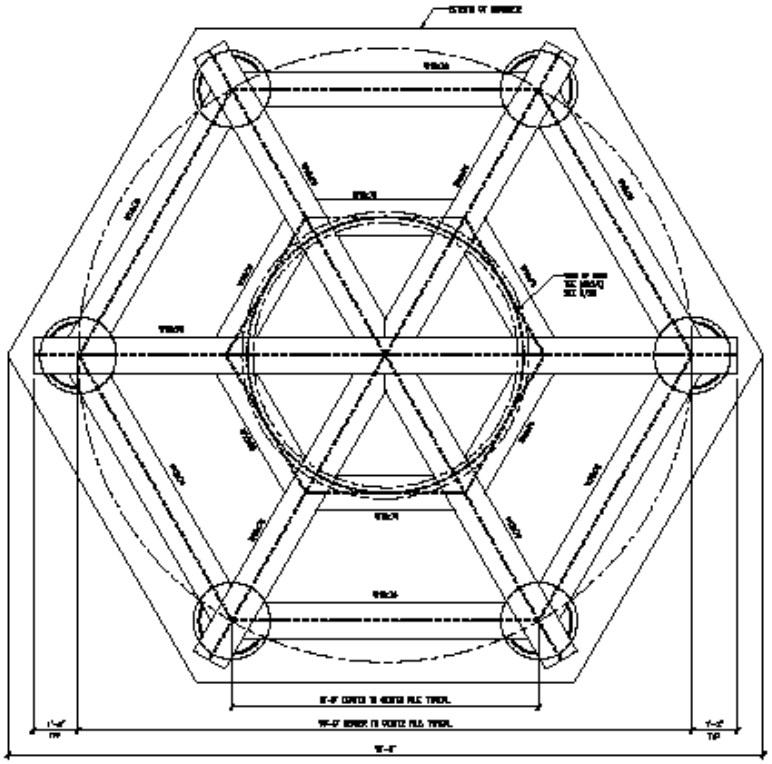
Six piles for a single tower foundation

Drilling out center of piles to 6 m below end of pile

Rock bolts would be placed into the rock and tensioned to the pile cap.

Additional Mass was added by placing a rebar cage and concrete in the pile.

The steel foundation cap contains I-Beams to connect the piles and a ring to make the tower base.

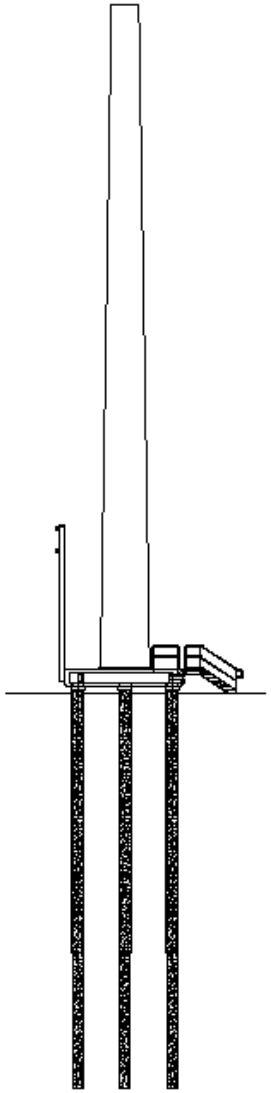


FOUNDATION PLAN

ALASKA VILLAGE ELECTRIC COOPERATIVE
4831 Eagle Street Anchorage, Alaska 99503

COFFMAN ENGINEERS
800 F Street
Anchorage, Alaska 99501
907-276-6664 Fax: 907-276-5042

Steel Foundation Star (Typical of 3)



