INVESTIGATION, DESIGN, CONSTRUCTION AND OPERATION OF DAMS IN COLD CLIMATES

COST ESTIMATING FOR COLD CLIMATE CONSTRUCTION

BY

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The Challenges of Dams in Cold Climates
Design, Construction, Permitting and Environmental Issues

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CONSIDERATIONS FOR COLD WEATHER ESTIMATING

▪ The Direct Cost of Doing the Work
▪ The Indirect Cost of Doing the Work
▪ The Expected Weather Conditions
   • Temp Ranges Typical for Project Site
   • Relative Humidity to be Expected
   • Snow Depths Typical for Project Site
▪ Ancillary Issues
   • Difficult Travel To/From Project Site
   • Dangers such as Avalanches
Direct Cost of the Work Due to Cold

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Concrete Work

- Will the batch plant need to be onsite, if so winterizing a plant so it will operate and produce spec concrete is costly and takes time. Also the aggregate and sand will need to be covered and heated to batch in the winter.
- If you have to transport concrete from off site the temps and distance will limit what you can batch and place. Make sure the commercial source is setup to produce winter concrete and what their no go temperature is (lowest temp they will batch at).
- Mixer truck should be kept in a heated shop, drum steel that is minus temps will chill a heated mix to freezing temps in 30 minutes or less
- Keep the frost out of the subgrade where the structure is to be placed. Loose fill or insulated blankets work well.
- Tent and heating if needed, should be sturdy enough to take the freezing temps and the winds associated with winter storms.
- Productions of forming and placing in the cold weather will greatly decrease depending on weather and if the work is under a tent. Access for form work under the tent and access for the placing system under the tent will require some labor to move and put back.
- Have a bull gang type crew full time of the winter concrete to tent, heat, move tents, and monitor curing periods 24 hours to make sure heating and cover is maintained.
- Use high quality vented heating system and monitor the air quality full time for safety.
- Removal of tent and heat will need to be gradual, to prevent thermal shock to the cured concrete. Example would be if your tented structure is at 50 degrees and it is zero degrees outside, it will take days to lower temps in the tent—check your specs.
Earthwork

- Study past climate records; temperature, snowfall, etc. Don’t forget the frequency and velocity of the wind. The wind was the biggest factor on the North Slope. It drove the wind chill factors down quickly and caused a huge amount of snow drifts, even behind a single lath.
- Understand how deep the frost penetrates the ground and how moist the existing ground conditions are.
- Do not run equipment on areas that will need to be excavated, they will drive the frost down even deeper. The exception would be when crossing muskeg areas, drive the frost down with LGP dozers and drags so heavier equipment can cross.
- Is there permafrost in the excavations? Is it the scattered softer permafrost that can be ripped or is it the massive, solid permafrost that will need to be blasted?
- Make sure to excavate blasted permafrost quickly before it refreezes.
- Do not run any equipment operations at -40°F or below. Major structural members of the equipment will fracture and fail. Operations between -30°F and -40°F should be closely looked at to determine if they are necessary.
- All fluids in equipment being shipped to cold weather climates should be changed to arctic grades prior to shipping the equipment.
- Mechanic maintenance factors go up greatly in cold weather, could be over double. Make sure they have temporary covers like parachutes and portable heaters to help them work efficiently as possible.
- Heated shops are necessary for major repairs.
- Crews need heated dry shacks to take breaks from the cold.
- Increased wear parts, ground engaging, etc.
- Don’t forget sanding equipment for haul roads especially in the spring.
- Will you have to shut down during spring break up if the temporary roads fail.
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TABLE 2-1. CONSTRUCTION PRODUCTIVITY EFFICIENCIES AS A FUNCTION OF TEMPERATURE AND RELATIVE HUMIDITY

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<tr>
<th>Temperature (°F)</th>
<th>Relative Humidity (%)</th>
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INDIRECT COST OF THE WORK DUE TO COLD

- Schedule
  - Project Overhead
  - Missed Milestones - LD’s
- Personnel Issues
  - Unexpected Craft Turnover
  - Disgruntled Staff
- Equipment Life Shortened
  - Equipment Issues that Show Up on Later Projects
- Quality Issues
**Blue Lake Dam Raise**

