12 Mar 1998, 1:00 pm - 2:30 pm

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Proceedings: Fourth International Conference on Case Histories in Geotechnical Engineering, St. Louis, Missouri, March 9–12, 1998.

REGULATORY, ENVIRONMENTAL AND GEOTECHNICAL SOLUTIONS TO CONSTRUCTION OF A ROADWAY EMBANKMENT OVER A LANDFILL

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Paper No. 10.11

ABSTRACT

The new Illinois Route 143 alignment was constructed with the new Clark Bridge that crosses the Mississippi River in Alton, Illinois. The new bridge forced the Illinois Department of Transportation (IDOT) to cross the Alton Commons Landfill with a new alignment. Approximately 318 meters of embankment with fill heights ranging between 4.5 to 7.6 meters were constructed on top of the landfill.

An Environmental Impairment Assessment, Preliminary Site Assessment (PSA), Phase II and Phase III investigations were completed in 1989 and 1990. Using "Brownfield" concepts, the Illinois Environmental Protection Agency (IEPA) approved the alignment construction without having to remediate the site. This approval was contingent upon the following three conditions:

- requiring a deed restriction,
- restricting groundwater use,
- prohibiting intrusive activities.

The landfill was preloaded with a test fill of 5.2 meters of soil and reloaded with 7.6 meters of soil when embankment construction commenced with the planned fill and an additional 3 meters surcharge. Settlement plates and inclinometers were used to monitor the earthwork performance during and after construction. As the landfill was loaded, consolidation was immediate, typically 5 to 7 days of loading. Total settlement including movement during preloading ranged between .6 and .9 meters for fill heights ranging between 5.5 and 7.6 meters. Settlement reading showed 10 to 15% of the landfill thickness consolidated beneath the embankment. Settlement two years after embankment construction showed the landfill was settling 1.8 centimeters per year. Settlement after three years showed less than 1 centimeter per year.

The ongoing movements is characteristic of secondary compression and possibly undrained creep. The landfill material does not fit the category of soil types or conditions that would be susceptible to creep; however, this is the most similar plastic deformation model available to the authors and as such undrained creep was qualitatively analyzed. The initial log of strain rate versus log time plots after primary consolidation was completed have a slope that is flatter than 1:1 indicating creep to failure. The plots for the last year have steepend indicating a stable condition.

KEYWORDS

Brownfields Program, Undrained Creep, ARAR's, Secondary Compression, Preliminary Site Assessment.

OVERVIEW

Open discussions were held with the Illinois Environmental Protection Agency (IEPA) after initial historical reviews prior to beginning site investigations. Meetings were continued throughout the investigation process. The result of these meetings provided IDOT the concerns of the IEPA and their requirements for investigations. Geotechnical issues were reviewed within IDOT. The work focused on the following items:

1. Regulatory: Applicable or relevant and appropriate requirements (ARAR's) were listed and reviewed by the Illinois Department of Transportation prior to initiating discussions with the IEPA. This standard procedure includes chemical specific, location specific and action specific ARAR's. This self initiated process and the continued meetings with the IEPA was key to successful completion.
2. Environmental: Establish the existing conditions within and around of the landfill. This included ground water investigations, contaminant types and susceptibility to leaching.
3. Geotechnical: Foundation settlement and stability. The varied landfill contents did not permit development of typical geotechnical pavements. Environmental concerns were known early in discussions with the IEPA to restrict design and construction.

FIELD INVESTIGATIONS AND LABORATORY TESTING

All field and laboratory testing is discussed in this section. Much of this work took place at various times throughout the investigation process and is not chronologically listed to keep this paper concise.

Borings were drilled through the landfill and five test pits were completed from January through October 1989. See Figure 1 for test pit and boring locations. The test pits were excavated with a backhoe in early February 1989 to depths ranging between 8 to 12 feet below the ground surface. During drilling and excavation the material encountered was visually classified and recorded. Samples were screened with a HNU and tested for hydrogen sulfide, methane and various other compounds using Draeger tubes.

