TA73

DEPARTMENT OF ENERGY
National Nuclear Security Administration
Los Alamos Site Office
Los Alamos, New Mexico 87544

JUN 0 2 2006

RECEIVED JUN 2006 NMED Hazardous Waste Bureau

ENTERED

Mr. James Bearzi, Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6303

Re: APPROVAL WITH MODIFICATIONS
REMEDY DESIGN WORK PLAN FOR THE TA-73 AIRPORT LANDFILL

Dear Mr. Bearzi:

In compliance with the conditions of NMED's "Notice of Approval with Modifications for the Remedy Design Work Plan (RDWP) for the Airport Landfills", attached are two hard copies and one disk copy of the following documents for review and approval prior to construction:

- Construction Quality Control Plan for the MatCon cover, including procedures for coring and testing.
- The Operation and Maintenance (O&M) Plan for the MatCon cover, including a schedule for inspections. The inspection schedule is also described in the Post-Closure Care and Monitoring Plan (PCMP).
- The draft design and construction plan for the mechanically stabilized earth (MSE) retaining walls (Walls 2-4). This design will be finalized when all NMED comments are incorporated. The design for the lower concrete wall (Wall 1) was submitted with Revision 1.
- The final design for the hangar pads, provided as Drawing 3003 in the tabbed section titled "Revised Drawings".

The final design for the MatCon cover was already provided in the drawings and specifications provided with RDWP Revision 1. Several MatCon aggregate-binder mixture formulations are undergoing hydraulic conductivity testing and a final mix design will be selected when results are complete. We will forward the mix design and test results to you upon receipt, which is expected within one week.

Sincerely,

for

David R. Gregory, P.E.
Federal Project Director

ES: 2BE-020

Attachments

cc w/o attachments:
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Contractor Quality Control Program Plan
LANL Airport Landfill Project

Prepared by:

Wilder Construction Company
1525 East Marine View Drive
Everett, WA 98221

April 2006

WILDER
WILDER CONSTRUCTION COMPANY

"This Contractor Quality Control Program Plan for MatCon™ Impermeable Asphalt, furnished by Wilder Construction Company (Wilder) of Everett, WA, including all text, tables, and forms, shall not be published, duplicated, used or disclosed in whole or in part for any purpose other than to evaluate MatCon for a specific site application or to manufacture and install MatCon™ for the specific project for which this specification has been submitted. Information contained in this document is strictly confidential and the proprietary property of Wilder. Any breach in this restriction will result in significant and substantial material loss to Wilder. The information subject to this restriction is contained on all sheets of this document."

CONTENTS

1. Contractor Quality Control Program Overview 4

1.1 Organization, Authority, and Responsibility 4

1.2 Definable Features of Work 6

2. Matcon Hma 6

2.1 Transportation of MatCon HMA 6

2.2 HMA Placement Equipment, Methods and Production 6

2.3 Compaction of MatCon HMA 6

2.4 Test Pad 7

2.5 Joints 7

2.6 Hydraulic Conductivity Testing 7

2.6.1 Methods 7
2.6.2 Chain of Custody 7

2.7 Finished Grades and Smoothness 8

3. Aggregate Base Course 8

3.1 Materials 8

3.2 Construction 8

3.3 Sampling 8

3.4 Testing 9

3.4.1 Aggregates 9
3.4.2 Smoothness Tests 9
3.4.3 Field Density Tests 9
3.4.4 Laboratory Density Tests 9
3.4.5 Thickness Tests 9

3.5 Maintenance 9

4. HMA Facility Quality Control 9

4.1 Overview 9

4.1.1 Mix-Design 9
4.1.2 MatCon Hot-Mix Asphalt (HMA) Facility 10

4.2 Area Specific Quality Control Measures 10

4.2.1 Mix-design 10
4.2.2 Hot-Mix Asphalt Facility (HMAF) 11
4.2.3 Protocols 12

4.3 Responsibilities and Authority for QC Related Corrective Action 15

4.4 Project Reporting 15

Attachment A—Guide Specifications

Attachment B—Forms

FIGURES

Figure 1. Wilder Construction Quality Control Organization Chart for Installation of MatCon® Cover 5

TABLES

Table 1. Sample and Testing Matrix Table, Hot-Mix Asphalt Facility. 12

Table 2. Summary of QC/QA Testing and Evaluation Procedures 13

1. CONTRACTOR QUALITY CONTROL PROGRAM OVERVIEW

As with any essential engineering structure the need to produce a consistent high quality product is of vital importance to ensure the longevity of the product and to meet technical and functional requirements. Wilder has long emphasized the need for stringent quality control (QC) in achieving these objectives and with MatCon structures quality is stressed in all phases of the creation of the product. To this aim Wilder has developed detailed quality procedures. This MatCon Quality Control Plan describes those procedures in the context of existing LANL Airport Landfill project plans, design drawings and specifications.

