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Technical Memorandum

To:	Doug Egnatuk (OPPD)		
From:	John Christiansen (HDR)	Project:	OPPD - FCS 2011 Flood Services
CC:	Dave Rohan, Larry Cieslik, Rick Niedergeses (HDR)		
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DISCUSSION OF PROPOSED DCP TESTING BETWEEN AUX/TURBINE BUILDINGS

According to OPPD drawings, a gap exists between the adjoining exterior foundation walls and pile caps of the Auxiliary Building and Turbine Building. This gap is called an "expansion joint" on the plans, and exists from the top of the Turbine Building foundation wall at elevation 1007.5 to the bottom of the Turbine Building pile caps, which vary in elevation from approximately 983.4 to 987.4. The bottom of the adjoining Auxiliary Building floor slab/pile cap is at elevation 983.5. Above the Turbine Building pile caps the drawings show that this gap is 1'9" wide between the Turbine Building foundation wall and the Auxiliary Building monolithic floor slab/pile cap and foundation wall. However, the Turbine Building pile caps project 1'3" outward from the foundation wall, narrowing the expansion joint gap to a 6 inch width from the top to the bottom of the Turbine Building pile caps. Plans indicate that the expansion joint is sand-backfilled from the bottom up to an elevation of roughly 1004. DCP testing will be performed through this sand-backfilled expansion joint. The target of the DCP testing is the sand below the bottom of the Auxiliary Building foundation level (elevation 983.5). To reach the target testing depth, the DCP test rods will need to extend through the sand backfill and down through the relatively narrow, 1'9" to 6" wide gap, which may require repeated attempts.

DCP testing will be conducted by a two-man crew from Thiele Geotech, Inc., using a Humboldt H-4218 Dual-Mass Dynamic Cone Penetrometer, which uses a sliding 10.1 pound or 17.6 pound drop weight to drive a 20-mm-diameter, 60 degree cone. As the cone is advanced into the ground, additional sections of rod are added to allow penetration to the desired depth. The number of blows and resulting penetration depths are recorded and provide a correlation to bearing pressure and California bearing ratio (CBR). The results can also be used to evaluate relative changes in soil density/stiffness as the penetrometer is advanced. Dynamic cone penetrometer testing will be conducted in accordance with ASTM D6951.

The expansion joint is covered by a series of steel plates, which rest on top of the Turbine Building foundation wall and are bolted to the Auxiliary Building foundation wall. At present, steel plates have been removed in the south half of the building, exposing the sand backfill. Some plates are covered by conduits and pipes and will not be removed. Limited observation indicates that the surface of the sand backfill varies from approximately 5.5 feet below the top of the Turbine Building foundation wall near column 1 at the south end, to approximately 4 feet below the top of the Turbine Building foundation wall near column 3. Placement procedures for the sand backfill are not known. The sand backfill may have been loose-dumped and allowed to consolidate over time, or it may have been initially compacted by some means such as flooding with water, which is a fairly common method of compacting sand backfill. We anticipate that the surface of the sand backfill could have random areas of depression, caused by consolidation of the backfill over time. The depth of any surficial depressions is expected to be minor (probably less than 12 inches) for a compacted sand backfill, and greater (possibly up to a few feet) for non-compacted sand backfill. If material at and below foundation level has been removed by the process of subsurface erosion/piping due to pumping, surficial depressions greater than this could exist. Since the contouring of the sand backfill surface may reveal the presence and location of underlying material loss, the surface of the sand backfill should be observed and documented by HDR before it is disturbed in any way, including testing, filling, digging, foot traffic, etc. Observation and documentation by HDR will consist of measuring the depth to the surface of the sand from the top of the Turbine Building foundation wall; taking photographs of the sand surface; and describing the sand surface.

The desired DCP test locations are partially obstructed with a variety of overhanging pipes, pipe hangers, conduits, and steel beams, creating congested and difficult access and work conditions. It therefore may not be possible to perform the testing while elevated above the top of the Turbine Building foundation wall. If it is not possible to work above the top of the Turbine Building foundation wall, the testing will be done in the 1'9" wide gap between the buildings while standing on the surface of the sand backfill. We have been informed by OPPD that this work area is considered a confined space, and that personal fall protection equipment is required. Fall protection equipment is also required by HDR for HDR employees and their subcontractor's employees who stand on the sand backfill surface. Before the testing is performed, HDR employees and their subcontractor's employees who enter this work area will receive fall protection training and confined space training from OPPD.

