Version 2006

GUIDE
TECHNICAL SPECIFICATIONS
SOIL-CEMENT-BENTONITE
SLURRY TRENCH CUTOFF WALL

{This technical specification is to be used to guide the writer in the contract requirements for Soil-Cement-Bentonite Slurry Wall construction for a specific site. Included are _____ to be filled in with project specific data. Also included are [ ] which denote options to be considered for specific design requirements. Parenthetic remarks { } are included when appropriate to provide the writer with additional, non-essential information.}

1.0 SCOPE OF WORK

This section of the specifications includes requirements for the Slurry Trench Cutoff Wall and related work as indicated on the drawings and as hereinafter specified. The work consists of furnishing all plant, labor, equipment, and materials and of performing all operations as required to construct the slurry trench cutoff wall.

1.1. Reference Standards

The following is a list of standards that will be referenced in this specification. Such referenced standards shall be considered part of these specifications as if fully repeated herein.

REFERENCE	***TITLE OR DESCRIPTION***
API Spec 13A	API Specification for Oil-Well Drilling-Fluid Materials
API RP 13B-1	API Recommended Practice Standard Procedure for Field Testing Water-Based Drilling Fluids
ASTM C 138	Test Method for Unit Weight of Concrete
ASTM C 143	Test Method for Slump of Concrete
ASTM C 150	Standard Specification for Portland Cement
ASTM D 422	Particle-Size Analysis of Soils
ASTM D 1633	Unconfined Compressive Strength of Soil-Cement
ASTM D 1140	Materials Finer than No. 200 Sieve
ASTM D 4318	Liquid Limit, Plastic Limit and Plasticity Index of Soils
ASTM D 4380	Density of Bentonite Slurries
ASTM D 4381	Sand Content by Volume of Bentonite Slurries
ASTM D 4832	Prep and Testing of Controlled Low-Strength Material Test Cylinders
ASTM D 5084	Hydraulic Conductivity Using a Flexible Wall Permeameter

1.2. Abbreviations and Definitions

A. API - American Petroleum Institute

B. ASTM - American Society for Testing and Materials

C. Owner - The Owner as referred to herein is _____.

D. Owner's Representative - The Owner's Representative or the Engineer is _____ (or individuals) designated by the Owner to act on its behalf in the execution of these specifications.

E. Slurry Trench - A narrow, vertical-walled trench of specified width excavated by the slurry trench method and backfilled with specified materials to form a cutoff wall of low permeability. The terms "Slurry Trench" and "Slurry Wall" are used interchangeably in these specifications.

F. Slurry Trench Method - A method of excavating a narrow, vertical trench using a slurry mixture to support the trench walls and prevent movement of groundwater into or through the excavated trench.

G. Water-Bentonite Slurry - A stable colloidal suspension of powdered bentonite in water. The terms "slurry" and "water-bentonite slurry" are used interchangeably in these specifications.

H. Cement Slurry (Cement Grout) – A colloidal mixture of Portland cement Type I or Type II (per ASTM C 150) and water and other suitable admixtures approved by the Engineer.

I. Soil-Cement-Bentonite (SCB) Backfill - A homogeneous mixture of specified soil material, bentonite, cement and water. The terms "soil-cement-bentonite backfill" and "backfill" are used interchangeably in these specifications.

J. Slurry Trench Specialist - An individual who has had proven and successful experience in slurry trench construction and is knowledgeable of: (1) the proper methods employed to mix slurry and backfill, (2) the use, testing and control of bentonite as a slurry, (3) construction equipment, (4) excavation and backfill operations, and (5) testing for slurry trench quality control.

K. Working Platform - The working platform is the surface of compacted fill and/or excavated surface from which the slurry wall is constructed.

1.3. Submittals

The following information shall be submitted at least [4 weeks] prior to construction.

1.3.1. Qualifications of Contractor

The Contractor, his subcontractor or his consulting advisor, shall submit evidence that he is experienced and competent to construct a soil-cement-bentonite slurry trench. The slurry trench company shall have at least five years of prior experience in contracting slurry walls, with at least five SCB slurry walls of similar scope and magnitude. This evidence will insure that the Contractor will have sufficient competent experienced personnel to carry out the operations specified.

In particular, a slurry trench specialist shall supervise the construction, slurry preparation, and quality control. The slurry trench specialist shall have at least [five] years of experience and/or [five projects] in successful construction of slurry walls, with at least two SCB slurry walls of similar scope and magnitude.

