

Failure Case Study of Construction at a Solid Waste Site  
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### ABSTRACT

A bus terminal, consisting of several buildings, was constructed on a closed solid waste landfill site in West Tennessee. A few years after the construction, severe structural problems developed: cracks on the floors and walls, methane gas coming through the cracks in the floor, differential settlements in the buildings. The foundations of the buildings were remediated. The probable causes of failure, the shortcomings during the construction phase, and the lessons learned are discussed in this paper.

### PROJECT DESCRIPTION

The project site was an old residential solid waste dump site. Four (one and two-story) buildings were planned for the site. The geotechnical investigation indicated the presence of residential waste up to a depth of about 60 feet; the maximum depth of the investigation was 110 ft. The floor system consisted of structural beams and slabs; the beams were located on pipe pile foundations. A methane gas collection system, consisting of a sand layer with a network of pipes, was placed on the waste site. During the construction, after the gas collection system was in place, one of the water mains broke, washing away part of the gas collection system.

After the construction was completed, the buildings were used as envisioned until the settlement of the foundations caused the walls to crack and methane gas from the solid waste came through the floor cracks. The differential settlements of the buildings exceeded about three inches. For health reasons of the employees, the buildings were evacuated and remediation was carried out to retrofit the foundations. However, the cost of remediation was reported to be a lot more than the construction cost.

## GEOTECHNICAL DETAILS

The soil investigation was done in 1977. Hollow core auger and hydraulic rotary methods were used in advancing the bore-holes. There were several obstructions in drilling; it is possible that the presence of concrete or asphalt blocks or car bodies or bricks were the cause. The depth of sanitary landfill varied across the site, with a maximum depth of landfill of about 60 feet. Below the sanitary landfill layer, layers of sand, clay, clayey sand, sandy clay, and gravelly sand were found. The blow counts (N-values) of the sand and clay layers varied from 7 to 66 blows/ft. which indicated that the soils ranged from loose/soft to very dense/hard.

## POSSIBLE REASONS FOR FAILURE

Pile foundation systems: It was not clear whether the piles were installed within the loose sandy layer or within the dense sand layer underneath the layer of solid waste; it is possible that the piles were not long enough. Also, the pipe piles used may not have been the correct size as recommended: the wall thickness may have been smaller. It is also not clear whether the piling contractor used any criteria in installing the piles.

The methane gas collection system: Perhaps the placing of the gas collection system may not have been the right choice. As the solid waste settles down, the differential settlement of the solid waste layer may not have helped the stability of the gas collection system. Partial collapse of the gas collection system due to the breaking of the water main did not help the overall integrity of the system.

The skin friction capacity of the pipe piles: Pile foundations derive their load carrying capacity from the friction between the walls and the soil surrounding them and the tip capacity at the bottom of the piles. If the piles located within a solid waste layer experience a downward pull because of the settling of the organic solid waste layer surrounding them (negative skin friction), the piles are pulled into the soil, thereby causing a settlement of the pile foundation system. Predicting the negative skin friction of the pile system at a landfill site is not possible because of the presence of extraneous materials, such as concrete, bricks, and organic waste material.

Remediation of the foundation systems: One of the internationally well-known remediation companies got the contract. This company installed minipiles bearing on the dense sand around or below 110 ft and the existing pipe piles were cut off just below the floor beams. It is understood that the total remediation cost was more than the original construction cost.

After the remediation was over, the owner sued all the subcontractors to recover the cost of the remediation. Pretrial depositions were taken; and, finally, the case was settled out of court. From an educational point of view, this case study may give students a better understanding of the concepts of pile foundation systems at a landfill site.

### CONCLUSIONS

Several geotechnical principles have been discussed using this case study:

(a) Performance of constructed facilities at any landfill or fill site is unpredictable since there is no sure way of estimating the total and differential settlements, especially when using shallow foundations or poorly designed and constructed deep foundations. (b) It is not possible to estimate the negative skin friction on the pile foundations; ways of minimizing the expected negative skin friction should be explored. (c) Any gas collection system needs to be anchored to some stable supports or such systems need to be designed to be able to withstand large differential settlements. (d) Design-build awards may bring down the costs and may allow some technical innovations in the remediation process. (e) Performance related specifications may also enable the contractors to come with unique solutions for the problems at hand. (f) Students may benefit from the failure case study approach of teaching the foundation courses.

### REFERENCES:

- 1) Author's personal files.
- 2) Loren D. Flick, et al., "Minipile Milestone in Memphis," Civil Engineering, September 1992, p 46-49.