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Date:	07-20-2012	Job No:	134-164565

DCP TESTING IN EXPANSION JOINT BETWEEN AUXILIARY/TURBINE BUILDINGS

PROJECT DESCRIPTION AND BACKGROUND INFORMATION

Dynamic cone penetrometer (DCP) testing was performed in a gap which exists between the adjoining exterior foundation walls and foundations of the Auxiliary Building and Turbine Building. The purpose of the DCP testing was to investigate for the presence of negatively affected soil (NAS) extending from beneath the Turbine Building to the adjacent Auxiliary Building. NAS is defined as soils with a DCP index greater than or equal to 4 inches per blow. DCP testing was conducted in accordance with ASTM D6951.

The gap between the Auxiliary Building and Turbine Building is called an "expansion joint" on OPPD plans. The expansion joint and foundation details are shown on OPPD drawings, including numbers 10768, 12195, 16517, 16518, 16519, and 16527. The location of this expansion joint is shown on Figure 1. The expansion joint exists from the top of the Turbine Building foundation wall at elevation 1007.5' to the bottom of the Turbine Building integral structural slab and pile caps, which vary in elevation from approximately 983.4' to 987.4'. The bottom of the adjoining Auxiliary Building pile-supported mat foundation is at elevation 983.5'. Above the Turbine Building structural slab and pile caps, the drawings show that this gap is 1'-9" wide between the Turbine Building foundation wall and the Auxiliary Building foundation wall. However, at elevation 989.4' the Turbine Building structural slab and pile caps project 1'-3" outward from the foundation wall, narrowing the expansion joint gap to a 6" width from the top to the bottom of the Turbine Building structural slab and pile caps. The expansion joint, foundation, and foundation wall configuration is depicted in Figure 2.

Plans indicate that the expansion joint is sand-backfilled. The recommended elevation of the sand backfill is not shown on the plans we reviewed, but anecdotal evidence from OPPD plant personnel suggests that it may have been filled to roughly elevation 1004', to match surrounding grade. The expansion joint is covered with steel plates. On the Auxiliary Building side the steel plates are bolted to the foundation wall. On the Turbine Building side the steel plates rest on the top of the foundation wall.

Placement procedures for the sand backfill are not known. The sand backfill may have been loose-dumped and allowed to consolidate over time, or it may have been initially compacted by some means such as flooding with water. Observations of the conditions in the top of the trench suggest that the backfill has gone through post-construction saturation/draining cycles associated with multiple high river and associated ground water events. Water can enter the trench from below, where the expansion joint is open to the underlying soils. Such cycles could have resulted in some settlement of the sand backfill. The following indicators of high water events in the expansion joint were observed:

- What appeared to be a high water mark was observed at approximately elevation 1006' on the foundation walls inside the expansion joint.
- The soil at the surface of the backfill was observed to have shrinkage cracks with curled edges, reminiscent of the surface of a dried pond or lakebed.
- Toward the middle and north end of the expansion joint, apparent erosion of the soil backfill surface due to water movement was observed.

Photo pages 1 through 3 show the surface of the backfill and the apparent erosion.

The depth of the backfill surface was measured relative to the top of the Turbine Building foundation wall at multiple locations. These measurements and associated observations are summarized in Table 1. The surface of the sand backfill generally slopes downward towards the south, with the highest measured location towards the north end (18") being as much as 53" (4.4') higher than the lowest measured location at the south end (71"). If normal construction practices were followed, it is likely that the sand backfill surface was relatively level immediately after the backfill was placed. However, since the placement procedures and initial elevation of the sand backfill are unknown, it is difficult to draw any firm conclusions from the sloping backfill surface.

DESCRIPTION OF DCP TESTING

DCP testing was conducted between June 18, 2012 and June 29, 2012 by a two-man crew from Thiele Geotech, Inc., and was observed by HDR. The DCP testing was performed using a Humboldt H-4218 Dual-Mass Dynamic Cone Penetrometer, using a sliding 17.6-pound drop weight to drive a 20-mm-diameter, 60 degree cone. As the cone was advanced into the ground, additional sections of rod were added to facilitate penetration to the desired depth. The number of blows and resulting penetration depths were recorded and provide a correlation to bearing capacity (page 8 of Portland Cement Association document titled "Design of Concrete Airport Pavement") and California bearing ratio (ASTM D6951). The results can also be used to evaluate relative changes in soil density/stiffness as the penetrometer is advanced (ASTM D6951).

The target of the DCP testing was the sand below the bottom of the Auxiliary Building foundation level (elevation 983.5'). To reach the target testing material, the DCP test rods extended through the sand backfill and down through the relatively narrow, 1'-9" to 6" wide gap. To allow access to the expansion joint backfill material, OPPD removed selected steel cover plates. The number of plates which were removed was limited by physical constraints including overhanging pipes, pipe hangers, and conduits. The number of DCP tests performed was limited by the configuration of the plate removal, the configuration and number of overhanging pipes and conduits, and the depth of the sand backfill surface. These constraints impacted and limited the accessibility of potential DCP test locations. Ultimately, 16 DCP tests were performed. DCP Test Data reports and Turbine/Auxiliary Expansion Joint DCP Test Hole graphs for all 16 tests are attached. Of the 16 attempted DCP tests, 8 tests successfully extended through the gap and into the target sand below the bottom of the Auxiliary Building foundation level (elevation 983.5'). The other 8 tests were terminated above the target material after reaching refusal on obstructions.