[The company name, key contact, and qualifications of the Contractor's off-site laboratory shall be submitted. The laboratory will have previous experience with slurry wall backfill materials, experienced laboratory technicians, and flexible wall permeability testing equipment.]

1.3.2. Work Plan

The Contractor shall submit a detailed operating plan describing his proposed construction equipment, procedures, and schedules. This shall include, but not be limited to, the Contractor's plan for:

A. Coordinating the construction, maintenance and removal of working platforms, mixing pads, and haul roads with the Owner, general contractor or other contractors on site.

B. Equipment set-up and site use layout including storage areas, haul roads and work platform dimensions.

C. Equipment specifications including: maximum depth capability of excavator; number and type of backfill mixing equipment; and specifications of slurry mixing equipment.

D. Procedure for water-bentonite slurry mixing, transportation and use.

E. Procedure for water-cement slurry mixing, transportation and use.

F. Procedure for trench excavation and backfilling.

G. Material properties, sources, and (manufacturer's) certificates of quality.

H. Control of drainage, spills, wastes, etc.

I. Clean-up, spoils disposal, slurry disposal

1.3.3. Quality Control Plan

The Contractor shall submit a quality control plan with details on personnel, responsibilities, inspections, and organization for insuring the quality of construction required by these specifications. The plan shall provide a table listing testing methods, frequencies, and minimum acceptable values. The plan shall explain the methods and locations for obtaining samples for testing and reporting schedules. Copies of quality control forms shall be submitted for review and approval.

1.3.4. Bar Chart Schedule and Sequence of Operations

The Contractor shall submit a detailed schedule and sequence of operations in a bar chart format. The submittal shall include a description of the schedule including typical working hours and days; sequence of operations; and maintenance schedule.

[1.3.5. Design Mix]

{This section would be included if a pre-construction laboratory design mix program is required to determine appropriate materials and material proportions for the required slurry wall performance. In the case of contaminated sites, a compatibility-testing program may also be required.}

{The following specific information shall be submitted prior to the start of slurry wall construction:}

A. [Sampling Plan. A description of the methods and locations of all samples used in the design mix testing.] {Generally, test borings and/or test pits are used to obtain soils samples.} Mixing water, [groundwater or leachate,] bentonite clay, and borrow soils (if needed) should also be obtained and tested.]

B. [Compatibility testing program report, including the results of chemical desiccation test, filter cake permeability tests, and sedimentation/flocculation tests. The successful bentonite clay shall be subjected to long-term permeability tests with the leachate. {Note: long-term test may require one or two months to complete}]

C. [Laboratory soil-cement-bentonite design mix and trial mix reports, including proportions, density, bentonite content, cement content, unconfined compressive strength, moisture content, gradations, [Atterberg limits,] and hydraulic conductivity on at least four [8] samples of the proposed design mix. {Note: laboratory testing may require four to six weeks to complete, or more depending on the number and complexity of tests required.}]

D. [Source and properties of all materials (water, bentonite, cement, on site soils, borrow soils, and any admixtures.)]

{Due to the time and uncertainty in laboratory testing, it is often advised that the owner or Engineer subcontract this work to an experienced slurry wall technical advisor early in the project schedule to avoid delays and uncertainty in construction.}

1.4 Reports

The following information shall be submitted to the Engineer on a regular schedule during the progress of the work. Daily reports shall be submitted by [noon of the day following the date of

the report]. Laboratory test results shall be submitted within [2 days] of receipt of the report from the laboratory. Final reports shall be submitted within [two to four weeks] of the completion of work.

1.4.1. Soundings and As-Built Profile

A record of sounds taken during construction including the depth of the trench, key, and backfill slope obtained each morning and evening. The soundings shall be used to generate an as-built profile of the trench, as constructed.

1.4.2. Fresh Bentonite Slurry Mix

A record of plant-mixed bentonite slurry quantities, proportions, properties, and admixtures made during construction. Adjustments to the slurry mixture shall be noted.

1.4.3. Trench Bentonite Slurry Mix

A record of in-trench bentonite slurry properties made during construction. Procedures and admixtures used to modify slurry properties shall be noted.

1.4.4. Cement Slurry Mix (or Cement Addition)

If the cement addition is in the form of slurry, the slurry proportions and mixing procedures shall be recorded. If cement is added in another form (dry powder, cement paste or other) the cement proportions shall be recorded.

