UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

Docket File (50-410)

MAY 15 1979

50-410

MEMORANDUM FOR: R. E. Jackson, Acting Chief
Geosciences Branch, DSE

FROM: R. B. McMullen, Geologist
Geology and Seismology Section
Geosciences Branch, DSE

SUBJECT: GEOLOGICAL INVESTIGATIONS AT NINE MILE POINT 2 DOCKET 50-410

A meeting was held on April 24, 1979 in Bethesda, Md. among representatives of Niagara Mohawk Corporation, its architectural engineer Stone and Webster, Inc., and its geotechnical consultant, Dames and Moore Inc., the New York State Geological Survey, the U. S. Army Corps of Engineers, and the Nuclear Regulatory Commission. A list of attendees is enclosed. The purpose of the meeting was (1) to provide the opportunity for Niagara Mohawk to brief those not familiar with the project, on the results of geological investigations that were carried out to define faults discovered during construction, and the rock mechanics characteristics of the site; and (2) to respond orally to NRC questions transmitted to Niagara Mohawk following staff review of the report entitled "Nine Mile Point Nuclear Station, Unit 2, Geologic Investigation."

The investigations were carried out between the fall of 1976 and the spring of 1977 as the result of the discovery of several faults during construction of the Unit 2 plant. The faults can be grouped into two principal systems. The first system is comprised of several minor folds and low angle thrust faults in the heater bay - radwaste building areas and in the cooling water intake shaft of the plant. These structures strike approximately north-northeast and dip at a low angle to the east. The second group of faults are two approximately N70°W striking, high angle faults, one located in the vicinity of the cooling tower south of the plant, and the other located north of the plant. Both sets show evidence of minor adjustments during the last 12,000 years. Geologic and rock mechanics studies were conducted to demonstrate that these faults were not a hazard, and to develop a design basis for high rock stresses at the site. The results of these investigations are summarized in the report referenced above.

mq

7907100690

A total of 18 questions (Q361.1 through Q361.18) were sent informally to the licensee. The licensee responded to all of them but Q361.14. The following is a brief summary of our understanding of Niagara Mohawk Corp's oral responses to the more significant questions. The questions asked by the NRC are attached as Enclosure 2.

The first question (Q361.1) is comprised of 4 parts and concerns the origin and antiquity of the thrust faults in the heater bay, radwaste building and the cooling water intake shaft. In part (a) the staff suggested an alternative origin for the deformation of the lacustrine clays in the heater-bay/radwaste fault as possibly being due to soil deformation that occurred during the rapid drawdown of glacial Lake Iroquois. The licensee's consultant presented arguments that led them to conclude that the contortions were caused by differential slippage along the rock strata bounding the clay. The evidence for that conclusion includes: (1) relatively high stresses parallel to bedding have been measured in rock at the site; (2) similar kinking or tight folding was found in Trench #4 where bedding-plane slippage has been demonstrated, and (3) rock squeeze features are a common occurrence throughout the Nine Mile Point region. They attribute the movement to relatively high lateral stresses in rock, and high fluid pressures in the rock that formed subsequent to the rapid drawdown of Lake Iroquois, which caused a reduction of shear strength along the fault plane.

Niagara Mohawk had assembled a three member geological panel to review site geotechnical investigations. One member of that panel is Dr. F. Donath of the University of Illinois. In response to our request (part b) for data supporting a conclusion by Dr. Donath cited in the report, that high confining pressures are needed for fault breakage at angles of 15° to 25°, the licensee stated that although nothing had been published on this, Dr. Donath is likely to have test data available. Sufficient time had not been available to acquire this data for this meeting, however, they did contact Dr. Donath and he reaffirmed his support of that statement. A more formal statement and available data will be provided in response to the question.

In response to part c of Q361.1, the licensee agreed that dilatancy cracking had occurred along the heater bay fault, but pointed out an important difference between the heater bay and the cooling tower faults. That

difference is that the cooling tower fault is characterized by dilation of beds from rock surface down with a progressive decrease in displacement with depth to depths between 150 and 200 ft. The heater bay fault, on the other hand, exhibits dilatancy only along the fault, with no dilation of beds above or below. This is therefore, believed to be an indication that higher confining pressures were involved in the last movement along the heater bay fault.

