MIDLAND - D. Gillen's Status Report
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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

AUG 28 1979

MEMORANDUM FOR: Robert E. Jackson, Chief
Geosciences Branch, DSS

FROM: Daniel M. Gillen, Geotechnical Engineer
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Geosciences Branch, DSS

SUBJECT: MIDLAND UNITS 1 & 2 - GEOTECHNICAL ENGINEERING PROBLEMS RELATED TO PLANT FILL

I am submitting for placement in the branch files, an outline of the geotechnical engineering problems related to the plant fill at the Midland Nuclear Power Plant site in Midland, Michigan. The outline lists pertinent criteria presented in the PSAR and FSAR and summarizes the foundation conditions and remedial measures (in progress and proposed) for all Category I structures founded on the plant fill.

The outline may be of some assistance in briefing the Corp of Engineers personnel that are expected to become involved in the review of Midland Units 1 and 2.

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Enclosure:
As stated

cc: w/enclosure
D. Hood
D. Gillen

XA 10pp.

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Midland Units 1 & 2
Docket Number: 50-329/330
History of Geotechnical Engineering Problems Related to Plant Fill

I. PSAR Criteria
  A. Foundation Conditions (Cat. I structures)
    1. Stiff to hard natural cohesive soils
      a. Reactor Building
      b. Part of Auxiliary Building
      c. Part of Service Water Pumphouse

    2. Controlled compacted fill
      a. Diesel Generator Building
      b. Part of Auxiliary Building
      c. Part of Service Water Pumphouse
      d. Borated Water Storage Tanks
      e. Diesel Generator Fuel Oil Storage Tanks
      f. Cat. I Pipelines and Duct Banks

  B. Plant Fill
    1. Up to 35 ft. of fill placed to bring plant to Elev. 634
    2. Materials considered suitable: sand and clay soils from plant and reservoir excavations
    3. Dames & Moore Report, June 28, 1968 (Part of PSAR)
      a. States preference should be given to placement of granular materials in plant area (ease of compaction)
      b. Placed at or near optimum moisture content
      c. 6-8 inch lifts (loose)
      d. Compaction criteria

| Purpose | Cohesive | | Granular | |
|---|---|---|---|---|
| Support of Structures | 100% | ASTM D-698 * | 85% | D-2049 |
| Adj. to Structures | 95% | | 75% | |
| Areal Fill | 90% | | 70% | |

*Modified to 20,000 ft lbs of compactive effort

      e. Estimated settlement of 1/2 inch or less for shallow spread footings in compacted fill

II. FSAR Criteria
  A. Foundation conditions unchanged (Fill and Natural cohesive soils)
  B. Plant Fill
    1. Text
      a. 35 ft. thick
      b. Compaction Criteria - Table 2.5-9
      c. Soils Used (Gradations) - Table 2.5-10
      d. Select sand backfill used around all structures
      e. Loose lift thickness $\leq$ 12 in.

2. Tables
   a. Table 2.5-9 (Minimum Compaction Criteria)

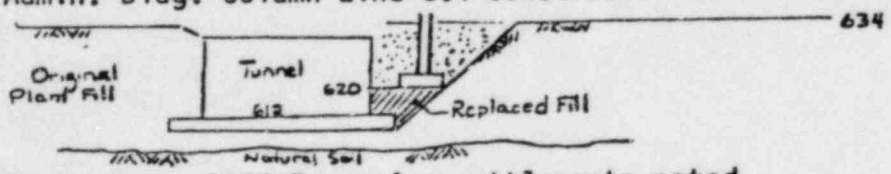
| Function | Zone | Type | Compaction Criteria |
|---|---|---|---|
| Adj to structures | Structural backfill | Sand | 80% D 2049 |
| Support of structures | — | Clay | 95% D 1557 (Modified to 20,000 ft-lbs) |

   b. Table 2.5-10 (Gradation Ranges for Fill)
      - Designates Random fill as Zone 2; having no gradation restrictions; any material free of humus, organics, or other deleterious material
      - Does not specify where random fill is placed

   c. Table 2.5-14 (Summary of Contact Stresses & Bearing Capacity)
      - Indicates that controlled compacted cohesive fill is the supporting soil for Diesel Generator Bldg.