Section 1.1 of this Plan describes the project organization and lines of authority for construction of the MatCon cover. Roles and responsibilities of MatCon Construction Quality Control (CQC) personnel are defined in the context of the existing LANL Airport Landfill Project Management Plan (PMP) (NWI 2006a) and the overall project Construction Quality Control Plan (NWI 2006b). Section 1.2 describes the definable features of work addressed by this plan.

Section 2 describes technical requirements and QC measures for transporting, placing and compacting MatCon asphalt; including construction, sampling and testing of test pads. Section 3 describes QC measures for constructing the aggregate base course to ensure an adequate subgrade for the MatCon asphalt. Section 4 describes QC measures to be implemented during MatCon production at the hot mix asphalt (HMA) mixing plant.

Appendix A- "Guide Specifications for MatCon Impermeable Asphalt" describes materials and methods for preparing MatCon hot mix asphalt at the mixing plant. Appendix B-"QC Forms" provides forms and checklists to be used throughout construction of the aggregate base, production of MatCon hot mix asphalt, and placement and compaction of the MatCon surface.

1.1 Organization, Authority, and Responsibility

Wilder Construction is a Subcontractor to North Wind, Inc ("the Contractor"), for the LANL TA-73 Airport Landfill project. The PMP (NWI 2006a) prepared for the LANL TA-73 Airport Landfill project identifies roles and responsibilities for project personnel including subcontractors. Figure 1 shows the subtier organization chart for Wilder Construction and it's subcontractors. All MatCon QC functions will be coordinated with and reported to the Construction Quality Control System Manager (CQCSM) through the MatCon Technical Lead. All project personnel will support implementation of the CQCP (NWI 2006b) including the three-phase CQC program.

Wilder Construction staff assignments for MatCon cover installation CQC include Mr. Jerry Thayer and Dr. Ron Terrell. Mr. Thayer will serve as MatCon Technical Lead. The MatCon Technical Lead will communicate any QC issues to the CQCSM and will support implementation of the CQCP (NWI 2006b) including the three-phase CQC program. All MatCon CQC submittals and reports shall be managed by the Contractor as directed in the CQCP (NWI 2006b) with the cooperation of the Wilder Technical Lead. Dr. Terrell will provide QC oversight of the MatCon binder production and the production facility, and will record and document information necessary to ensure that MatCon binder is produced in accordance with the specifications.