The licensee stated that any future adjustments (part d) on the cooling tower fault would be minor and would proceed at a slow rate. Studies indicate that there was likely an initial rock burst that generated this feature. The available geologic evidence supports a decay in stress since that time accompanied by slow deformation of the glacial and post-glacial soils and the bedrock.

The heater bay fault is either related to middle to late Paleozoic (400 to 225 mybp) deformation or is younger than Cretaceous (136 to 65 mybp) normal faulting at the site. The licensee favors the latter interpretation based on the absence of what is assumed to be hydrothermal mineralization of Cretaceous age in the heater bay fault and the presence of this material in the cooling tower fault. The heater bay fault is considered to be older and to have had lower rates of movement that the cooling tower fault.

In response to Q361.2 the licensee stated that future minor adjustments along bedding planes, joints and faults caused by rock squeeze cannot be ruled out. Therefore, the design of walls and slabs is based on parameters associated with this phenomenon. A brief presentation was given by Stone and Webster, Inc., describing first, the stress assumptions provided by Dames and Moore, Inc., the analyses techniques used, and finally, the way the structures are being designed and constructed to accommodate that rock squeeze. 1200 psi in an east-west direction was assumed for the maximum principal stress and 400 psi was assumed for the minor stress, based on the results of the geologic investigations. Selection of these assumptions has resulted in the necessity to cut the rock walls back 6 inches away from the structures. This slot beneath the foundation slab has been filled with specially designed vermiculite concrete. The type of material to be used to fill the wall slot as not yet been decided. The 6" slot is based on a study of other rock embedded structures in the region. The maximum closure that could be found in the region was about 9 inches at the Lockport Bridge on the St. Lawrence River. Therefore, a 12 inch closure was considered to be conservative for Unit 2.

It is planned to over-excavate the cooling water tunnel and isolate the 4-1/2 foot diameter intake pipe from the bedrock, in order to protect it from rock squeeze. A projection of the drainage ditch fault to the west northwest would cause it to intersect this tunnel. If this fault is analogous to the cooling tower fault, recent deformation is confined to the upper 200 feet of rock. The licensee is therefore considering drilling the tunnel below 200 feet to avoid the rock that has been affected by post-glacial buckling.

The twelve line wall of Unit 2 is the only wall that has not been separated from bedrock. It has been designed to resist rock squeeze and has been instrumented at 12 locations with 24 strain gages. Readings are being taken on a bi-monthly basis. The instruments are placed where maximum stress is anticipated and where bedding plane slip is considered most likely to occur, based on the geologic mapping.

The licensee plans to continue monitoring as long as the results indicate movement or if there are indications that the water table is rising. Ground water levels are significant because the site bedrock, particularly the more shaly sections, show a high affinity for water. Laboratory tests demonstrate that when stresses are reduced rock swell becomes important in causing movement.

The licensee reported in response to Q361.4 that there was evidence of rock movement during excavation. These include two rock buckles, several open joints, and numerous offset drill holes. The two buckles were concentrated along thin siltstone beds that were unloaded during excavation. The first buckle occurred in the control building excavation and was 1-1/2 inches high by 35 to 40 feet long and its strike was N35°W. It formed 3 to 4 weeks after excavation and was characterized by a fractured crest. The second buckle was oriented N8°W to N30°E, was about 14 feet long, and was located in the floor of the circulating water encasement trench. Its wave length was about 10 feet and amplitude 3/4". Dilation was associated with this feature. The open joints were observed in the floors of excavations and varied in width from 2 to 20 mm. The offset drill holes were generally displaced 1/4 to 1/2 inch toward the cut rock face, however, several of the holes were offset in a direction parallel to the rock face. Most displacements were in the upper section of rock, but some were observed in the deeper excavations.

Bedrock monitoring systems employed around the site (Q361.5) include the following:

1. Instrumentation related to construction activities:
   a. settlement-heave monuments installed before excavation. For various reasons these monuments failed during excavation;

   b. pins installed adjacent to the rock slot to measure closure. The measurements indicated very minor maximum closure during the first 18 to 20 months, then cyclic closing and opening on the order of a fraction of an inch during winter and summer, respectively. No movements occurred after foundations were completed.

   c. 4 survey benchmarks on the axes of the reactor were installed before excavation. No movement has been detected within the limits of accuracy of the survey techniques; and

   d. survey monuments installed at ground surface around the plant area. These are now inactive but were monitored for 14 months and no deflection was detected;

2. Instrumentation carried out by Dames and Moore during the geological investigations includes:
   a. vertical inclinometers installed in Trench 5, in the circulating water trench, and the circulating water incasement trench;

   b. multipoint extensometers in Trench 5 and the main excavation;

   c. stress meters in several overcore holes around the site, both adjacent to the cooling tower fault and remote from it; and

   d. pins around a rock slot cut into the bottom of Trench 5.

