TNRCC REGULATORY GUIDANCE

Municipal Solid Waste Division
RG-282
April 1997

SUBJECT: Soil-Bentonite-Slurry Trench Cutoffs in Solid Waste Land Disposal Site Application

Note: This document is a revision of Technical Guide No. 2, which was produced by the Bureau of Solid Waste Management, Texas Department of Health, when that agency was responsible for regulating municipal solid waste. That function is now the responsibility of the Texas Natural Resource Conservation Commission (TNRCC) Municipal Solid Waste Division. This document differs from Technical Guide No. 2 only in that references to the responsible agency have been updated, typographical errors have been corrected, and a standard TNRCC format has been adopted.

Introduction

The primary use of slurry walls in solid waste disposal is in the prevention of groundwater seepage into excavations, and in preventing seepage of pollutants out of excavations that may contaminate groundwater. Although bentonite-stabilized soil slurry has been used in trench-cutoff walls in the United States for over 50 years, the construction and evaluation methods associated with such projects are being upgraded through continuously changing technology and equipment utilization. In the past, slurry walls evolved primarily from on-site construction with a "cut-and-try" methodology rather than a planned geotechnical approach to evaluation and construction of this system of groundwater protection. The Municipal Solid Waste Division of the Texas Natural Resource Conservation Commission (TNRCC), through its facilities evaluation, groundwater protection, and groundwater monitoring programs and its monitoring of the agency's surveillance and enforcement programs, will review and evaluate such groundwater protection measures utilizing data obtained from the review of available technology and on-site monitoring procedures. This document provides technical guidance on proper slurry-trench construction under current state-of-the-art practices, and is subject to revision by the Municipal Solid Waste Division as conditions and circumstances warrant.

Trench Excavation

General

Prior to undertaking the actual trenching, it is advisable to survey and station the planned alignment of the slurry wall. The stationing should be in 100-foot increments and should be used as primary

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reference during construction and quality control testing. In addition, the elevation of each station should be established and recorded on the station survey stakes so that correlation with boring data may be made during trench excavation.

Clearing of a work area should be completed prior to excavation so that a bulldozer has a working platform in which to mix and blend backfill with trench slurry. As an estimate, the width of the work area should be twice the depth of the trench excavation.

On some sites where the surface conditions are soft and/or wet and where the weight of the equipment digging the slurry trench is greater than the natural surface can support, a working pad or berm should be constructed. This surface pad should be built up and compacted to that height which is needed to support the backhoe or dragline used for trench excavation. This pad is normally about 2 feet in height and may act as the foundation for a future overlying levee once the slurry wall is completed.

Equipment Typically Used for Trenching:

- Backhoe for excavations up to depths of 50 feet
- Dragline for excavations to depths between 60 and 100 feet
- Clam bucket for excavations to depths greater than 50 feet

Important Considerations

- The trench excavation should be at least 24 inches wide, or wider if needed to withstand hydrostatic head or to obtain the equivalent permeability of 3 feet of clay with a coefficient of permeability of 1×10^{-7} cm/sec. A 36-inch width is recommended.
- The key at the trench bottom should penetrate at least 3 feet into a soil whose permeability coefficient equals 1×10^{-7} cm/sec or less.
- A continuous visual inspection of the material excavated at the trench bottom is necessary to assure keying into the required soil. An inadequate key will destroy the effectiveness of a slurry wall.
- The bottom of the trench should be sounded with a weighted tape every 10 to 25 feet of trench length and the soil representative of the bottom sampled for testing. Atterberg limits tests and grain size analysis should be run on a minimum of 5 percent of these samples. The samples tested should be of those which may appear to be questionable CH soil. If all trench samples appear acceptable, then a random sampling should be taken from soils excavated in the key.
- The bottom of the trench can be cleaned with a clam bucket or a backhoe. Air lifting of the bottom is of no benefit unless the material is sand or gravel. Normally, the slurry in the trench bottom is as good as the backfill which will be placed in the trench.

- The trenching operation should maintain an adequate distance ahead of the backfilling operation. This distance of separation should be at least 30 feet from the toe of the backfill slope to the point of excavation. The heel of the backfill slope should be 180 to 300 feet from the excavation in progress depending on the slope of the backfill in the trench. These distances yield a preferred 6 to 10 horizontal to 1 vertical slope on the backfill placement.