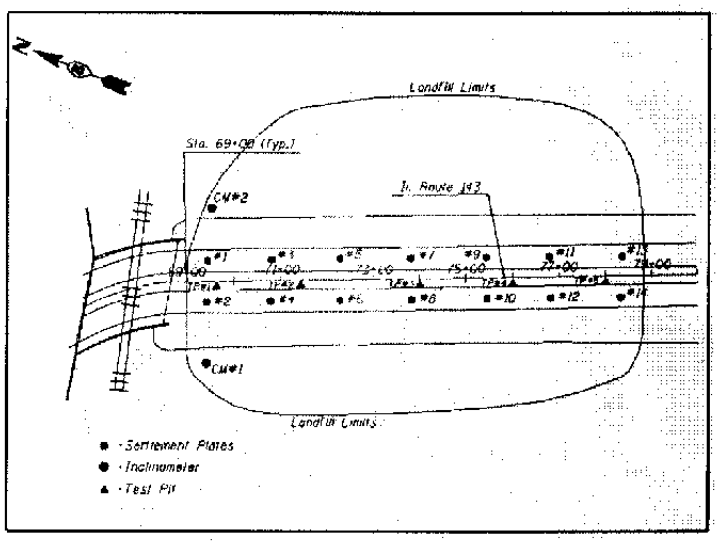

Fig. 1 -- Location Map

The top two to three feet of each test pit consisted of the sandy cinder fill material. Below this layer, medical waste, bricks, metal, decomposing wood, plastic and paper products were found. A mild ammonia odor was present during excavation. Based on field classifications, 10% of the waste was organic of subject to decompose. Layers of sand and clay mixed with the refuse were also encountered, indicating the refuse may have been placed in layers and covered with soil on an intermittent basis. In some areas the ratio of soil to trash was as high as 1:1. The refuse and soil appeared to be relatively compact. No extremely loose deposits or voids were encountered in any of the test pits. Groundwater in TP #1 was recorded at 10 feet below the ground surface. The groundwater elevations at the remaining test pits varied between 4 to 6 feet below the ground surface, all at or near the same elevation.

All landfill samples collected from the test pits were analyzed for metals, volatile organic compounds (VOC's), semi-volatile organic compounds (SVOCs) and total petroleum hydrocarbons (TPH). TP #3, TP #4 and TP #5 were also tested for Ammonia as a result of on site screening with Draeger tubes. Many compounds were detected, but the only significant concentration detected in all of the test pit samples was 11,000 mg/kg lead from TP #1. This concentration exceeded IEPA clean-up objectives.

A boring designated LB105 was drilled at TP #1 to further evaluate the lead contamination. A truck-mounted hollow stem auger drilling rig using a split-spoon sampler was used to collect soil samples at three depths. Samples were analyzed for EP-toxicity lead. The EP-toxicity test measures the amount of lead that will leach into the landfill. The analytical results for these samples were .14 mg/L lead collected at 5 to 7 feet, .12 mg/L lead collected at 10 to 12 feet, .0058 mg/L lead collected at 15 to 17 feet.

During June of 1989 four monitoring wells were installed along the perimeter of the landfill. Well LB101 was installed north of the landfill in an up gradient direction and wells LB102, LB103, and LB104 were installed south of the landfill in a down gradient direction. Boring logs from the monitoring wells show the top 10 to 15 feet of soil consisting mostly of sandy clay, cinders and various trash. Underlying the landfill material are fine to coarse sand with occasional clay lenses. Ground water readings identified two bearing zones. Well LB101 monitored groundwater in the top 10 to 15 feet of fine grained cinder fill material. Wells LB102, LB103, and LB104 monitored groundwater in the sand below the cinder fill and clay lenses.

Groundwater samples collected from the wells were tested for VOC's on the Target Compound List (by Method 8240), the total lead and polynuclear aromatic hydrocarbons (PAHs or PNAs). Samples collected during well drilling were scanned with an HNU and no VOC contamination was detected. As a result, no soil samples from the monitoring well borings were analytically tested. Based on the following parameters detected in the groundwater samples, minimal contamination was in the perched aquifer and the sand aquifer.

* Well LB101 13 ug/L tetrachloroethene
* Well LB101 4 ug/L 1,2-dichloroethene
* Well LB103 3 ug/L chlorobenzene
* Well LB104 16 ug/L 1,2-dichloroethene.