In general the results appeared to show that:

(1) In Trench 5, there is a progressive relief of the following stress conditions: normal stress, shear stress on bedding associated with north sloping trajectory, and shear stress associated with the stress history of the fault. There is continuing adjustment of the buckle along the cooling tower fault. Trench 5 is being obliquely distorted in addition to a progressive closure of the pit.

(2) In the main excavation the extensometers indicate gradual minor deformation. The stress meters show an apparent progressive reduction of stress.

(3) Minor deflections were detected by the inclinometers in the vicinity of the circulating water trench; and bedding plane slip was observed south of the circulating water incasement trench.

The licensee reported, in response to an NRC oral question, that a small crack in the northeast corner of the secondary containment of Unit 1 may be related to rock squeeze. They are monitoring it at the present time.

In response to Q361.9 regarding variation of stress adjacent to the cooling tower fault, the licensee's consultant indicated that such differences were not unusual because the measurements were obtained on opposite sides of the fault in different stress regimes, and that the measurements were made at different distances from the fault.

Q361.16 was concerned with the east-southeast extension of the cooling tower fault and its overall length. The licensee responded that they did not trace the fault to the east because it was significantly longer than the 1000 feet cited in Appendix A as being the minimum length of a fault requiring a detailed investigation. They simply went on to conduct a detailed fault investigation. They do believe, however, that the fault is diminishing toward the east because stratigraphic displacement is decreasing in that direction.

Question 361.14 asked the licensee to relate the structural geology defined at the site to other structures in the region. To emphasize the importance of the request, an example of a previously unknown significant geologic structure was given. The structure cited was the Demester faulted anticline which was discovered during investigations for the nearby New Haven site. Niagara Mohawk felt that this should be addressed by the utility building that site, and had not planned to answer this question, but would do so if requested formally.

A brief caucus was held among the Corps of Engineers, the NY State Geologic Survey and the NRC. The consensus of opinion was that Niagara Mohawk should respond to question Q361.14 in considerable detail. We also requested that the Utility keep us informed as to (1) the results of the on-going monitoring program, (2) any design or construction modifications of significance to the plant's safety, and (3) its resolution of the cooling water intake tunnel design in light of rock squeeze and the possibility of its intersection in the Drainage Ditch fault.

We informed Niagara Mohawk representatives that we would formally transmit most of these questions along with other questions generated as a result of this meeting within about two weeks. We also told them that in general most of the answers provided orally during the meeting were adequate with the few exceptions described above.

Original Signed by
R. B. McMullen

R. B. McMullen, Geologist
Geology & Seismology Section
Geosciences Branch
Division of Site Safety and Environmental Analysis

DISTRIBUTION:
DOCKET FILE (50-410)
NRR RDG
GB RDG

cc: R. Denise
H. Silver
S. Wastler
P. Kuo
R. McMullen
T. Wilkenson, C/D, Buffalo, NY
R. Lutton, C/E, WES
H. Bailey, NYSGS
A. Varela, Region I

OFFICE	DSE:ST:GB					
SURNAME	RBM RMcMullen:sb					
DATE	5/11/79					

Enclosure 1

LIST OF ATTENDEES

NRC

P. Kuo
S. Wastler
P. Sobel
H. Lefevre
R. Jackson
J. Lane
H. Silver
R. McMullen

Corps of Engineers

T. Wilkinson, Buffalo District
R. Lutton, WES

Dames & Moore, Inc.