Wilder Construction Company
Quality Control Organization Chart

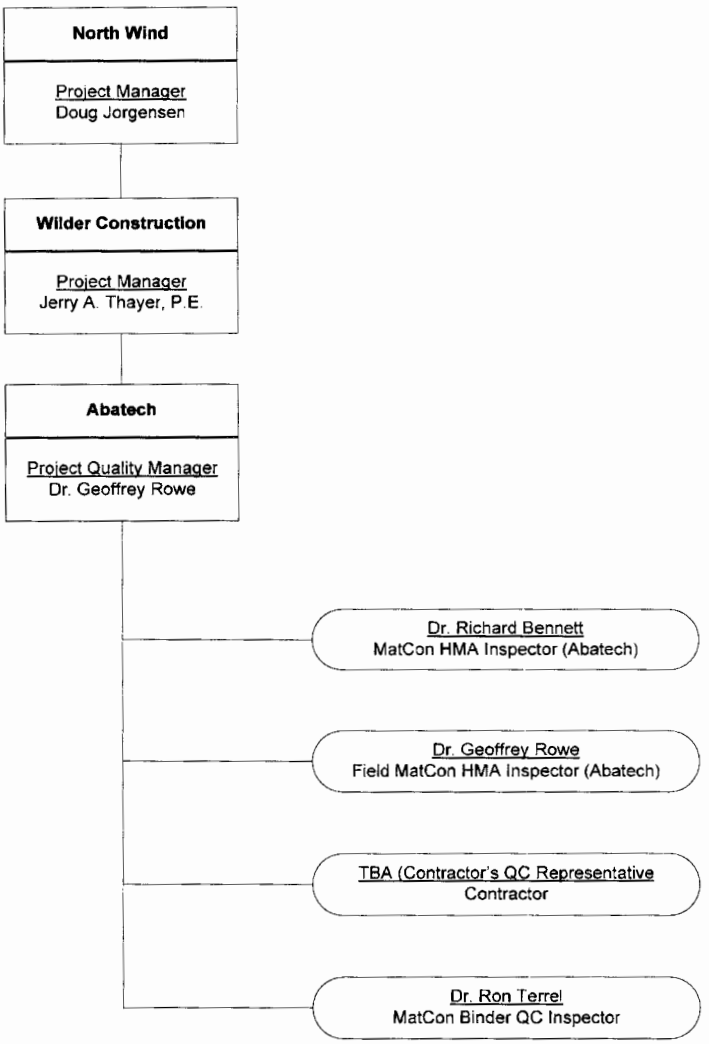

Figure 1. Wilder Construction Quality Control Organization Chart for Installation of MatCon® Cover.

Wilder subcontracts other QC and oversight functions to Abatech Inc., an independent firm of professional engineers specializing in asphalt systems, to verify that all MatCon QC directives have been achieved for a given site. Abatech staff members for this project as identified on the organization chart are Dr. Geoffrey M. Rowe and Dr. Richard A. Bennett. Dr. Rowe will manage QC activities for MatCon installation, reporting on a day to day basis to Mr. Thayer. Dr. Bennett will serve as MatCon hot mix asphalt (HMA) field inspector and will be responsible to inspect the HMA facility's testing methods that will be performed in accordance with the contract specification. Alternatively, the Technical Lead may serve as the MatCon hot mix asphalt (HMA) field inspector. The MatCon HMA Inspector and the MatCon Binder QC Inspector will all report to the MatCon Technical Lead. The detailed quality plan for the MatCon product is given in Appendix A - Quality Control Plan for MatCon Installation.

1.2 Definable Features of Work

Definable Features of Work (DFOWs) as identified in NWI (2006b) addressed under this plan include installation of the aggregate base course, as part of "Installation of gas venting system"; and "Installation of MatCon cover." Quality requirements for these DFOWs not otherwise addressed under NWI (2006b) are addressed herein.

2. MATCON HMA

This section describes technical requirements and QC measures for transporting, placing and compacting MatCon asphalt.

2.1 Transportation of MatCon HMA

The MatCon HMA will be transported from the asphalt plant (assumed to be Cook's Espanola Transit Mix's Associated plant facility in Santa Fe, NM) with covered trucks. The beds of these trucks will be coated with an approved citrus release agent to prevent the HMA from adhering to the truck bodies. Excessive release agent will be drained prior to loading. Tarps will be used to cover the load in order to protect the HMA from weather and help to prevent heat loss during transport. Loads that have crusts of cold, unworkable material or that have become wet will be rejected.

2.2 HMA Placement Equipment, Methods and Production

The following equipment will be utilized to place, compact and finish the MatCon HMA:

- 1-each, Paving Machine, to be inspected and approved by Wilder
- 2-each, 10-12 Ton Vibratory, Smooth Drum Roller
- 2-each, 10 Ton Rubber Tired, Pneumatic Rollers
- 1-each, 3 Ton Vibratory, Smooth Drum Roller
- 1-each, Hand Guided Vibratory Plate Compactor.

A back-up paving machine will be on standby and available to be used on the project in the case that the primary paving machine experiences equipment failure. The MatCon HMA will be dumped from the trucks into the paving machine. Excess material behind the paver will be removed and placed back in the paver or hopper or removed from the site. Broadcasting the material onto the mat will not be permitted.

The paving contractor (ETM or Parker) anticipates average placement of approximately 1,200 to 1,300 tons of MatCon HMA within a nine (9)-hour work period, excluding time for jobsite set-up and cold joint grinding.

2.3 Compaction of MatCon HMA

Compaction efforts will begin as soon as the HMA will support a roller without undue displacement. It is estimated, based on the approved HMA Mix Design that the ideal compaction temperature range is from 175 to 180°C. Compaction efforts shall continue until the mat has a total air voids content of 3% or lower. Areas that are inaccessible to rollers shall be thoroughly compacted with the use of hand operated vibratory plates.