- Bentonite slurry level in the excavated trench should not be allowed to drop more than 1 foot from the surface.

- The slurry filled trench should not be allowed to stand open without backfill placement for a period exceeding 24 hours.

- Upon completing the slurry trench construction around the entire perimeter of the site back to the point of origin, an overlap of 20 to 30 feet should be placed into the previously backfilled trench. This overlap guarantees a complete tie at the base by removing the inclined soil at the point of origin thus ensuring the trench key.

Bentonite Slurry

General

The bentonite slurry introduced during trench excavation performs three vital functions. First, it stabilizes the sidewalls of the trench to control the potential for caving. This is achieved through the formation of a filter cake on the sidewall surfaces and by the mass weight of the mud counteracting any stress within the trench walls. Second, the bentonite slurry filter cake penetrates the sidewall soils to a depth determined by the soil density and grain size. This filter cake effectively lowers the coefficient of permeability of the sidewall soils. Third, the bentonite slurry which is placed in the trench during excavation is dipped out of the trench, sluiced with the excavated soil, and replaced in the trench as stabilized backfill.

A detailed explanation of the effect of the filter cake on lowering sidewall permeability can be found in David J. D'Appolonia's paper entitled "Soil-Bentonite Slurry Trench Cutoffs" in the April 1980 *Journal of the Geotechnical Engineering Division of the ASCE*.

Important Considerations

- Only a premium grade of sodium bentonite or equivalent should be used. This bentonite should not contain any of the additives used in oil well drilling.

- The percentage of bentonite used in the slurry mix is usually between 5 percent and 7 percent by weight in clean water. The viscosity of an appropriate percentage of bentonite admix should have a Marsh funnel value of 40 seconds or greater after hydration for a minimum of eight hours.

- The water used for mixing should be of relatively high quality with no more than 500 ppm total dissolved solids (TDS) and a pH = 7 ± 1.0. The use of water

which has greater than 500 ppm TDS will necessitate a 10 percent increase of bentonite to the original 5 to 7 percent. The following is the proper bentonite-to-water relationship depending on the quality of the water used in the mixture.

Bentonite/Water	Water Quality (TDS)
20 lbs/barrel of water	< 500 ppm
22-23 lbs/barrel of water	> 500 ppm

The importance of good-quality water is readily apparent. Therefore, unless the mixing water is from a municipal water supply system, it is necessary that the water be tested prior to use for slurry mixing. The water quality test data should be part of the quality control documentation.

- It is best to have two ponds in which to prepare the bentonite slurry. One pond should be used for mixing, and the second pond should be used for hydration of the slurry. The slurry should hydrate from 8 to 24 hours prior to introduction into the trench. The hydrated slurry should have a Marsh funnel value of 40 seconds or greater. Ponds can be deleted if tests prove mixing in the trench with a high-shear mixer can produce 40 Marsh funnel seconds.

- The unit weight of the bentonite slurry should be checked with an appropriate mud balance, which can be purchased from any large drilling mud supplier.

  Unit weight of bentonite slurry
  Pond = 64.5 to 69 pcf maximum
  Trench = 75 to 85 pcf maximum

  Note: The unit weight of trench slurry should not exceed 85 pcf. If the value is higher, it may cause backfilling problems.

Backfill

General

Once sufficient length of trench is excavated and filled with bentonite slurry, the backfilling should take place. The backfill material is a mixture of the trench spoil and bentonite slurry, or, in special cases when these will not combine into an acceptable low-permeability mixture, the slurry is mixed with an imported select material. Due to the added cost of importing material, it is advisable to design an appropriate mixture with trench-excavated soil and add dry bentonite plus slurry when needed to lower the coefficient of permeability to the required level.

The trench spoil is prepared as backfill by sluicing the soil with the slurry which is bladed with a bulldozer until thoroughly mixed. This mixture is then pushed into the trench at the point at which the backfill rises to the ground surface. At no time during the placement of the backfill material should it be allowed to free fall through the slurry in the trench.