J. Fischer
T. Harper
J. Szymanski
W. Lu
J. Markham

Niagara Mohawk Corporation

N. Rademacher
E. Klein
C. Terry

New York State Electric & Gas

J. Boudgett

Stone & Webster

F. Kovensky
J. Mullin
T. Couglin

New York State Geological Survey

H. Bailey

Enclosure 2

NINE MILE POINT NUCLEAR STATION, UNIT 2

DOCKET NO. 50-410

GEOLOGIC INVESTIGATION

Q361.1 Either additional evidence, re-analysis, or discussion is needed to clarify your position that the thrust faults mapped in the heater bay and radwaste buildings and the intake shaft are not capable within the meaning of Appendix A 10 CFR Part 100 and are instead old faults which have had minor post glacial adjustments. The last paragraph on page 3-15 of Volume I describes four lines of evidence from which the age of these structures can be inferred:

a. The presence of glacio-lacustrine clay within one of the low angle thrust faults is used to argue that the fault pre-dates glacial Lake Iroquois. Elsewhere in the report (Executive Summary, page 3-2) it is stated that these clays are contorted, suggesting the possibility of minor adjustments during the latest Pleistocene or Holocene. Another interpretation of equal likelihood is that the deposition of these clays within the fault and their subsequent deformation is related to the soil mechanics as a result of impoundment and rapid drawdown of Lake Iroquois during Late Pleistocene and Early Holocene. Based on your detailed observations made during mapping of this fault, provide data and discuss the various ways that the deformation features in the lakebed clays could have developed considering the geologic events that have taken place in this region. What is the most probable cause of these features? Provide the basis for your response.

b. The second line of evidence cited for the age of these structures is experimental data which indicate that a high confining pressure is necessary for a fault to transect thin bedded strata at angles of 15^0 to 25^0. A personal communication with Donath is cited. Provide the data that supports this conclusion.

c. The third line of evidence stated on page 3-15 is that the sinusoidal forms of folds in the heater bay and radwaste areas suggest higher stress magnitudes and confining pressures than were necessary for buckling on the Cooling Tower fault. It is also stated that dilation does not appear to be associated with these structures as is the case with the Cooling Tower fault. Provide the references or other data that support the interpretation that greater confining pressures were present during formation of these structures than during last movement along the Cooling Tower fault. One possible arguement that should be considered is that the presence of glacio-lacustrine clay within one of the faults is evidence for dilation. Provide additonal support for the interpretation that dilatant fractures are absent in the heater bay and radwaste area.

d. A fourth line of evidence given is that the necessary stress orientation for causing most of the geologic structures in the main power block island are probably similar in orientation to those responsible for the development of the regional fracture pattern that is believed to have occurred during the Late Paleozoic. However, the current stress regime at this location, based on in-situ

measurements made during this investigation, are relatively high and also commensurate with the orientations, attitudes and sense of last movements along the thrust faults in the heater bay, radwaste building and the intake shaft. Expand your discussion of the origin of these features including all the data that indicate age and causes of the deformation. Perform an analysis to assess whether or not current existing stresses in the vicinity of Unit 2 will produce adjustment-type movements on the low angle thrust faults. Among the factors to be considered in this analysis are: orientations and magnitudes of stresses, pore pressures, swelling characteristics of bedrock, and effective stresses normal to the fault plane.

Q361.2 Based on a telephone conversation conducted on March 14, 1979 between representatives of Niagara Mohawk Corporation and its geotechnical consultants, Dames and Moore, Inc., and the NRC, it is our understanding that you have elected to support the concept that the faults in the power block area are not tectonic faults in the sense of Appendix A, 10 CFR Part 100, and that last adjustments on them are related to deglaciation phenomena and the rock mechanics properties that characterize the upper 200 feet of site bedrock. In the subject report you have attempted to define the rock mechanics characteristics in detail and apparently have developed design criteria believed to be conservative.

These criteria are not in the report. The assumptions that were used to develop these criteria are not identified in the report. If the intended course of action is to show that the plant is designed to withstand minor adjustments in rock, you may in lieu of the data and analyses requested in Item 361.1 provide the geotechnical assumptions, and rock mechanics criteria that are to be utilized in the design of all Category I structures. Discuss how these values were selected from the data presented in the report. Additionally, there appears to be a gap of information linking the investigation results and analyses presented in the report and the decision to accommodate any potential rock movements in the structure design rather than to demonstrate that no rock movement is likely during the life of the plant. Please provide a complete and detailed discussion of the rationale that led from conclusions arrived at during the investigation to the decision to modify the design of the relevant structures. What design and construction measures will be taken to accommodate the high lateral bedrock stresses imposed on the cooling water tunnels?

Q361.3 During the telephone conversation referenced above, the licensee stated that the structures are, in effect, isolated from the bedrock by the presence of a slot cut between the structure walls and foundation and rock. The slot below the foundation slabs is filled with vermiculite concrete. What material is to be used in the slots around the walls? What is the design width of the slots, and what is the basis for the selection of that slot

width?