2.4 Test Pad

Prior to full production HMA placement, the paving contractor will construct a test pad at a representative area at the LANL TA-73 airport landfill, between 1,000 and 3,000 square feet in size, to verify that the project's specifications can and will be achieved. The test pad will be constructed using full-scale paving equipment, and will be cored and tested for hydraulic conductivity as described in Section 2.6. Full-scale production will not proceed until laboratory results are achieved; or alternatively work can proceed at risk, with any material placed prior to subsequent failing results for hydraulic conductivity testing (Ksat< 1E-08 cm/sec) removed and replaced after attainment of passing results. During construction of the test pad a rolling pattern will be established that can achieve the prescribed compaction requirements.

2.5 Joints

Cold joints will be minimized by paving in an organized fashion around the site, always tying into previously placed mats. At the end of each shift of paving, the cold joint will be cut back a minimum of one (1) foot with a cold planer to create a smooth, clean edge to tie into with the next day's paving. Dust, sand, or other objectionable material will be cleaned from the joint and it will be coated with CRS-1 type tack prior to placing MatCon HMA adjacent to the joint.

2.6 Hydraulic Conductivity Testing

MatCon HMA core samples will be taken from the compacted and finished surface cover at a frequency of one per 40,000 square feet of asphalt placed. Samples will be taken from the compacted and finished test pad at a frequency of one per 1,000 square feet, with at least three core samples collected from the pad. Samples shall be taken in a manner that represents the entire paving area. All core samples shall be tested for density and hydraulic conductivity in accordance with ASTM D 5084.

2.6.1 Methods

Core sampling will be conducted in accordance with ASTM D 5361, "Standard Practice for Sampling Compacted Bituminous Mixtures for Laboratory Testing". The geotechnical testing laboratory (GTL) as identified in NWI (2006b) will perform the sampling, sample handling, shipping and testing. Sample handling will be in accordance with ASTM D 5079 for labeling, packaging and chain of custody. Core holes will be filled in accordance with the MatCon Guide Specifications, Attachment A.

2.6.2 Chain of Custody

Samples will be collected and handled in accordance with ASTM D4840-99(2004), "Standard Guide for Sampling Chain-of-Custody Procedures". These procedures are intended to document sample possession during each stage of a sample's life cycle, that is, during collection, shipment, storage, and the process of analysis.

Chain of custody will be documented on chain of custody forms. Chain of custody forms and procedures will be submitted by the paving subcontractor or testing laboratory for approval by North Wind at least 14 days prior to sampling.

2.7 Finished Grades and Smoothness

Within five (5) days of the completion of placing the MatCon HMA, the paving contractor will test for conformance with the specified plan-grades and smoothness requirements. The Contracting Officer will be informed of the results of these tests, in writing, within these five (5) days.

The finish elevations at the peaks, ridges and valleys of the asphalt concrete cap may not be within the specified tolerances of plan-grades. These areas will be "rounded" to accommodate practical construction methods, and still provide for positive drainage and the minimum specified thickness of both the aggregate base rock and the asphalt concrete. The paving contractor will perform a water test in the presence of the Contracting Officer to verify that positive drainage has, in fact, been achieved.

3. AGGREGATE BASE COURSE

The aggregate base course shall comply with the provisions of U.S. Army Corps of Engineers Specification Section 02722, "Aggregate Base Course," modified as necessary for use at the airport landfill. Any modifications will be recorded as a field change. The Contractor will accept the compaction and grading of the sub-base soils before beginning placement of base coarse material. Prior to placement of MatCon HMA, the Contractor shall certify that the aggregate base course is compacted and graded to the specified compaction and tolerances, respectively. In addition, prior to the placement of HMA, the base course surface will be cleaned of any foreign or objectionable material with power or hand brooms.

3.1 Materials

Base course aggregates shall consist of durable and sound crushed gravel, crushed stone or crushed slag, free of lumps or balls of clay or other objectionable matter. Base course material composition shall be as described Section 02722.

3.2 Construction

The graded aggregate base course shall be constructed on the prepared subgrade as indicated on the drawings. Completed areas will be protected against detrimental effects and will be reconditioned, reshaped and recompacted as necessary. Material will not be deposited into piles during placing operations. Compacted course 6 inches in thickness will be placed in 6 inch lifts. Material water content will be maintained during placing to obtain specified compaction. Achieve specified compaction with steel-faced, vibrating or pneumatic-tired rollers.