TOWER & FOUNDATION SECTION

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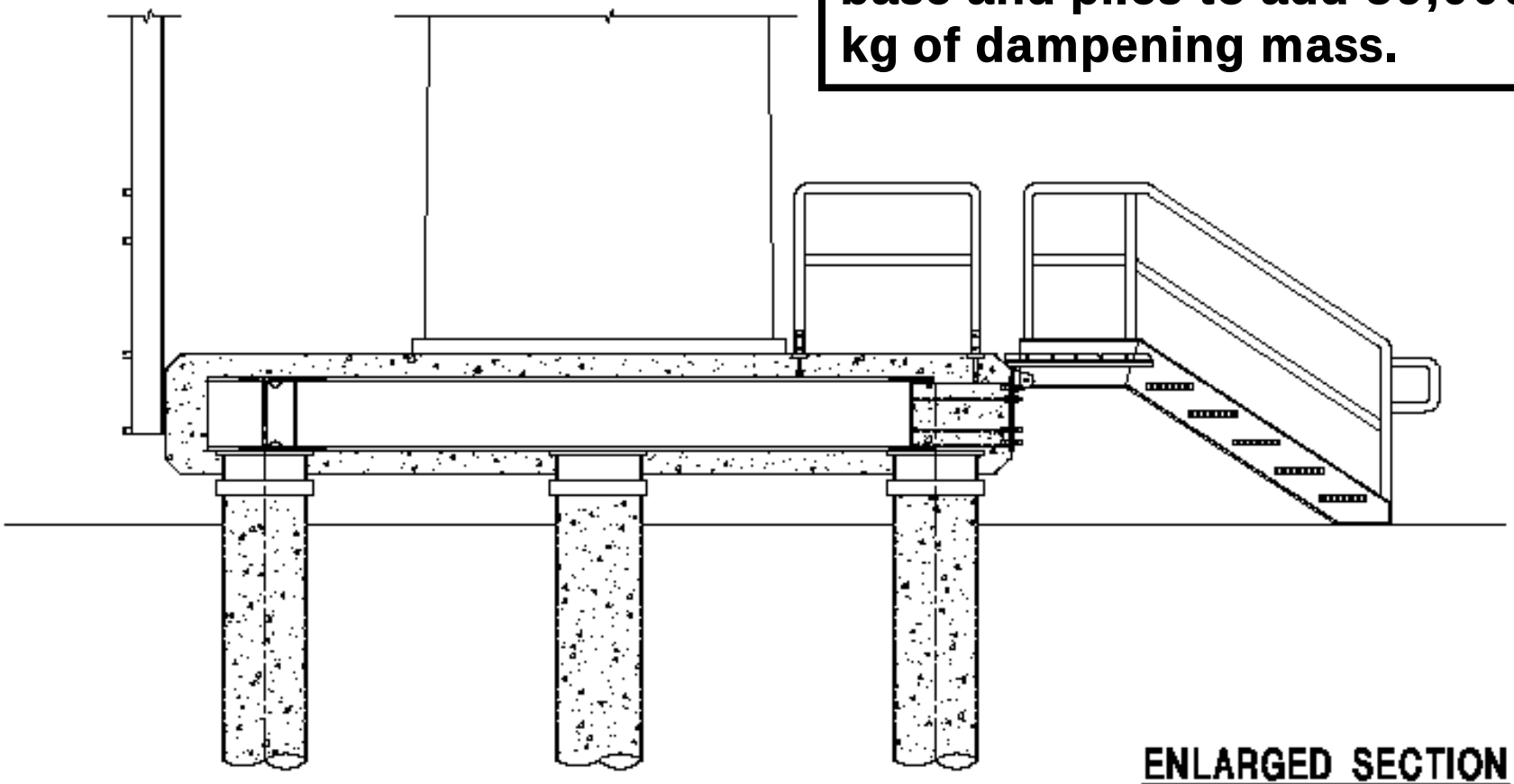
Concrete and rebar was incorporated into the tower base and piles to add 59,000 kg of dampening mass.