1.4.4. SCB Backfill Mix

A record of SB backfill material quantities, properties, and mix adjustments made during construction. Location of sample and number of molded specimens for laboratory testing shall be noted.

1.4.5. Quality Control Data

A record of quality control samples, tests and test results.

2.0 MATERIALS

2.1. Bentonite Slurry

Bentonite slurry shall consist of a stable colloidal suspension of bentonite in water and shall be controlled in accordance with the most current API Recommended Practice 13B-1, and the following requirements:

> **A**. At the time of introduction of the slurry into the trench, the slurry shall be a mixture of not less than [5%] bentonite in water. Additional bentonite or admixtures may be required depending on the hardness and temperature of the water and the quality of the bentonite. The slurry shall have a minimum apparent viscosity of [40] seconds reading through a Marsh Funnel Viscometer, a pH between 6 and 10 units, a minimum density of 64 pcf, (1.03 gm/cc) and a filtrate loss of [25] cubic centimeters in 30 minutes at 100 psi.

B. The slurry mixture in the trench shall have a unit weight not less than [64] pcf (1.03 gm/cc), not greater than [85] pcf (1.36/gm/cc) or 15 pcf less than the backfill unit weight, or as approved by the Engineer.

2.2. Bentonite

Bentonite used in preparing slurry shall be pulverized (powder or granular) premium grade sodium-cation montmorillonite and shall meet the most current API Standard 13A, Section 4. The yield of the bentonite shall be [90] barrels per ton.

2.3. Cement

Cement shall be Portland Type I or Type II (per ASTM C 150). Cement additives and/or replacements may include fly ash (per ASTM XXX) and ground granular blast furnace slag (per ASTM C 989) and any other cementitious additives which produce acceptable material properties and are accepted by the Engineer.

2.3. Water

Fresh water, free of excessive amounts of deleterious substances that adversely affect the properties of the slurry shall be used to manufacturer bentonite slurry. It is the responsibility of the Contractor that the slurry resulting from the water shall always meet the standards of this specification.

2.4. Additives

Admixtures of the type used in the control of oil-field or concrete slurries such as softening agents, dispersants, and retarder, plugging or bridging agents may be added to the water or slurries to permit efficient use of materials and proper workability. The Engineer shall be advised of all additives used.

2.5. SCB Backfill

The material for trench backfilling shall be composed of fresh slurry, trench slurry, cement {or cement slurry} and selected soils obtained from a designated borrow area and/or trench spoils. Trench slurry may be disallowed if additives are not acceptable to the Engineer. The soil shall be friable and free from roots, organic matter, refuse, or other deleterious materials. The backfill shall be thoroughly mixed and reasonably well graded between the following gradation limits:

Screen Size	**Percent Passing**
(U.S. Standard)	**By Dry Weight**
3”	[100%]
No. 200	[>20%]

The permeability of the backfill shall be less than [$1x10^{-6}$ or 5×10^{-7}] cm/sec. The slump of the backfill shall be [5 to 8] inches, and the density of the backfill shall be at least 15 pcf greater than the density of the slurry. {NOTE: Backfill design should accommodate, if possible, the trench spoil and/or local soils. Dry bentonite and/or cry cement may be added to reduce permeability, make poor soils acceptable, or to reduce slump of wet mixes. In general, slurry addition is more workable and successful than dry addition.}

3.0 SLURRY TRENCH CUTOFF

A slurry trench cutoff wall shall be constructed to the lines, grades, and cross sections indicated on the drawings. The trench shall have essentially vertical walls, a minimum width of [30] inches, and shall extend through the overburden and key a minimum depth of [3] ft into the designated stratum. In the event of the refusal of the excavating equipment in the key at a depth of less than [3] feet, the Engineer may approve a lesser key A generalized description of the soil profile through which the slurry trench cutoff is to be constructed is provided on the boring logs attached to this specification.

3.1. Tolerances

The following tolerances shall apply to the slurry trench dimensions and construction.

A. The slurry trench shall be essentially vertical. The working platform and/or excavating equipment may be leveled to be plumb with [3%] of vertical.

B. The depth of the slurry trench shall be measured or surveyed to within [6 inches] of the desired elevation.

C. The excavating tool shall be at least as wide as the design width of the slurry trench.

D. The slurry trench shall follow the designed alignment within [2] ft of the centerline. The slurry trench may vary from the designed alignment {e.g. at corners or turns} if approved by the Engineer.