Q361.4 Was there evidence of heave in the bedrock floor or differential movements along faults, joints or bedding plans during the excavation of the unit 2 site, or at any time following the completion of those excavations? Describe the amount, direction and rate of movement of any such adjustments.

Q361.5 It is our understanding that instruments have been installed at various locations in bedrock around the site and that a monitoring program has been underway for the last year and a half. Provide the results of this study to date including a complete discussion of any anomalous readings. Do you plan to continue monitoring stress in site bedrock in the future? Are structures being monitored to assure that they are not being affected by high stresses in rock? Discuss the criteria that govern limits of rock movements, which indicate whether or not a potential problem is developing.

Q361.6 The thorough investigation and analysis of the Cooling Tower fault has allowed for a reasonable interpretation with respect to its history of movements since Late Paleozoic, including a determination of the causes of those respective movements. Evidence acquired in a smaller study is also presented which leads to a conclusion that the Drainage Ditch fault is similar to the Cooling Tower fault with respect to origin, history of displacements, senses of movement, and orientation. A postulated projection of the Drainage Ditch fault would intersect the tunnels beneath Lake Ontario. Evaluate the potential effects on an engineered structure, including intake

and discharge tunnels, overlying or cutting across such a feature, considering the types of adjustments (rates and magnitudes of movements) that you consider possible in the future.

Q361.7 Evidence was presented in the report that demonstrated that the Cooling Tower fault zone was of limited extent, at least to the west northwest, and that the most recent movements on the fault were confined to the upper 200 feet of rock. Can a similar conclusion be made regarding the reverse faults and the Drainage Ditch fault? Provide the basis for your conclusion.

Q361.8 On Page II-C-1 and Table II-D-3 in Volume II, it is not clear where the MP sample series came from. Provide profiles and/or plans showing the precise location of these samples.

Q361.9 In Volume III, pages 3-14 through 3-18, low stress values measured in boring OC-3 are attributed to the close proximity of this boring to a projection of the Cooling Tower fault to the west. An inconsistency is apparent in that mostly high stress measurements are obtained in boring OC-2, which is drilled adjacent to the Cooling Tower fault. Please discuss how nearness to the fault can explain low in-situ stress values in one area but does not seem to effect the magnitude of stress in another location near the fault.

Q361.10 Reference is made to Volume III, last paragraph on page 3-23 and item 3 on page 3-24. The former states that the maximum principal stress outside of the fault block plunges toward the southeast. The latter indicates that areas unaffected by faulting show a southwest plunge of the stress trajectory. Please clarify this apparent inconsistency.

Q361.11 Please define "unacceptable lag times" as used in the next-to-last paragraph on page 5-2, Volume III.

Q361.12 Provide an analysis to support your conclusion in Volume III Section 5.0 that the lower piezometric head in the vicinity of the fault zone is the result of an increase in storage space within the Whetstone formation due to a continuation of buckling along the fault zone.

Q361.13 Describe quality control of strain monitoring to isolate the effects of moisture content and temperature from boundary and residual strain conditions.

Q361.14 A very specific investigation and evaluation of geologic structures on the site has been carried out, however, there is an apparent gap between consideration of these structures and their relationship to geologic structures in the immediate area around the site. For example, a very significant structure was discovered after completion of your study and investigated on the New Haven site a few miles to the east. Expand your evaluation of geologic structures on site to include a consideration of the relationship between those structures and other known structures around

the site.

Q361.15 On the Surficial Geology map, Plate 1-11, Volume II, a circular peat deposit, about 1/4 mile in diameter is mapped immediately south of the site. While all other deposits of peat and muck shown on the map are related in some way to mapped drainage systems, this one is not. Discuss the origin of this feature and provide the data supporting your interpretation.

Q361.16 The west-northwest termination of the Cooling Tower fault is apparently somewhere between Trench 2 and Pit 1. What is your estimate of the east-southeast extent of the Cooling Tower fault? Provide the basis for your answer.

Q361.17 To what geologic event do you attribute the development of the zone of breccia along the Cooling Tower fault?

Q361.18 Dilation of the bedding is apparently 6 feet greater on the north side of the Cooling Tower fault than it is on the southern side. If your interpretation as to the cause of dilation (high pore pressures) is correct, the magnitude should approximately be equal on both sides. Why is there greater dilation to the north than to the south?