ENLARGED SECTION

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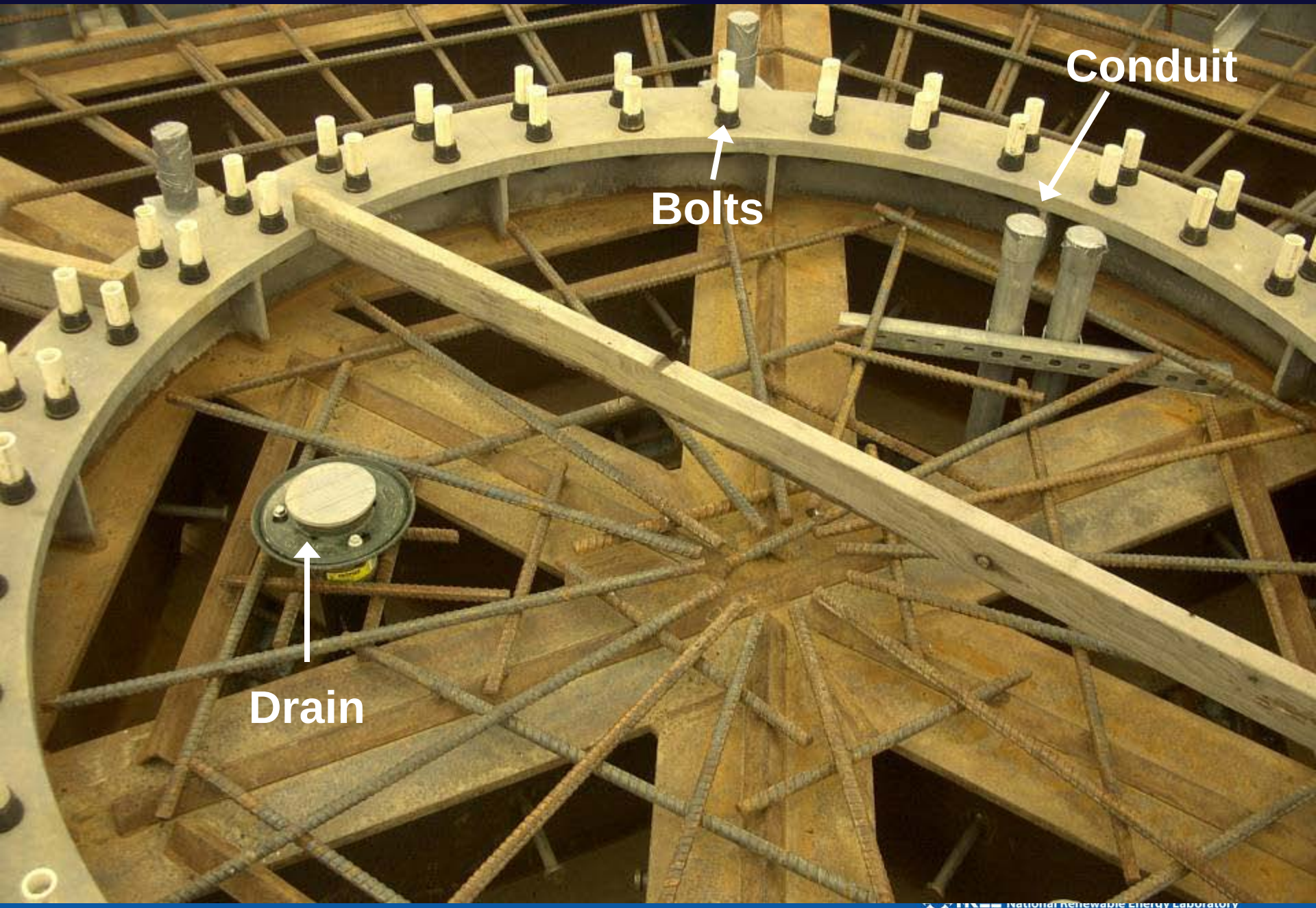
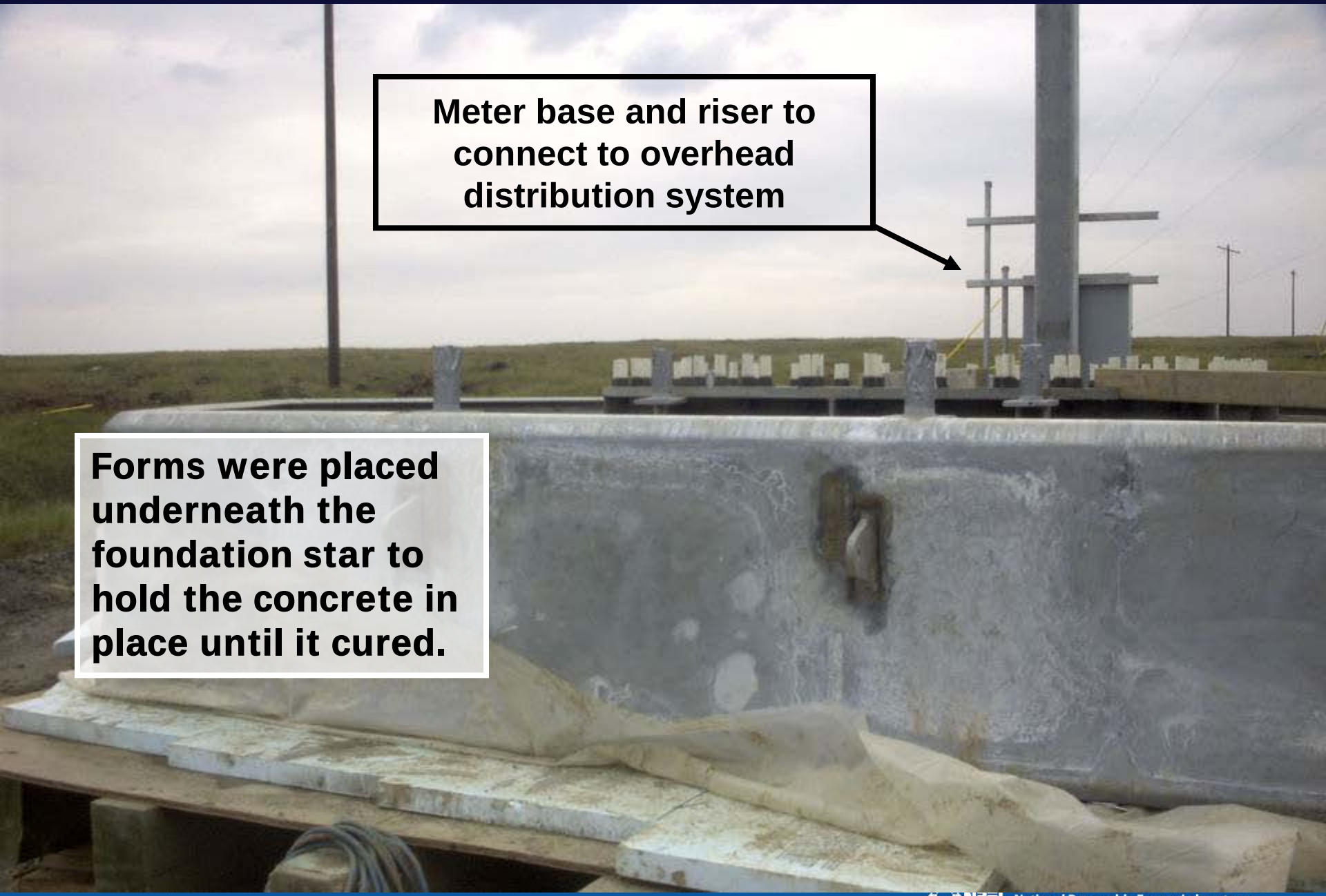
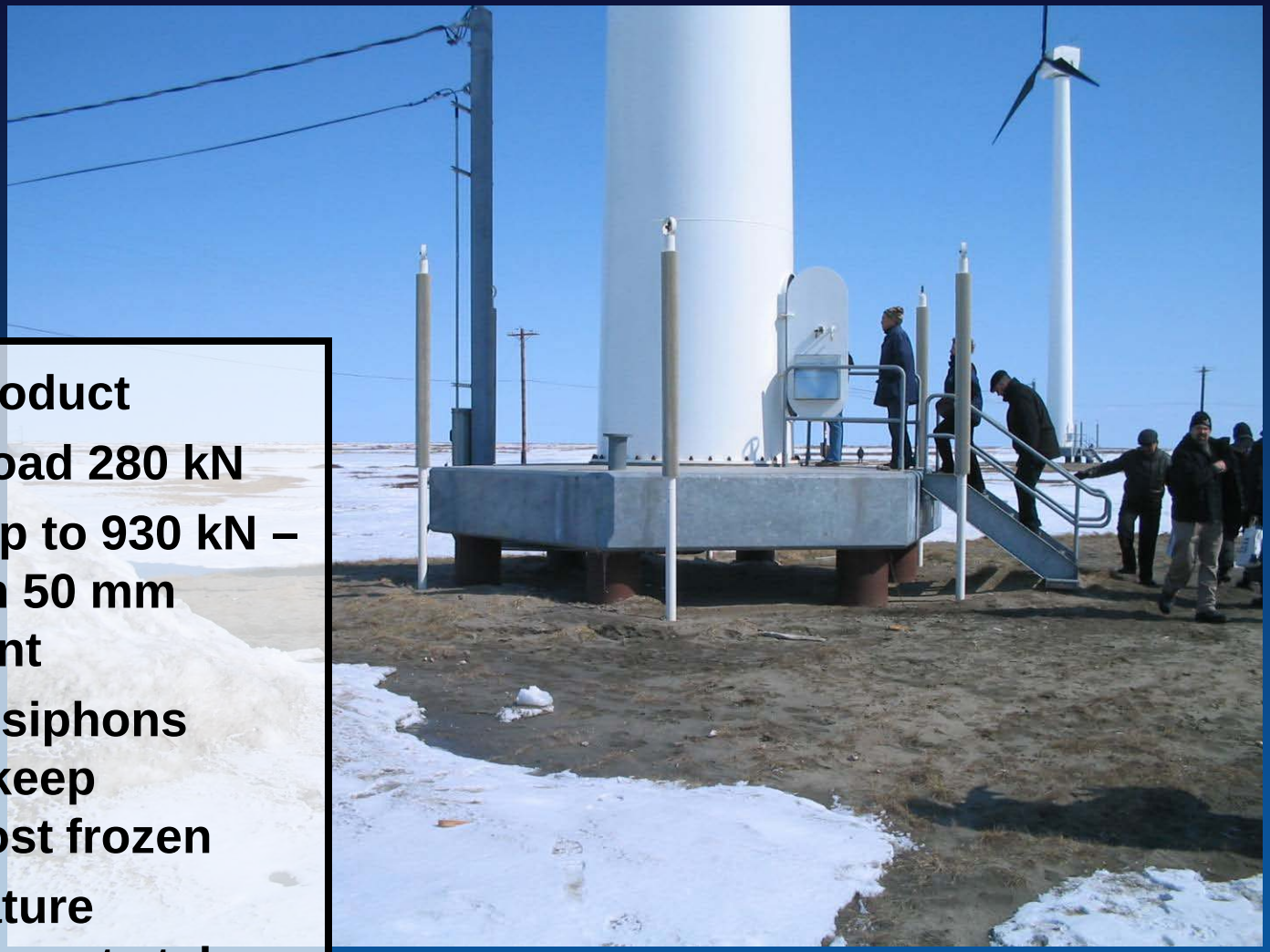
Rebar Cage to go into a pile.


Conduit
Bolts
Drain


Meter base and riser to connect to overhead distribution system
Forms were placed underneath the foundation star to hold the concrete in place until it cured.



Finished Product

- **Design load 280 kN**
- **Tested up to 930 kN – less than 50 mm movement**
- **Thermal siphons used to keep permafrost frozen**
- **Temperature measurements taken regularly**