E. Construction will not be permitted when the air temperature is below [20ºF] or when severe weather conditions may compromise the quality of the work.

F. Overlaps and changes in direction of the slurry trench shall require an over excavation at least [5 ft] beyond the centerline of the trench. In cases where the trench must be re-excavated (for example, due to an extended shutdown, cave-in, rework, etc.) the overlap into acceptable backfill shall be at least [10 ft].

4.0 EQUIPMENT

4.1. Trench Excavation

Excavation of the slurry trench cutoff wall shall be accomplished by use of any suitable earth-moving equipment, or combination thereof, such as a backhoe, clamshell, chisels, and ripper teeth so the trench can be carried to its final depth of cut continuously along the trench alignment. The excavator shall have the capability to excavate at least [2 to 5] ft deeper than the maximum depth shown on the plans. Special chopping, chiseling or other suitable equipment may be used as necessary to satisfactorily accomplish the required excavation. The width of the excavating tool shall be equal to or greater than the specified minimum width of the slurry trench. Additional equipment such as airlift pumps and slurry desanders shall be used, if required, to clean the trench bottom slurry in accordance with the requirements of the specification. The trench excavation equipment shall be capable of excavating the required key into the designated stratum.

4.2. Slurry Batching Plant(s)

The slurry batching plant shall include the necessary equipment including a high shear mixer capable of producing a colloidal suspension of bentonite [and/or cement] in water, pumps, valves, hoes, supply lines, and all other equipment as required to adequately supply slurry to the trench and/or the backfill mixing operation. Storage ponds [or tanks] shall be provided [as needed] to store initially mixed slurry to allow hydration, and to retain a reserve in case substantial slurry loss through underlying previous zones occurs. All slurry held in storage shall be agitated or recirculated to maintain a homogeneous mix. All slurry for use in the trench or backfill shall be prepared using a suitable mixer. No slurry is to be made in the trench. Mixing of water and bentonite [and/or cement] shall continue until all particles are fully hydrated and the resulting slurry is homogeneous.

4.3. Backfill Mixing and Placing

Equipment for mixing and placing backfill may consist of any suitable earthmoving or grading equipment, such as bulldozers, or blade graders or backhoes, or blenders such as a pug mill, that are capable of thoroughly mixing the backfill materials into a homogeneous blend having the required gradation and properties and placing the material in the trench as specified. Soil clods shall be broken to [4 to 6] inch maximum size by the backfill preparation equipment and methods employed. Deleterious materials and debris, oversize particles, shall be removed from the backfill before approval for placement.

5.0 EXECUTION OF THE WORK

5.1. Slurry Trenching

Excavation shall proceed continuously from the starting point to the finishing point. Slurry shall be introduced into the trench at the time trenching begins and shall be maintained in the trench during excavation and until backfilled. The Contractor shall maintain the stability of the excavated trench at all times for its full depth. The level of the bentonite slurry shall always be maintained at least [3] ft above groundwater level and shall not be permitted to drop more than [2] ft below the surface of the working platform. The Contractor shall have personnel, equipment, and prepared slurry ready to raise the slurry level at any time. To this end, the Contractor shall have personnel on call as necessary to check the trench levels and to raise the slurry level weekends and/or holidays included.

5.2. Key

Unless otherwise directed, the bottom of the slurry trench will be keyed the minimum specified penetration into the specified stratum indicated. If the backhoe or a clamshell are unable to achieve the minimum specified penetration into weathered rock stratum with the assistance of ripping teeth, or drop chisels, the minimum penetration requirements will be modified and the trench excavation will be terminated at refusal of the excavating equipment. {Note: Typical refusal is less than 3 inches of penetration in 15 minutes of continuous effort with a {[Cat 330 backhoe.]} The depth to the top of the stratum shall be measured after these soils are identified in the excavation spoils. The final depth and key penetration of the trench shall be measured and checked by the Contractor and approved by the Engineer immediately following excavation.

