SCOMM

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12/12/79

Enclosed is a Consultant report on Susitna.

Brian's leaving town tonight on a 3-wk. combin. legisl. work & vacation in lower 48.

Any questions of consultant, Larry Katkin, can be directed to him at 456-3250.

Glenda Stanton
A.A.

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S. R. BOX 10612 – FAIRBANKS, ALASKA 99701 – PHONE (907) 479-8107

GEOTECHNICAL EVALUATION

THE SUSITNA HYDROELECTRIC PROJECT

Prepared by Lawrence Katkin

Dynamic Research Corporation

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SCOPE OF THE REPORT

Originally, this report was to be an evaluation of the geotechnical portions of the three proposed feasibility studies for the Susitna Hydroelectric Project.

Since one of the three studies has already been decided upon by the Alaska Power Authority, the original intent of this report has been somewhat altered.

Because all of the proposed feasibility studies have based their procedures and conclusions on previous studies performed or contracted-out by the U.S. Army Corps of Engineers, this author has researched all of the current studies dealing with the Susitna Hydroelectric Project. He has, furthermore, evaluated the conclusions reached by the U.S. Army Corps of Engineers as well as the proposal introduced by Acres American Incorporated, focusing attention on how well they address the potential geologic hazards involved in this project.

GEOTECHNICAL OVERVIEW OF THE PROJECT

A geotechnical site evaluation of a project of this type is basically concerned with two things:

1) The suitability of the foundation

2) The existence of a sufficient quantity of suitable construction materials which are to be derived from the earth.

Some geotechnical parameters to be considered in the evaluation of the proposed foundation and reservoirs are:

1) The seismic activity of the area
2) The seismic stability of the rocks and soils
3) The porosity and permeability of the rocks and soils
4) Potentially hazardous geologic structures
5) Permafrost with thaw-unstable properties
6) Frost-Susceptible soil

The parameters involved with the construction materials to be derived from the earth are as follows:

1) Determine the existence of necessary quantities
2) Determine the quality of the material
3) Determine the amount of processing necessary to produce the quality needed
4) Determine potential problems involved with excavation of materials.

EARTHQUAKE EVALUATION OF THE SITE

The propcsed sites lie in an area which has been determined to be of considerable seismic activity. In order to accurately calculate the hazards of earthquake potential in this area, a thorough seismic history is necessary.

In 1971 the USGS set up a network of seismic stations in southern Alaska which were effective in accurately determining the location and magnitude of the epicenters in the proposed dam sites.

The tectonics of the region are too poorly known at this time to make a reliable prediction for the distribution of events which may strongly shake the damsite (Kachadoorian, 1975). In addition, the Denali fault, which lies less than 80 km. North of the proposed damsite, is a major strike-slip fault with geologic evidence for a 3 cm./year average Holocene slip. This fault could sustain an event of 8.0 magnitude on the Richter Scale (Kachadoorian, 1979).

The most recent report issued by the U.S. Army Corps of Engineers (Supplemental Feasibility Report, Main Report 1979), quotes a recent United States Geological Survey Report as saying:

> " Reconnaissance of the proposed Devil's Canyon and Watana Damsites and reservoirs did not uncover evidence of recent or active faulting along any of the known or inferred faults. Their studies did not find any evidence of the Susitna Fault which was previously thought to exist a short distance west of the Watana Damsite; therefore, they were not able to confirm the existence of such a fault. "

After reading the same USGS Report ("Reconnaissance of the Recent Geology of the Proposed Devil's Canyon and Watana Damsites

Susitna River, Alaska"), I find that the conclusions drawn by the U.S. Army Corps of Engineers are out of context and misleading.

Under the section entitled "Procedures", the USGS authors state:

> "Our criteria for designating a fault as active were corstrained by the local geology. Much of the area around the Devil's Canyon and Watana Damsites is covered by late Wisconsin glacial sediments."

When the USGS authors made the statement that they could not find evidence of active faulting, they were making that statement in regards to the specific technique of ground and aerial observation, and based solely on that technique.

Although the potential hazard of earthquakes is somewhat understated by the U.S. Army Corps of Engineers, the Acres American proposal thoroughly addresses those potential hazards.