C. Subsequent Changes to FSAR (applied in field)
   1. Table 2.5-9
      a. Type of materials for various functions is not listed
      b. Zone designation for support of structures is no longer blank ⇒ now reads "Zone 2"
      c. Note 3 added: when sand used as Zone 2, 80% D 2049 is required
      d. Note 4 added: lean concrete allowed as alternate for structural backfill. Structural backfill around structures may also support another structure.
   2. Table 2.5-14
      a. Controlled compacted cohesive fill listed under supporting soils is changed to Zone 2 in every case.
      b. Note 2. Ultimate bearing capacity is being reevaluated for number of structures supported by Zone 2 material
   3. NOTE: The incorrect reporting in the FSAR of the type of fill being placed is presently under review for I&E penalty action.

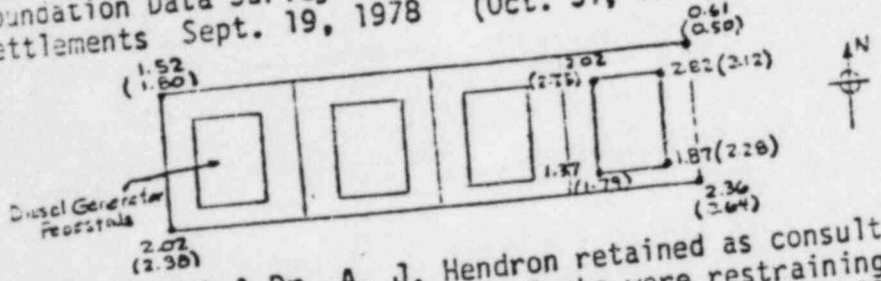
III. History of Geotechnical Engineering Problems
   A. Administration Building (Non-Cat. I): First Indication — Not Categ. I
      1. Admin. Bldg. Column Line 0.4 constructed as follows:




      2. Early Sept. 1977; Excessive settlements noted
      3. Removal of Column PA0.4 revealed soft foundation material

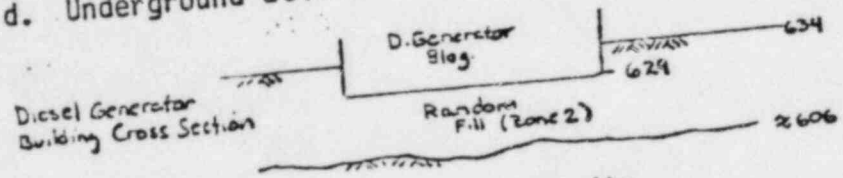
4. Subsequent investigations & tests resulted in the conclusion that material under and adjacent to the subject footings had insufficient bearing capacity (insufficiently compacted fill (clay))
5. Soft materials removed and replaced with lean concrete and footings reconstructed

B. Diesel Generator Building (Cat. I Structure)
1. Settlement data first recorded July 10, 1978. (larger than expected)
2. Settlement approaching maximum value in FSAR Fig. 2.5-40 August 21, 1978
3. Exploratory Program begun August 25, 1978 (Dutch cone)
4. Oral report to NRC (I&E) Sept. 7, 1978
5. Foundation Data Survey Program expanded Goldberg, Zoino & Dunnicliff
6. Settlements Sept. 19, 1978 (Oct. 31, 1978) (in inches)



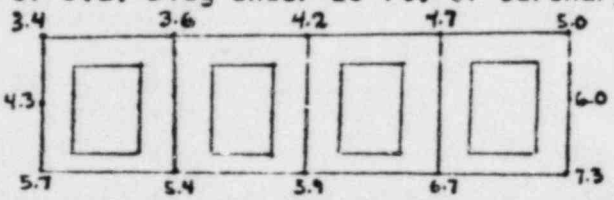

Report not submitted to NRC to Bechtel

7. Dr. R. B. Peck & Dr. A. J. Hendron retained as consultants
8. Determined that Electrical Duct Banks were restraining the DG Bldg. from settling uniformly. Duct banks isolated 11-16 to 11-24-78
9. Gaps of 1 1/2 in. between mudmat and footings in NE corner; began to close immediately on isolation of duct banks
10. Instrumentation installed by Dunnicliff:
    a. 39 piezometers
    b. 28 settlement markers; 32 settlement platforms; 45 borros anchors
    c. Cracks mapped & strain gages installed
    d. Underground utilities in vicinity profiled and monitored




11. Results of soil borings and test pits
    a. Blow counts indicate wide variance in compaction (as low as 2/ft in spots)
    b. %compaction in Test Pit: 87-101%
    c. Moisture contents: 2 to 35%
    d. Shear strengths (unconfined compression): 100 to 3646 psf