5.3. Cleaning Trench Bottom

Upon completion of excavation, any loose material or cuttings shall be removed from the bottom of the trench with the excavation tools or other suitable means such as air lift pumps. If the unit weight of the slurry in the trench exceeds the specified limits, or becomes unworkable, the heavy

slurry shall be removed from the trench by airlift pump, clamshell, or other methods approved by the Engineer or the excess solids shall be removed from the slurry by settling ponds, screening, or desanding. The trench bottom shall be cleaned of debris and excess sand sediment backfilling. The trench shall be sounded immediately before placing backfill, and soundings shall be compared to the trench excavation soundings to verify the bottom. At a minimum, soundings shall be taken each morning and each evening and compared to monitor for cave-ins or excessive settlement.

5.4. Backfill Mixing

The backfill shall be mixed [beside the trench or in a designated (remote) location] on site. If the backfill is mixed beside the trench, the contractor shall control and provide sufficient equipment and work platform space to support slurry spills, trench stability, and mixing equipment operation. Unmixed materials shall not be allowed to fall into the trench. If the backfill is mixed in a remote location, the contractor shall build and maintain adequate haul roads and the mixing pit or pad. The mixing pit or pad shall be lined with compatible soils or other materials to prevent contamination from unsuitable materials. In either case, the contractor shall be responsible for the quality of the backfill.

Borrow materials and bentonite may be pre-mixed by blending in mechanical blenders or by windrowing, disk harrowing, bulldozing, blading or by other approved methods. Mixing and blending shall be performed in such a manner as to produce the required gradation of backfill. The backfill material shall be thoroughly mixed into a homogeneous mass, free of large soil clods, lumps or pockets of fines, sand, or gravel.

Cement, bentonite, and soils shall be mixed until homogeneous, tested for acceptability {typically slump and proportions}, and then immediately placed in the trench before it can harden or set. SCB shall be mixed in discrete batches not to exceed 50 CY by mixing the ingredients together in lined pits, bermed areas, steel boxes, pugmills, or other suitable container. SCB shall not be mixed in uncontrolled proportions on the ground. Cement may be {in fact it is recommended} pre-mixed with water to form a slurry for mixing with the other ingredients.

The SCB shall be sluiced with bentonite slurry from the trench or fresh bentonite slurry during blending operations. Sluicing with water will not be permitted. Occasional particles of up to [4 to 6] inches in their largest dimensions will be permitted. Just prior to placing, the backfill material shall have a slump of [5 to 8] inches. To this end, the materials shall be shall be sampled and tested for permeability, unconfined compressive strength, density, and slump after preparation. {Note: tests of permeability and UCS must be performed after the SCB has hardened.}

5.5. Backfill Placement

The backfill shall be placed continuously from the beginning of the trench, in the direction of the excavation, to the end of the trench. The toe of the slope of the trench excavation shall precede the toe of the backfill slope so that the toe of the backfill shall not be closer than [20] ft to the toe of the excavation slope, or as required to permit proper cleaning of the trench bottom as approved by the Engineer. Excavation shall not exceed [150] ft from the toe of the backfill. Excavation must permit inspection and measurement immediately after completion and prior to backfilling. Placing operations shall proceed in such fashion that the surface of the backfill below the slurry shall follow a reasonably smooth grade and shall not have hollows, which may trap pockets of slurry during subsequent backfilling. Free dropping of backfill material through the slurry will not be permitted. Initial backfill shall be placed by lowering it to the bottom with clamshell bucket or backhoe until the surface of the backfill rises above the surface of the slurry or by lead-in slope. Additional backfill may then be placed in such manner that the backfill enters the trench by sliding down the forward face of the previously placed backfill. To accomplish this, sufficient backfill shall be piled behind the crest of the existing backfill slope to cause a mud wave

action at the face of the backfill. The backfill shall not be dropped or deposited in any manner that will cause segregation.

The Contractor shall be prepared to remove, displace, or treat cement-bentonite gel that forms in the trench, if it interferes with backfill placement. Toward this end the Contractor shall be prepared to probe through any gel to properly sound the depth of the trench.

An acceptable substitute for the initial placing of backfill by the use of a clamshell bucket may be a lead-in trench. The lead-in trench shall begin at a point outside of the limits of work and provide sufficient distance for the backfill face to form, by placing the backfill into the trench, before the toe of the backfill reaches the point where the cut-off is required. The lead-in trench shall be [1v: 1h] or flatter

6.0 TREATMENT FOR TOP OF BACKFILL

The surface of the backfill shall not be allowed to desiccate prior to placing the final cap. A temporary covering may be used to protect the backfill prior to placing the final cap. Temporary crossings of compacted soil or trench plates shall be used for heavy equipment crossings. The temporary covering shall consist of at least 1 foot of uncompacted backfill placed within [one] day after the SCB backfill is placed. After a minimum of one week, the temporary cover may be removed. Any depressions or settlement shall be repaired by placing additional backfill or the permanent cap.