Backfill Placement

Bentonite percentage

The backfill should have at least 1 percent bentonite by weight plus whatever additional bentonite is necessary to obtain an impermeable barrier equivalent of 3 feet of soil whose coefficient of permeability is 1×10^{-7} cm/sec.

The combined slurry and trench spoil mixture should have a slump cone value of 4 to 6 inches. A 4-inch slump is ideal.

When slurry is mixed with trench-excavated soil or select material, the resultant mixture should have the following approximate bentonite percentage of the total mix:

dry soil + slurry (4" slump) = approx. 3 percent bentonite

wet soil + slurry (4" slump) = approx. 1.0 to 1.5 percent bentonite (it is recommended that additional dry bentonite be added in this case during sluicing to increase the total percentage)

Water content of the backfill should be 25 to 35 percent, but may be higher if fines content is high.

Backfill soil characteristics

Backfill should consist of well-graded silty or clayey sands with a minimum of 20 to 30 percent of −200 sieve fraction. The majority of the fine fractions (10^{+} percent) should be plastic. Percentages of clay fractions should be determined by hydrometer analysis.

The minimum plasticity index of the backfill should be 25. This should be determined on the −40 sieve fraction.

Backfill slope

With a slump of 4 to 6 inches, the backfill slope should range from 1:6 to 1:10 (vertical to horizontal distances).

It is important to maintain the above-mentioned slope during backfill placement to avoid a curl front which may encapsulate a slurry pocket in the wall.

Backfill density

It is important that the backfill density be greater than that of the slurry within the trench. This density should be at least 15 pcf heavier than the slurry mix (slurry mix should be approximately 85 pcf or less). It is not necessary to desand slurry unless the slurry density is so great that it will cause a placement problem for backfilling.

Slurry Trench Capping

Once the slurry trench is completed and all quality control tests prove the adequacy of the construction, the surface of the trench should be adequately capped. This capping should be done with uniform-quality cohesive soils under density-controlled conditions. The final compacted cap should be a minimum of 2 feet in thickness and should be properly crowned to drain. The slurry trench is not to be considered completed until this capping is completed. This is necessary for safety reasons and for keeping the trench contaminant-free.

Quality Control Testing

All tests should be referenced by station numbers. The following tests and rates of testing should be considered as minimums. Additional evaluation should be done at the project engineer's discretion.

Trenching

Parameter	**Rate of Testing**	**Acceptable Range**
Bottom sounding	Each 10 to 25 linear feet of trench	Trench design depth
Sample material from bottom key	Visually check each excavated bucket and sample 5% of the bucket loads for Atterberg limits and grain size	PI ≥ 25 −200 percentage ≥ 50