SEISMIC STABILITY OF THE SITE

The earthquake stability of the soil and rock in the damsite area is equally as important as the frequency of magnitude of earthquakes in the region.

On March 27, 1964, a major earthquake hit Alaska. This tragic event yielded a wealth of information regarding the earthquake susceptibility of soils.

Some of the major damage to the Anchorage area was caused by normally stable soils which liquefied, due to the severity of shocks caused by the earthquake. Many of those soils which were liquefied, caused stable soils above to float.

In Homer the vibrations of the earthquake caused large bodies of sand and gravel to consolidate, thus causing well pipes which were flush with the ground, to protrude several feet above the ground.

Inhabited places, however, which were located closer to the epicenter, felt little or no effect because of their location upon bedrock.

Thus, in order to properly evaluate the damsites, there should be an intensive investigation to determine the location and extent of any soil that is considered earthquake susceptible. Soils that either settle or liquefy when acted upon by earthquakes are considered earthquake susceptible.

The only discussion of earthquake hazards noted by the U.S. Army Corps of Engineers is in the report entitled "Earthquake

Assessment at the Susitna Project, Alaska" written by E.L. Krinitzky of the U.S. Army Engineering Waterways Experiment Station.

This report sufficiently addresses the problems that can be caused by earthquakes, such as the plastic properties of rock understrain, landslide activity along the fault, etc. But no mention is made of liquefaction.

The Acres American proposed study does intend to investigate liquefaction of areas along the transmission line and major access routes. Although their study is limited to those areas, just their mention is enough to note that they are aware of this potential geologic hazard.

Note: R. Migliaccio, founder of the R & M Consultants, which is the geotechnical subcontractor for Acres American, is an expert in the field of earthquake susceptibility. Mr. Migliaccio was instrumental in documenting and evaluating the damage which occurred in the 1964 Alaska Earthquake.

GEOLOGIC STRUCTURES

The one potentially hazardous geologic structure is the existence of faults.

As previously stated, the study area lies in an area of considerable seismic activity. Many of the previous studies of the area have tried to correlate the relationship of seismic activity to the faults.

According to Kachadoorian and Moore 1978, E.L. Krinitzkey 1978, it is difficult to correlate the relationship of seismic activity to the faults due to a lack of accurate data.

Although there has not been any definite correlation between the local faults and seismic activity, it is important to note that there are a good number of faults. Table 1 on the following page lists the faults in the study area.

Another potential problem could arise from the altitude of some of the bedding planes.

The right abutment of the proposed Devil's Canyon Site exhibits bedding planes that strike approximately N70^{o}E and dip 60^{o}E. The configuration of the bedding altitude and the canyon alignment may result in the bedding planes corresponding rather closely to the theoretical shearing plane formed by the arch thrust at the abutment (U.S. Army Corps of Engineers, 1976).

The left abutment of the Devil's Canyon Site exhibits southernly dipping beds on an overhanging cliff. In some cases southernly dipping beds have resulted in large blocks separating from adjacent bedrock. (U.S. Army Corps of Engineers, 1976).

EARTHQUAKE INDUCED BY THE PRESENCE OF THE DAM ITSELF

In addition to the naturally occurring earthquake activity in the region, there is also the hazard that filling a reservoir may trigger a potentially dangerous earthquake (with as large a magnitude as 6.0 on the Richter Scale) in the immediate vicinity of the damsites (Lahr and Kachadoorian, 1975).

In a recent USGS Report ("Reconnaissance of the Recent Geology of the Proposed Devil's Canyon and Watana Damsites, Susitna River,Alaska"), it is highly recommended by authors Kachadoorian and Moore that continuous monitoring by a local network of seismic stations in the region begin well in advance of the filling of the reservoirs. Unless the natural seismic level is established, an important opportunity to study induced seismicity will be lost.

Both the U.S. Army Corps of Engineers and Acres American have thoroughly addressed this potential problem.