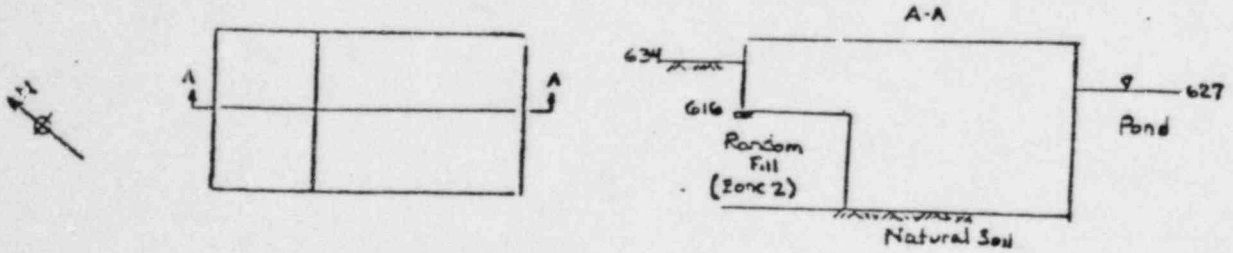
12. To consolidate the soft underlying random fill a preload program was planned.
    a. Temporary reinforcement of the adjacent below grade Turbine building wall was installed
    b. Granular fill was placed in and around the D.G. Bldg. to elevation 654 (20'); began February 1979, completed April 7, 1979
    c. Cooling Pond filled concurrently with preload placement to raise GWT to maximum Elev. 627.
13. The two 20-in. and two 6-in. condensate lines were cut outside the Turbine Bldg. to prevent overstress during preload.
14. Last section of structure (roof slab) poured on March 22, 1979
15. Liquefaction analysis of loose sand fill beneath DG Bldg.
    a. Indicates sands (NW Quadrant) are susceptible to liquefaction
    b. Proposed chemical grouting to stabilize sands
    c. Recent change to permanent dewatering system to replace chemical grouting (see Page 8. )
16. Settlement of D.G. Bldg under 20 ft. of surcharge (6-29-79) (in inches)




17. Present plans call for removal of preload in September, 1979.
18. Preload (full scale load test) data will provide relationship between settlement and load ⇒ used to predict residual settlements of structure

C. Service Water Pumphouse
    1. Construction Sequence.
        a. Excavation to Elev. 586' in Summer 1976.
        b. Remove pockets of loose sand and dewater
        c. Portion founded on natural materials built in fall and Winter 1976-77.
        d. Backfill under cantilever position placed Jan-April 1977.
        e. Slab and walls for cantilever portion-Spring & Summer 1977.
        f. Exterior backfill placed at various times between Fall 1977 and Fall 1978.

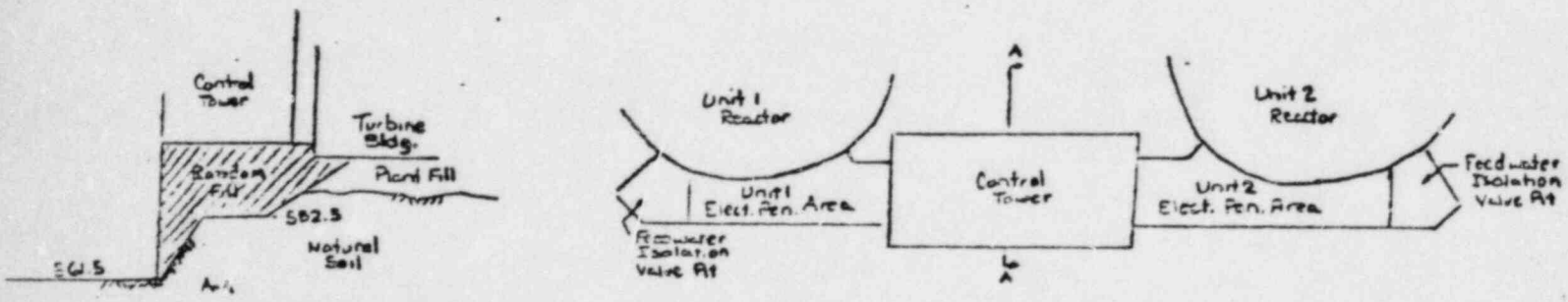
    2. Plan and Cross Section:



3. Soil investigations in the vicinity of the service water pumphouse and other structures founded on the plant fill (random) were initiated based on the problem at the D.G. Bldg.
4. Borings adjacent to portion of SW Pumphouse founded on fill indicate loose to dense sand backfill ⇒ borings to investigate fill under structure proposed.
5. Supporting soil conditions: soft to very stiff clay and loose to very dense sand backfill over medium to very dense sand over glacial till.
6. Investigative conclusions
   a. Some areas of support fill have not been sufficiently compacted
   b. No settlement evident because existing dead loads are being supported by cantilever action
   c. Analysis indicates total design load cannot be supported by cantilever action.
7. Proposed corrective action
   a. Predrilled bearing piles to be placed under the north wall of the structure ⇒ concrete filled steel pipe piles penetrate into bearing stratum at Elev. 587 ft; Design capacity - 100 tons
   b. Horizontal loads will be carried by deeper part of structure
   c. Detail drawings on Fig. 83. (Revised)

D. Auxiliary Building Electrical Penetration Areas, Feedwater Isolation Valve Pits, and Control Tower
1. Foundation Backfill
   a. Backfill placed between Summer 1974 and Fall 1975
   b. Materials: Random Fill placed in stages with intermittent layers of lean concrete.
   c. Number of access ramps present in area of backfill

2. Plan and Cross Section



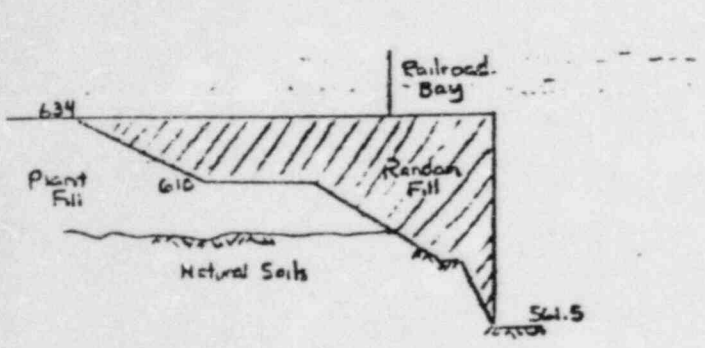

3. Soil Exploration
   a. Twelve borings made in area
   b. Control Tower (3 borings)
      - Medium to very dense sand backfill over glacial till
      - local void under mudmat Elev. 590-589 (boring Ax-9)
   c. Unit 1 Electrical Penetration Area (2 borings)
      - dense to very dense sand backfill with occasional layers of loose sand and soft clay over glacial till - layer of concrete Elev. 583.5 to 580.

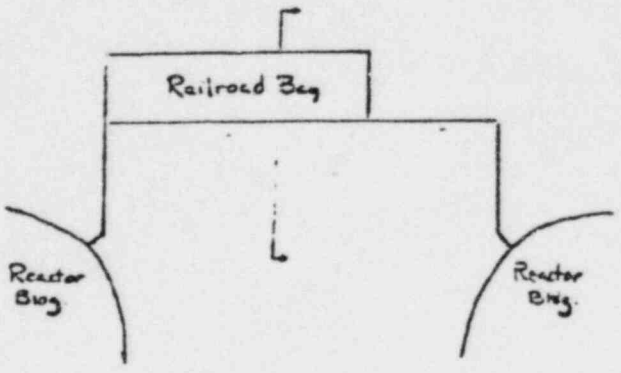
d. Unit 2 Electrical Penetration Area (2 borings)
   - Generally same as C.
e. Units 1 and 2 Feedwater Isolation Valve Pits (5 borings)
   - Loose to dense sand and medium to very stiff clay backfill with occasional soft zones over dense glacial till - concrete used as backfill in spots

4. Deficiences
   a. Void under concrete mudmat in control tower area
   b. Backfill material under electrical penetration areas and valve pits has not been sufficiently compacted
5. Planned corrective action
   a. Pressure grouting to fill the void under the mudmat.
   b. Unsuitable backfill under elect. pen. areas and valve pits removed and replaced by lean concrete ≥ 2000 psi comp. strength
      - Temporary support for valve pits ⇒ supported externally from turbine bldg. and buttress access shaft
      - If external support of Elect. Pen. areas is necessary, steel girder resting on containment ring girder and turbine building crane column will be provided.
      - Instrumentation installed to monitor the movements of Elec. Pen. areas during dewatering and excavation operations
      - Excavation areas will be dewatered
      - When dewatering has lowered GWT to Elevation 600 ft., access shafts will be dug from 634'to 603' and tunnels made under valve pits
      - Temporary support system installed under the ends of the electrical penetration areas jacked piles, caissons or concrete piers.
      -Excavation and removal of unsuitable fill will be done by manual or mechanical means
      -Upon completionof excavation, the excavated area will be backfiled with lean concrete; 5 ft maximum lift thickness (first lift 2 ft); successive lifts doweled into preceding lift.
   c. Crack monitoring continuing
   d. New seismic analysis will be made