An electromagnetic terrain conductivity geophysical survey was conducted throughout the proposed right of way. This method was selected for ease in conduct, reduction and ability to detect leachate plumes, voids and metallic objects such as drums. The field work was completed in one day and reduction in two days. No contaminants, tanks, voids or barrels were detected.

REGULATORY AND ENVIRONMENTAL CONCERNS

Preliminary Site Assessment and Environmental Impairment Assessment

State and federal laws impose such high risk that due diligence is required to assess environmental risks and associated liabilities that may accompany right of way acquisition. Laws that impose such risks include the Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). To assess environmental conditions, a Preliminary Site Assessment (PSA) and Environmental Impairment Assessment (EIA) was conducted by IDOT and the Illinois State Geological Survey (ISGS). In addition to environmental risks and liabilities, conditions that could affect construction costs, cause construction delays and jeopardize worker safety are evaluated in the preliminary site assessment.

The PSA and EIA included a historical review that helped characterize the locations and nature of environmental risks and liabilities. The review revealed this site is listed on the Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS). Aerial photographs taken from 1941 through 1986, Office of the Illinois State Marshal's Underground Storage Tank (UST) List, IEPA's Leaking Underground Storage Tank (LUST) Incident Report list, U.S. Geological Survey topographic and Sanborn Fire Insurance maps and various other written information were reviewed. The Alton Commons Landfill was officially operated by the City of Alton from 1940 to 1950. The PSA revealed the landfill was used through 1970 by various parties. The landfill encompassed a 25 acre area and ranged between 15 to 20 feet in depth. Based on the available information it was assumed the debris was placed with minimal compaction. Records documenting a liner or daily covers were not found. Placement of the cap was not part of a closure plan. Capping of a portion of the landfill with 2 to 4 feet of clay and sand was completed in conjunction with the construction of a levee built by the Corps of Engineers in 1954.

While in official operation the landfill accepted sanitary, industrial and hospital wastes. A glass company located in the immediate vicinity of the landfill deposited waste glass in the landfill. Construction and street repair debris was also accepted by the landfill. There were numerous refineries in the area and it was common practice in the 1960's at this landfill to use their waste to "burn down" the landfill debris. The Alton Department of Public Works maintained a storage and repair facility over a portion of the site and during the late 1960's and 1970's used the landfill for disposal of street and sewer cleaning debris. Most of the surface cover material consisted of street and storm sewer cleaning debris.

Interviews of long time local residents and reviews of available documents regarding the landfill did not disclose recorded disposal of hazardous waste. In addition, several leaking underground storage tanks (LUST's) were identified upstream in the groundwater flow path from the landfill.

Phase II and III Investigation

As discussed in the Investigations and Testing section, there is an upper perched groundwater and lower groundwater zone as identified and tested in the Phase II and Phase III investigation. According to the Illinois Groundwater Protection Act the perched zone is considered Class II (general resource) groundwater and as such is non-potable. The sand aquifer 15 to 20 feet below the ground surface is considered a potential source of drinking water and subject to Class I (potable resource) groundwater and was required to be potable. The hydrogeologic modeling and testing showed contamination from LUST sites upstream in groundwater flow. This and additional contamination was carried through the landfill but not into the lower sand aquifer. However,

groundwater contaminants in the landfill were below the Class I and II criteria, respectively.

All landfill and water samples were analyzed for metals, VOC's, SVOCs and TPHs. The only significant concentration detected was the lead from TP #1. The concentration decreased with depth and the EP toxicity test showed the leachable lead to be below action levels. With the exception of the inorganic lead, no contamination above any state or federal action levels were detected in soil or water samples. The numerous contaminants, the underlying Class I groundwater source and the uncontrolled landfill would permit any action by the IEPA.

Brownsfields Concept

One of the newest and most innovative programs for cleaning up contaminated properties is known as "Brownfields". "Brownsfields" is a term used to describe contaminated, unproductive, and abandoned industrial properties. The Illinois Brownsfield legislation was enacted in final form in 1996. The Brownfields program encourages the redevelopment and clean up of industrial properties. Both the USEPA and IEPA are encouraging private properties to enter these programs. When IDOT submitted the results of the landfill environmental investigation to IEPA, the Brownfields program was not formalized; however, the initiatives used to streamline the revitalization of an unproductive urban sites were utilized.