Upon completion of backfill placement and before desiccation of the backfill surface can occur, the cutoff trench shall be covered in accordance with the final cap details shown on the Drawings.

7.0 CLEAN-UP

After completion of the backfill and capping, all remaining excavated material and slurry shall be removed and the surface shall be cleaned and leveled as directed by the Engineer. Excess slurry shall be disposed by drying, mixing with dry materials or spreading in thin layers on adjacent areas designated by the Engineer. No slurry shall be left in ponds, and all ponds shall be pumped dry and backfilled in a controlled manner.

8.0 QUALITY CONTROL

The Contractor shall maintain his own quality control for the cutoff wall construction under the direction of a qualified geotechnical engineer. Testing requirements are specified herein.

8.1. Trench Continuity and Key

The Contractor shall be responsible for demonstrating to the satisfaction of the Engineer that the trench is continuous and keyed the minimum specified depth into the designated stratum. The Engineer will be available onsite to verify these measurements. Trench continuity shall be assured by the action of movement of the trench excavation equipment such that the digging tools can be passed vertically from top to bottom of the trench as well as moved horizontally along the axis of the trench without encountering unexcavated material. Penetration of the bottom of the trench into the aquiclude shall be demonstrated at [10 to 20] ft. centers by observation of the excavation spoils from the trench and by direct measurement of the top of the designated stratum and the final excavated trench depth to the satisfaction of the Engineer.

8.2 Materials

A. Bentonite: Manufacture's Certificate of Compliance with the API specification shall be obtained from the manufacturer for each shipment of bentonite delivered to the site.

B. Cement: Manufacture's Certificate of Compliance with the ASTM specification shall be obtained from the manufacturer for each lot of cement delivered to the site.

C. Water: Water for slurry mixing shall be tested once each [change in water source].

D. Prepared Backfill: Soil-cement-bentonite backfill shall be tested prior to placement in the trench by conducting tests to determine slump and density. Laboratory testing of the backfill for unconfined compressive strength and permeability shall be conducted [once for every 2000 cy] of backfill mixed. Permeability testing shall be performed to verify the prepared material meets specification. Permeability and strength determinations may follow placement.

E. Fresh Slurry: A complete series of tests shall be conducted from the mixer or tank containing fresh slurry ready for introduction in the trench at least twice per shift.

F. Trench Slurry: Slurry in the trench shall be tested at least twice per shift. Samples shall be obtained from [the mid-depth] of the trench near the excavator.

8.3. Soundings

Soundings shall be taken every [10 to 20] ft along the trench centerline using a weighted tape, cable or other device. Soundings shall be recorded to the nearest 0.5 ft. Soundings shall record the following:

A. Top of Key Stratum: The top elevation of the key stratum shall be determined based on an examination of cuttings taken during excavation.

B. Bottom of Excavation: The elevation of the trench shall be determined subject to approval by the Engineer.

C. Bottom of Excavation Prior to Backfilling; Soundings shall be used to monitor for sidewall collapse and accumulation of sediments.

D. Profile of Backfill Slope: The SB backfill slope and trench bottom shall be sounded at the beginning and end of each shift and converted to an as-built drawing. This drawing shall be reviewed daily as an indication of trench collapse, excessive settlement or sloughing.

8.4 Quality Control Testing Equipment

A. The field laboratory shall be equipment with the following equipment, at a minimum:

1.Marsh funnel and cup – 2 sets

2.Mud balance – 2 sets

3.Sounding cable – 2 sets

4.pH tape – 1 set

5.Standard Filter Press w/ graduate cylinder – 1 set

6.Slump cone and rod – 1 set

[**7**.Sand content kit – 1 set]

[**8**.Standard #200 sieve with hot plate (or microwave oven) and balance – 1 set]

[**9**.Modified Filter Press for on-site permeability test – 1 set]

B. A qualified off-site laboratory shall be engaged to perform the tests listed below. Samples shall be delivered to the laboratory on an expedited schedule and test results shall be reported the same week as the samples are received.