E. Auxiliary Building Railroad Bay

1. Plan and Cross Section



2. Soil Exploration
   a. Three borings in area
   b. Medium to very dense sand backfill over dense glacial till
   c. Some concrete also used as fill
   d. Analysis indicates that the fill can safely withstand the imposed loading
3. Deficiency
   a. The upper 18 ft of sand may be susceptible to liquefaction
   b. Plan to stabilize sand by chemical grouting since changed to permanent dewatering system

F. Borated Water Storage Tanks
1. Field exploration indicates stiff to very stiff, sandy silty, clay, fill over dense glacial till
2. Applicant indicates that this condition is suitable for support of these tanks
3. Future plans
   a. Construction will be completed
   b. Tanks will be filled with water to make a full scale load test of the foundation soils
   c. Piping connections will be made; selected points on piping between tanks and Auxiliary Building will be monitored for settlement.
   d. Estimate of long term settlement to be determined based on measured settlements of loaded tanks
   e. Removal of tanks remains a viable alternative if unanticipated settlements occur that require remedial action.
4. Broken air line embedded in fill
   a. May 16, 1979, I&E inspector observed a bubbling phenomenon occurring in the vicinity of the tanks.
   b. Cause diagnosed as broken pressurized airline embedded in the fill; air line was shutoff and relocated (note: Bechtel was aware of situation months earlier)
   c. Applicant agreed that degradation of the foundation materials may have occurred.
   d. Borings and/or test pits would be performed to investigate the extent of the problem.

G. Diesel Generator Fuel Oil Storage Tanks
1. Soil conditions
   a. Supported on medium to stiff sandy clay backfill
   b. Surrounding backfill: loose to dense sands and very soft to stiff clay
   c. Fill underlain by dense glacial till
2. Tanks are filled with water at present, and settlement is being monitored (no settlement observed to date)
3. If limited residual settlement cannot be assured, tanks will be surcharged in excess of full weight, or be removed and reconstructed.

H. Utilities (Cat. I)
   1. Piping
      a. Service Water Line (Serv. Water Pump Structure to Auxiliary Bldg.)
      b. Service Water Line (Serv. Water Pump Structure to Diesel Gen. Bldg.)
      c. Emergency Diesel Fuel Oil Lines
      d. Borated Water Lines

   2. Electrical Duct Banks
      a. Auxiliary Bldg. to Service Water Pump Structure
      b. Auxiliary Bldg. to Diesel Generator Bldg.
      c. Diesel Gen. Bldg. to Diesel Fuel Oil Tanks and Service Water Valve Pits
      d. Auxiliary Bldg. to Borated Water Tanks

   3. Service Water Valve Pits (Units 1 & 2)

   4. Supporting Soil Conditions
      - soft to very stiff clay and loose to very dense sand (random fill) variable supporting conditions

   5. A representative group of Cat. I piping was profiled by a Nold Aqueducer settlement gage (profiles show significant differential settlement)

   6. Checks on electrical ducts showed no obstructions

   7. The borated water lines will be profiled by optical means

   8. The Applicant's field inspection, drawing review, and stress analysis of Cat. I piping indicate that the stress levels are and will be within the code allowables

   9. There are no planned remedial measures for Cat. I utilities

I. Permanent Dewatering System
   1. To eliminate any liquefaction potential of the sands (replaces chemical grouting)

   2. Preliminary details
      a. Lower piezometric level from elevation 627 ft to approximately elevation 600 ft
      b. Exterior curtain of wells completely surrounding the power block area.
      c. Series of interior lines of wells to aid drawdown
      d. Further details forthcoming

IV. Comments

A. Outstanding information

1. Results of full scale loading tests of Diesel Generating Building and Borated Water Storage Tanks; residual settlement prediction
2. Results of investigation of broken air line embedded in fill at tank farm; remedial measures;
3. Permanent dewatering system details; additional settlement to expect from dewatering

B. Technical Specifications to be required

1. Permanent dewatering system
2. Future Monitoring program for all Cat. I structures on plant fill (special attention to utility connections).