The Brownfields initiatives are based on risk assessments associated with intended future use of sites. For instance, remediating an old industrial site for a new commercial development to standards less stringent than those associated with a residential property or children's playground site. Through the brownsfield program, a property can be remediated to an acceptable condition, and still protect human health and the environment. For an investor this means spending less money than would otherwise be required to build in the suburbs. For local agencies this means an increase in employment and taxes.

In conjunction with the new cable stayed Clark Bridge, the city of Alton proposed significant improvements to the downtown area where the Alton Commons Landfill is located. These improvements included a multi-million dollar marina and gambling boat complex. A bike trail crossing the new Clark Bridge and extending north along the Great River Road was also included. A connector street between the new IL 143 alignment and the downtown area had been in the planning stages for over 15 years, but had been shelved several times. Developers for this project were leery of revitalizing a blighted industrial site adjacent to a landfill. Through the Alton Commons Landfill project, it was hoped that the frame work for negotiated cleanup standards and institutional concerns such as capping, fencing or deed restrictions would open the door for redevelopment.

The Level 1 Endangerment or Risk Assessment Report for the Alton's Common Landfill proposed the embankment constructed over the landfill would serve as a permanent cap. No remediation efforts were proposed. The department emphasized that embankment construction would not enhance the leaching of any contaminants. An easement from the city of Alton would be granted instead of purchasing right-of-way and property use would be limited to roadway use exclusively. IEPA evaluated the report and considered the relative risk of exposure with no remediation, site location and how the property would be used. IEPA concluded that no cleanup objectives were required with the understanding that exhumation of landfill waste, intrusive activities in the landfill or point source water infiltration from the roadway would not be allowed. This included all excavation and pile driving.

As with any landfill, the potential exists for environmental risks and liabilities. According to current legal opinion, IDOT as holder of an easement, would not be considered a landfill facility operator or land owner. However, if the laws or interpretations thereof change, IDOT could become a potentially responsible party to the landfill. Based on the IEPA's decision not to issue cleanup objectives, landfill acquisition through an easement commenced. The barriers, provided by G. Vanderlaan, are the following:

- Risk of liability for past contamination
- High cost of site assessment and cleanup
- Uncertain cleanup standards
- Negative public perception
- Lender liability
- Lack of available public funding.

This is where "no further action letters" issued by IEPA come into play. No prudent investor would participate in a Brownfields program without some level of comfort. In Frank Prillaman's, *"EPA Announces New Policy on 'Comfort' Letters for Brownfields"* article, this letter releases property owners from performing any further cleanup of a site. The letter provides information for an investor to make an informed decision regarding the purchase and/or development of the brownfields property. A site may not be suitable for all uses and the "no further action letter" is based on the effectiveness of the engineered conditions. As with the Alton Commons Landfill property, which will be restricted to roadway use only and the embankment cap will serve as the engineered condition. If the use of the site changes to require greater protection of public health than provided by the original remedial response, the "no further action letter" will be terminated.

GEOTECHNICAL ANALYSES AND CONSTRUCTION

The key to the regulatory agency not objecting to the embankment construction became the geotechnical challenge. Construction of an embankment and surcharge of 40 feet in height over an uncontrolled landfill was not disclosed in a review of the available technical literature.

Initially, the contractor was directed to preload the landfill with 40 feet of uncompacted fill with 1h to 1v (1:1) side slopes. Limited fill material as a result of construction delays precluded the contractor from constructing the 40 foot preload. Between March of 1990 and April 1991 seventeen feet of uncompacted soil was temporarily stock piled on top of the landfill. Most of the material was end dumped from trucks with minimal spreading and compaction effort. Settlement plates were installed and monitored. Settlement from March of 1990 to April 1991 ranged between 1 to 1.7 feet for the 17 feet of initial filling. Settlement plate readings showed eighty five to ninety percent of settlement took place within the first 7 to 14 days of loading.