1. Permeability of SB backfill by ASTM D5084

2. Grainsize of SB backfill by ASTM D422.]

8.5. Permeability Measurements

Flexible wall permeability tests shall be conducted on samples of the backfill to determine compliance with these specifications. Samples of the SB backfill shall be obtained [from the mixing area] and sent to the off site laboratory for testing. The test parameters shall be as follows:

A. Average Effective Confining Stress = [15] psi.

B. Hydraulic Gradient = [<30]

C. Permeate = [site groundwater]

[Permeability tests may also be performed on site, using an approved fixed wall apparatus. The fixed wall test is a filter press modified to operate at 1 to 10 psi. Test results from the fixed wall test must be reduced by a factor to be equivalent to flexible wall tests. The fixed wall tests must be compared to flexible wall tests performed during the pre-construction design mix to determine appropriate testing time and test parameters as well the reduction factor. Fixed wall tests may be performed except that for every 5 fixed wall tests, at least one flexible wall test shall be performed.]

8.6. Documentation

Results of all tests performed shall be recorded on forms acceptable to the Engineer and signed by the Slurry Trench Specialist. These forms will be available to the Engineer at all times for his inspection. Copies of all quality control documents will be submitted daily to the Engineer for his verification.

An as-built profile drawing of the trench bottom and backfill slope shall be continuously maintained by the Contractor. The profile shall indicate the extent of excavation and backfill at the end of each working day. The daily profile shall be drawn in an electronic (EXCEL) format or by hand, as directed by the Engineer.

9.0 MEASUREMENT AND PAYMENT

Payment for the slurry trench shall be made at the contract price per square foot of slurry wall. Such price shall include all costs for the construction and completion of the slurry wall. No separate payment will be made for materials, equipment, slurry, records or quality control. Final acceptance of the slurry wall will be based on meeting all the requirements for the slurry wall dimensions, bentonite slurry, and permeability of the SB backfill.

Measurement for the slurry wall shall be based on the area in square feet of the completed slurry wall measured in a vertical plan through the centerline of the slurry trench from the top of work platform to the bottom of the excavated trench. Measurements shall be based on surveys and soundings taken at the site as directed and approved.

Table 1: Soil – Cement – Bentonite Slurry Trench Quality Control Testing Plan

Property	Requirement	Min. Test Frequency	Test Method	Comment
Bentonite Powder				
a. YP/PV Ratio	> 3	1 per truck or RR car	API Spec 13A	Premium Grade Certification
b. Viscometer at 600 rpm	> 30	1 per truck or RR car	API Spec 13A	by Manufacturer
c. Filtrate Loss	< 15 cc	1 per truck or RR car	API Spec 13A	
d. Moisture Content	< 10%	1 per truck or RR car	API Spec 13A	
e. Residue > 75 micrometers	< 4%	1 per truck or RR car	API Spec 13A	
f. Certification	Meets API 13A, Section 9	1 per truck or RR car	Section 9	90 bbl/ton
Water for Slurry Mixing				
a. pH	6 to 8	1 per source	API RP 13B-1	May be modified for potable
b. Hardness	< 100 ppm	1 per source	API RP 13B-1	Source or treated w/ additives
c. Total Dissolved Solids	< 500 ppm	1 per source	EPA 600	
Initial Bentonite Slurry *(Prior to introduction to the trench)*				
a. Viscosity	> 36 seconds	2 per shift	ASTM D-6910	
b. Density	≥ 64 pcf	2 per shift	ASTM D-4380	
c. Filtrate Loss	< 30 cc	2 per shift	API RP 13B-1	
d. Bentonite content	≥ 4%	1 per project	Weight-Volume	Demonstration calculation
In-Trench Bentonite Slurry				
a. Viscosity	> 36 seconds	2 per shift	ASTM D-6910	
b. Unit Weight	> 64 pcf	2 per shift	ASTM D-4380	Also > 15 pcf less than SCB
SCB Backfill Material				
a. Slump Cone	3 to 7 inches	2 per shift	ASTM C-143	
b. Gradation	15 < #200 < 85%	1 per 2,000 cy	ASTM D-1140	Laboratory or Field test
c. Density	15 pcf > In-trench slurry	2 per shift	ASTM C-138 or D-4380 mod	
d. Permeability	< 1 x 10^{-6} cm/sec	1 per 2,000 cy	ASTM D-5084	Laboratory test
e. UCS	≥ 30 psi	1 per 2,000 cy	ASTM D-2166	Laboratory test