TABLE 1.* Inferred faults in the general area of the Devil's Canyon and Watana damsites, Susitna River, Alaska

Number	Designation	Type	Remarks
1.	Zone of intense shearing	Thrust	Evidence is stratigraphic and petrographic.
2.	Talkeetna Thrust	Thrust	Evidence is stratigraphic.
3.	Near Watana Creek	Thrust	Evidence is stratigraphic.
4.	Near Portage Creek	Thrust	Evidence is stratigraphic.
5.	Chulitna River	Thrust & Vertical	Evidence is stratigraphic.
6.	North of VABM Sheep	Strike Slip	Right lateral with some vertical displacement.
7.	West of VABM Sheep	Strike Slip	Two faults: left lateral & right lateral.
8.	Susitna Fault	Strike Slip	Evidence is topographic lineament; inferred to be right lateral from seismic data.
9.	Near Clarence Lake	High Angle	Displacement apparently vert.
10.	Near VABM Windus	High Angle	Displacement apparently vert.
11.	North of VABMs Grebe-Mt. Watana	Thrust	Evidence is apparently strat.
12.	East of VABM Sumartidason	Strike Slip	Evidence is questioned.
13.	Watana Creek	Normal	Evidence is stratigraphic.
14.	Along Portage Creek	Thrust	Alternate trace for number 4.
15.	North of Denali	Thrust	Evidence is apparently strat.
16.	Cretaceous to recent shearing	Complex	Evidence partly stratigraphic

*Abridged from "Reconnaissance of the Recent Geology of the Proposed Devil's Canyon and Watana Damsites, Susitna R., Alaska" (Kachadoorian & Moore, 1979).

POROSITY AND PERMEABILITY

A potentially serious hazard for any dam is its failure due to uncontrolled seepage. Porosity (the volume of air space in a rock or soil) and Permeability (which deals with the interconnections between these small airspaces) are two engineering properties of soil and rock that cannot be overlooked.

In addition, the ponding of water (which could thaw permanently frozen soils) could highly affect the permeability of rocks and soils in the area.

Since permafrost does exist in the reservoir area of the Watana site, these potential hazards should be carefully studied.

It has been mentioned that a deeply buried channel striking east-west has been located on the Left Abutment Saddle Dam at the proposed Devil's Canyon Site. This feature has higher permeability than the surrounding rocks. It could be necessary to either seal this channel or else excavate and backfill with nonpervious materials.

PERMAFROST

The subject of potential hazards due to permafrost has previously been mentioned in the section dealing with porosity and permeability.

It should also be noted that many soils which are permanently frozen are earthquake susceptible when in the thawed state.

Permafrost has been a subject of an intensive amount of research. Both the U.S. Army Corps of Engineers and Acres American are well aware of its characteristics and effects.

MATERIALS

Recent investigations by the U.S. Army Corps of Engineers have indicated that the gravel necessary to build the earthfill dam at the proposed Watana Damsite does not exist in sufficient quantities for the construction of the dam.

The Watana Dam design has been altered accordingly by changing the gravel shell to a rock shell and by widening the semipervious core.

Table 2 lists the types and quantities of materials necessary to construct the proposed Watana and Devil's Canyon Dams. Although it is reasonable to substitute crushed rock for gravel fill, a question arises as to whether the designers plan to use processed rock to replace the aggregate in the concrete, if sufficient quantities of gravel are not to be found.

This is an important question as regards the quality and cost of the proposed project and one which will eventually have to be addressed.

TABLE 2 *

Type of Material	Devil's Canyon Dam (cu/yds)	Watana Dam (cu/yds)
Concrete Requirements	2,600,000	2,000,000
Impervious Core		7,373,000
Semipervious Core		6,077,000
Fine Filters		5,621,000
Coarse Filters		2,201,000
Pervious Rock Shell		36,297,000
Riprap		223,000

*Data supplied by the U.S. Army Corps of Engineers, 1979

CONCLUSIONS

This report has illustrated that the proposed Susitna Hydroelectric Project poses several geotechnical problems as to its feasibility. Most of the problems should be answered by the study to be performed by Acres American Incorporated.

However, with the amount of data which has been collected to date, it seems difficult to say whether the project is or is not feasible. A more logical assessment of the situation could be made upon gathering and compiling more extensive data.

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