The contract plans called for 2:1 side slopes but 1:1 slopes were utilized in the initial filling. Conventional soil type strength tests of the landfill material were not completed because of the impossibility of retrieving samples. The intent of the preload was to help determine the side slope angle. In addition, the highly heterogeneous composition of the landfill would have resulted in a wide range of strength values. As a result standard slope stability analyses were not conducted. An inclinometer was installed during the 13 months of preloading the temporary 1:1 side slopes showed no signs of instabilities.

The temporary surcharge was removed April 1991. The landfill was reloaded in August 1991 when construction of the IL 143 embankment commenced. In addition to the 25 feet of fill, a 10 foot surcharge was constructed on top of the embankment to accelerate the landfill consolidation. Based on the amount of immediate settlement that took place during the preloading, it was estimated most of the settlement would elapse during the first 120 days. Settlement plates and inclinometers were installed prior to fill placement. Construction of the 25 foot fill and the 10 foot surcharge was completed November of 1991. During embankment construction the settlement plates and inclinometers were monitored on a regular basis. This information would be used to determine when the surcharge could be removed and paving of the new IL 143 could begin.

Additional inclinometers were installed along the toe of the bridge cone end slope. See Figure 1. The inclinometers were installed 25 to 50 feet below the ground surface along the perimeter of the embankment. Inclinometers were monitored bi-monthly. Figures 2 and 3 show the cumulative resultant deflection plots for inclinometer readings between August 1991 and August 1994. Each plot shows movement perpendicular to the slope and indicates the movement is outward. The maximum horizontal movement in the refuse layer is 12 to 24 feet below the ground surface. The maximum deflections for inclinometers CM #1 and CM #2 were 0.9 and 1.2 feet, respectively. Most of the movement took place during construction of the embankment. The readings show the ground is moving horizontally away from the embankment at a current but decreasing rate of approximately 0.15 inch per year. Based on the rate of movement and the inclinometer plots, there are no indications that a failure surface has developed at this time.