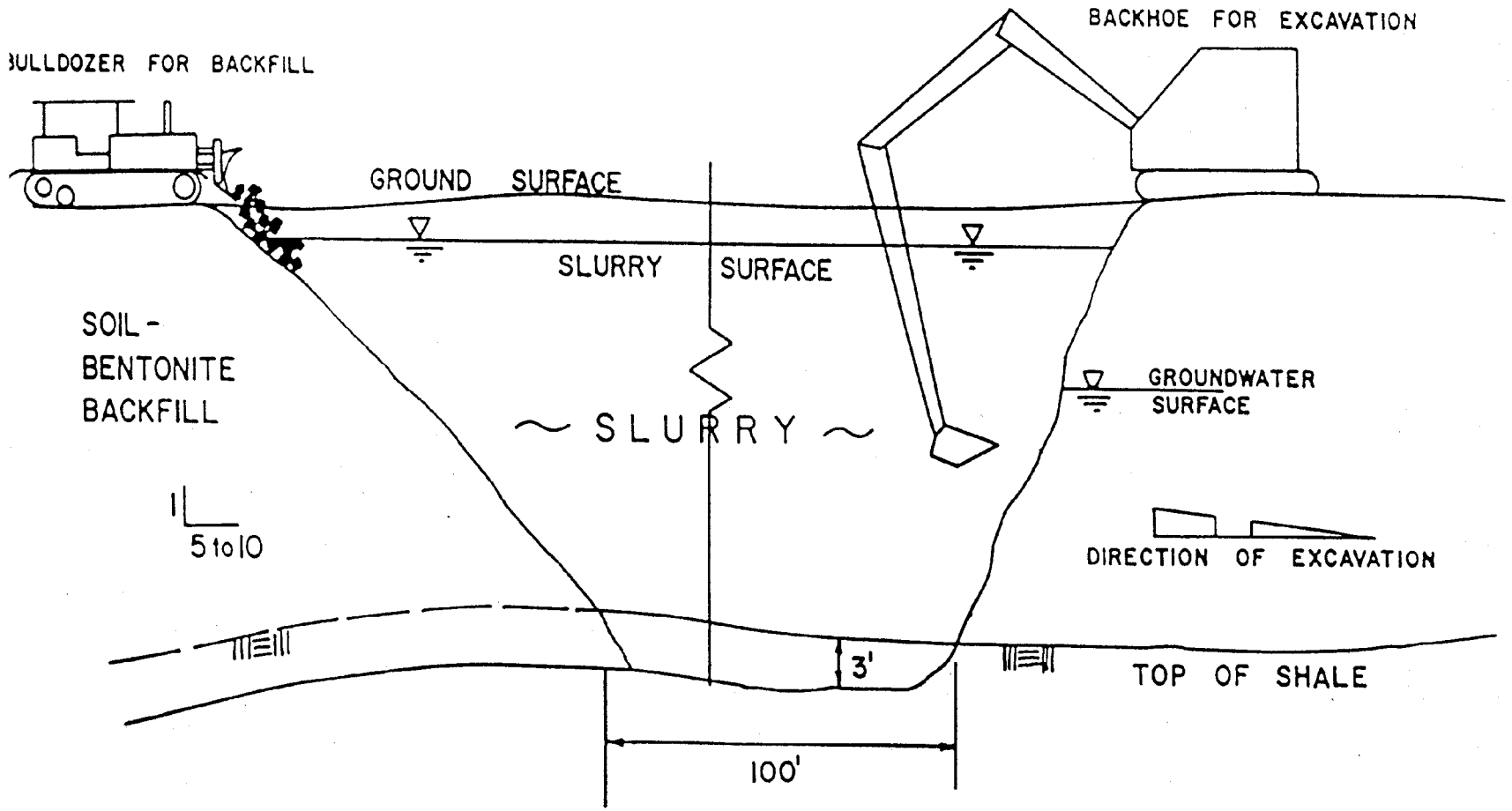
Slurry

Parameter	**Rate of Testing**	**Acceptable Range**
Bentonite	Manufacturer's certificate on each truckload	
Water	pH and TDS—each source	pH 7 ± 1/TDS 500 ppm
Marsh funnel (hydration pond)	Test frequency equal to four times the trench depth or a distance of 200 linear feet whichever is less but should not exceed a lapsed time period greater than four hours, or more often if viscosity is below 40 sec.	40 sec +
Unit weight (trench) with mud balance	Two each at a rate equal to four times the trench depth or a distance of 200 linear feet whichever is less but should not exceed a lapsed time period greater than four hours (one at 3/4 of the depth of the trench and one at 5 feet from the surface of the trench)	85 pcf or less

Backfill

Parameter	**Rate of Testing**	**Acceptable Range**
Slump	One each at a distance equal to twice the depth but not greater than 100 linear feet	4 to 6 inches
Gradation (−200)%	One each at a distance equal to twice the depth but not greater than 100 linear feet of backfill placed	20-30% dry weight
Atterberg limits	One per 100 linear feet of backfilled trench length	PI $\geq$ 25
Coefficient of permeability	Daily or once for each 1,000 cubic yards, whichever is more frequent	1×10^{-7} cm/sec. Note: The combination of backfilled trench width and coefficient of permeability should be equivalent to 3 feet or more of soil with a coefficient of permeability of 1×10^{-7} cm/sec.

SCHEMATIC OF S-B SLURRY WALL CONSTRUCTION



From paper - "Quality Control of Soil - Bentonite Slurry Wall Construction - A Case History"
by Jack S. Haston, P.E. and Glenn C. Goss, P.E.

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