DCP test locations and elevations are summarized in Table 2. The 16 new DCP test locations, as well as previous DCP test locations are shown on Figure 1. Whether the new DCP tests reached the target material below the bottom of the Auxiliary Building foundation level or not is indicated on Figure 1 by the letter "Y" for "yes, reached target material", or "N" for "no, did not reach target material", in parentheses below the test number. The tests which did not reach the target material reached refusal on obstructions above target depth. Refusal was indicated when consecutive blows of the DCP test hammer achieved zero penetration and the DCP hammer apparatus visibly bounced due to the tip resting on hard material which may have been concrete, pieces of rock, or steel. The lowest NAS elevation which was documented in previous DCP testing is noted in parentheses below test numbers 2-1 through 2-8, and 2-25. Photo pages 1 through 6 show the expansion joint, the backfill surface, and DCP tests being performed.

During testing, particular attention was paid to the DCP blow counts and movement of the rods within the expansion joint sand backfill, since the backfill created frictional drag on the rods. It was noted that:

- During DCP testing, blow counts in the backfill were low but variable with depth, indicating that the rods were moving relatively freely and did not have excessive friction from the wall backfill.
- After testing, the rods could be pulled out of the wall backfill by hand with minimal effort, again indicating that the rods were moving relatively freely and did not have excessive friction from the wall backfill.

Based on these observations it was determined that the impact of the wall backfill on the blow counts was minimal, and was relatively uniform from hole to hole. This information is important because it verifies that the DCP test results below the wall backfill were not significantly altered by the presence of the wall backfill. The DCP test results below the wall backfill were therefore valid indicators of conditions below the wall backfill, and can be reasonably compared to the DCP results in the Turbine Building.

As previously noted, 8 of the 16 DCP tests successfully extended through the expansion joint gap and into the target sand below the bottom of the Auxiliary Building foundation level. Some of the tests were performed in areas which are adjacent to previously identified NAS under the Turbine Building basement floor. In each of the 8 successful DCP tests, blow counts increased immediately and significantly near elevation 983.5' (bottom of Auxiliary Building foundation), and then remained high for the remainder of the test. The high blow counts indicate dense to very dense consistency of the sand. The elevation where increased blow counts were encountered correlates with the top elevation of the vibroflotated sand which is known to exist under the Auxiliary Building. No loose zones were found below the elevation of the bottom of the Auxiliary Building foundation. The 8 DCP tests which reached the target material extended to elevations ranging from 980.3' to 977.8'. In each case the DCP test depth was limited by difficult driving conditions in the dense to very dense vibroflotated sand, as indicated by high blow counts.

FINDINGS AND CONCLUSIONS

From the DCP test results we have drawn the following conclusions:

- Dense to very dense vibroflotated sand was encountered in all 8 of the 16 DCP explorations that extended through the narrow gap at the bottom of the expansion joint during this exploration program. According to recommendations from Dames & Moore (see attached letter dated August 1, 1968), the vibroflotation-improved sand extended approximately 5 feet under the west side of the Turbine Building based on their recommendation that the vibroflotation compactive influence extend a distance of 5 pile diameters beyond the peripheral row of piles supporting Class I structures. The presence of dense to very dense vibroflotated sand beneath the west edge of the Turbine Building could impede development of NAS soils in the direction of the Auxiliary Building.
- New DCP tests 1-2-3 and 1-2-4 extended to elevations 977.8' and 978.7', respectively. Adjacent previous tests 2-8 and 2-25 in the Turbine Building identified NAS extending to elevations 982.5' and 982.1', respectively. The new tests extended below the bottom elevation of the previously identified NAS in the Turbine Building. The new tests did not identify the presence of any NAS immediately adjacent to the Auxiliary Building.
- New DCP tests 3-4-1 and 3-4-2 extended to elevations 978.6' and 978.3', respectively. Adjacent previous test 2-6 in the Turbine Building identified NAS extending to elevation 978.3'. One of the new tests extended to the bottom elevation of the previously identified NAS in the Turbine Building, and the other test extended to within a few inches of this elevation. The new tests did not identify the presence of any NAS immediately adjacent to the Auxiliary Building.
- At all 8 DCP test locations which reached the target material, no evidence of NAS extending into the vibroflotated sand immediately adjacent to the Auxiliary Building was found. This was true even adjacent to previously identified NAS under the Turbine Building.