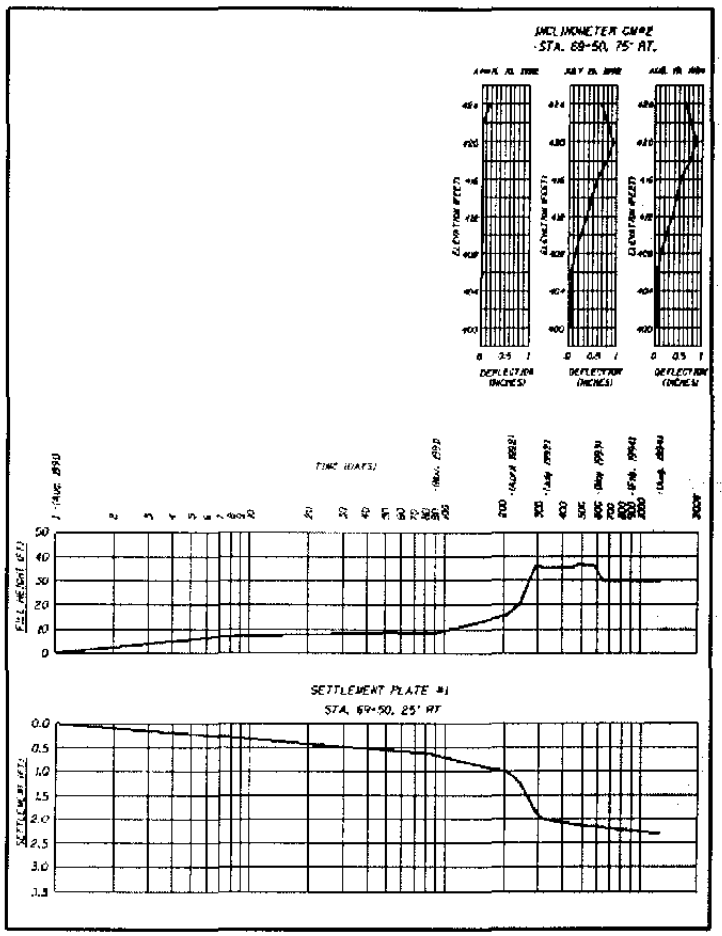

Fig. 2 - Settlement and Inclinometer Plots

A total of fourteen settlement plates were installed prior to fill and surcharge placement. As the landfill was loaded, settlement was relatively immediate and settlement curves from all 14 settlement plates showed similar linear rates of settlement. Unlike normal clay soils the landfill consolidated immediately, typically 5 to 7 days of loading. As depicted on Figures 2 and 3 the maximum rates of movement occurred immediately after additional fill was placed. Because the settlement along the preloaded section was not monitored between the time the surcharge was removed and embankment construction commenced, it was unclear if the landfill rebounded after the load was removed. Assuming the refuse did not rebound significantly, total settlement including movement during preloading ranged between 2 feet and 3 feet for fill heights ranging between 18 and 25 feet. Settlement readings for all settlement plates showed 10 to 15% of the

landfill thickness consolidated beneath the embankment. Settlement plots two years after construction showed the landfill is settling vertically at a current but decreasing rate of .7 inch per year. Plots five years after construction show no movement.

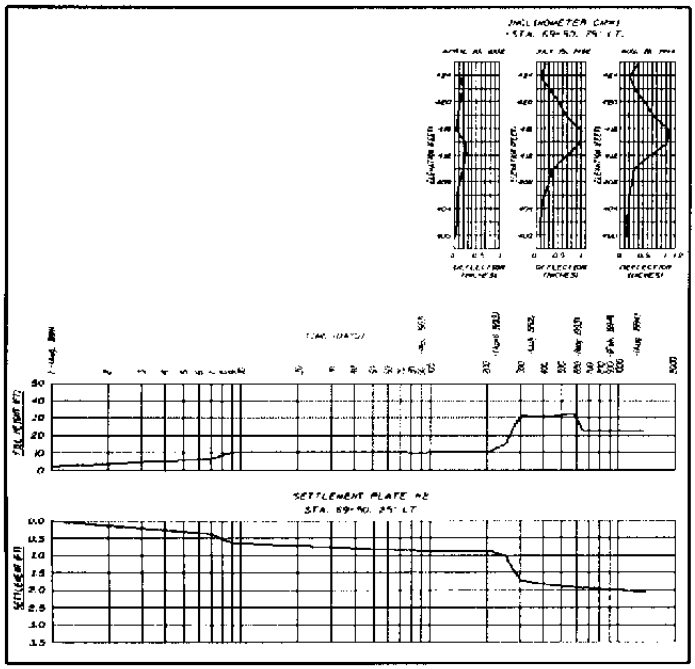

Fig. 3 -- Settlement and Inclinometer Plots

The horizontal and vertical movements are characteristic of secondary compression and possibly undrained creep. The landfill material does not fit the category of soil types or conditions that would be susceptible to creep; however, this is the most similar plastic deformation model available to the authors and as such undrained creep was qualitatively analyzed. The initial log of strain rate versus log time plots after primary consolidation was completed have a slope that is flatter than 1:1 indicating creep to failure. The plots two years after construction have steepened indicating a stable condition.

CONCLUSION

The key to success in working with regulatory agencies is patience and flexibility. A thorough investigation and knowledge of ARAR's is essential in gaining the confidence of the regulatory agency. The easiest and least expensive engineering solution may not be the most acceptable to the regulatory agency. The $100M Clark Bridge project required the connection to be built over the landfill and this priority framed all work on this project. The numerous meetings with the agency, detailed reviews and investigation and testing fulfilled all due diligence mandated or implied in environmental legislation. Using initiatives, now formally set forth in the Brownfields Program, an expedited IEPA approval was achieved. Due care was fulfilled by following the mandates of the regulatory agency which included no intrusion into the landfill which would enhance horizontal or vertical leachate movement. Also, no additional influx of surface water was permitted. The environmental risks to the department were minimized by the aforementioned actions and the acquisition of the property through an easement.

The geotechnical risks were at least as great as the environmental. The risks could have been minimized by ground improvement. Ground improvement techniques possibly causing ground water contamination and negative impacts to the landfill implicating IDOT in future liabilities forced IDOT to design the embankment based on field observations. Asphalt pavement was designed and constructed in anticipation of uneven settlement and potential instabilities. Instabilities will impose risk and additional due diligence and care during investigation and correction. The current indications are that all risks were minimized based on monitoring to date.

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