- Hot water for mixing / Cover and tent batch plant
- Road Maintenance / Ice(snow) Removal on access road up to dam – concrete trucks and crew access.
- Crew Fatigue – heavy bags, wet clothes – working in steady rain and snow all day with limited access back to staging area and warming shack
- Cover and heat placements – difficult to secure on dam face, especially with wind.
- Wind caused lots of issues with crane access and placing with bucket
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**Keeyask Hydroelectric Generating Station**

- In addition modify shift so there is no down time between shifts ... run 2-12hr shifts or don’t run at all... even 2hrs between shifts will allow hyd fluids to cool even if its idling as hyd fluid isn’t circulating or making and temps... in addition the buckets on the excavators will cool and many times we ripped the bottom right out of a PC1250sp heavy rock bucket.

- Use webasto diesels heater, battery blankets, and Alaska patches on hyd and fuel systems on any equipment to be used intermittently. Have a hot line to plug in the iron, and use the webasto timers

- Have an equipment warm up check list i.e.. Cycle main boom slowly 10 times, same for stick.... Lift right track off ground cycle forward low gear 20 sec and so on

- Steam trucks are needed to free frozen rollers and clean ice off of equipment for maintenance

- To maintain capacities – beds need to be scraped every few loads material dependent.... Buckets can be cleaned with I beam buried in frozen ground – they will also need to be cleaned with a seam wand daily

- Load drilled holes asap – the frost will close the hole

- Understand the project schedule – if it needs to be done in extreme winter in needs to go 24/7 or not go at all

- Understand your project – can’t build with clays or any material requiring a moisture related compaction spec

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Concrete Protection

- This can obviously be extensive. I believe ACI requires all surface temps on which concrete is to be placed to be at or above 35°F. Depending on ambient temps, this may require covering surface with blankets or blankets with heat. Similarly, for freshly placed concrete, it needs to be protected from freezing during its curing period, which may be for up to 7 days. If you have to keep it protected for, say 7 days, that may mean you can’t uncover it to advance the work in that time frame, thus impacting the schedule of that element. At Muskrat, we cannot place RCC on surfaces less than 41°F (we’re trying to get them to drop it and using ACI as backup).

- Overall you have to weigh risks vs reward by pushing into periods with frequent and prolonged freezing temps. At Gilboa, we would place into the end of November where during the day it gets above freezing, thus allowing placement, then cover with blankets. The mix warmed up nicely and with blankets we never got in trouble because the nightly temps at that point in time were maybe in the high teens or low 20s. The purchase of blankets and some time for the crew before and after placement to cover definitely adds cost, but not significant enough to warrant not advancing the work. Whereas at Muskrat (the unions up there exacerbate the problem too) you spend a FORTUNE doing anything in the cold. Up there it gets very cold, so you usually need multiple layers of blankets and heat to keep your concrete from freezing. If I had to guess, I bet at Gilboa we spent an additional 25%-35% on cold-weather concreting, whereas at Muskrat I bet it can be 50-100% more.

Earthwork Re-Work

- At Muskrat, rock fill can usually go off in the cold weather with not too many problems (other than keeping your equipment running which costs more in the cold). However, materials with moisture and requiring compaction (our clay core in the South Dam for example) will obviously freeze up. Even in November when it can get pretty cold at night, if we’re only placing single shift it was common to come in with the top 4-6 inches of the clay core frozen, requiring a few hours at the start of shift to scrape that frozen material off, scarify the unfrozen, and begin placing new. We did a bit of this in 2015 when we first started on the Upstream Cofferdam starter groin and soon realized it was costing probably double on that activity. The owner eventually relaxed their spec allowing us to place core material on previously frozen material, but that was due to the upstream cofferdam being a temporary structure. For permanent works, such as the South Dam, they would never go for it and it just makes sense to shut down once heavy frosts start to set in.
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QUESTIONS?

IF I CAN’T ANSWER OR YOU THINK ABOUT IT LATER -

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