3.3 Sampling

Prior to production and delivery of aggregates, at least one sample will be collected in accordance with ASTM D 75. Each sample will be collected by taking three incremental samples at random from the source material to make a composite sample of at least 50 pounds. Sampling will be repeated when source material is changed or when unacceptable deficiencies or variations from specified grading of materials are found in testing.

During construction, one random sample from each 1,000 tons of completed course material will be collected in accordance with ASTM D 75. Each sample will be placed in a clean container and properly labeled to identify sampler, sample location, date and project number.

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3.4 Testing

3.4.1 Aggregates

Each sample will be tested for gradation in accordance with ASTM C 136. Sieve analysis on material passing the No. 200 sieve will be performed in accordance with ASTM C 117.

3.4.2 Smoothness Tests

Smoothness will be determined suing a 10-foot straightedge, applied parallel with and at right angles to the center line of prepared area. Deviations will be corrected in excess of ½ inch by loosening, adding or removing material, reshaping, watering and compacting.

3.4.3 Field Density Tests

One test (ASTM D 1556 or ASTM D 2022 and ASTM D 3017) will be taken for each 10,000 square feet of each layer of base course.

3.4.4 Laboratory Density Tests

Laboratory density tests will be performed in accordance ASTM D 1557, Method D.

3.4.5 Thickness Tests

The surface of the finished aggregate base at any point will not vary more than 15 mm (0.05-foot) above or below the grades shown on the drawings. Base course thickness will be measured at intervals such that there will be a depth measurement for at least each 10,000 SY of complete base course. Depth measurements will be made by test holes at lease 3 inches in diameter, through the base course. Correct as necessary per specifications.

3.5 Maintenance

The completed base will be maintained prior to paving. Maintenance includes drainage, rolling, shaping and watering, as necessary, to maintain the course in proper condition. Deficiencies which develop during maintenance will be corrected to conform to specified requirements. Sufficient moisture will be maintained to through light sprinkling to prevent a dusty condition.

4. HMA FACILITY QUALITY CONTROL

4.1 Overview

Quality control is essential to the performance of MatCon® impermeable asphalt as an impermeable modified asphalt RCRA cap. Two distinct and critical areas in the MatCon impermeable asphalt manufacturing and installation process are the Mix Design and operation of the Hot Mix Asphalt Facility.

4.1.1 Mix-Design

The first phase of the mix-design is to verify the formulation of the MatCon Binder for the specific project. In this step, the MatCon modifier is blended with high quality conventional asphalt cement to prepare the MatCon Binder. The second phase of the mix-design utilizes the prepared MatCon Binder

to develop and confirm a Job Mix Formula (JMF), that when implemented at a Hot-Mix Asphalt Facility (HMAF) will result in MatCon HMA modified asphalt capable of being installed and subsequently performing as the desired impermeable material. MatCon modifier and high quality asphalt cement (collectively called MatCon Binder), and MatCon Guide Specification compliant aggregates local to the project job site are evaluated in a battery of tests, blending conditions, and temperatures to verify material compatibility, application rates, and other key HMAF process and hot-mix paving control parameters such as temperature, viscosity, flow, and compactability. The mix-design most importantly establishes material proportioning data curves that directly correlate field density and air voids of compacted MatCon to hydraulic conductivity. These relationships are then used for field construction control during full-scale MatCon installation to ensure permeability of the final product is < 1 E-08 cm/sec in the final MatCon cover.

4.1.2 MatCon Hot-Mix Asphalt (HMA) Facility

The HMAF utilized for any MatCon project must have a demonstrated experience and history of working under a well established QC program such as the Federal or applicable State DOT qualifications and specifications. Additional experience in producing modified hot-mix asphalt and Superpave mixes is highly desired. Production of MatCon HMA at the HMAF must be performed using aggregates, MatCon Binder, and hot mixing procedures that comply with the JMF and the MatCon Guide Specifications. At the HMAF, aggregate characteristics including gradation, moisture, temperature, and process feed rate must all be controlled. In conjunction with aggregate control, HMAF's must also accommodate specific needs for MatCon Binder storage and process delivery systems that include continuous recirculation mixing, heating capabilities, and flow-proportional feeding systems. The ability of the plant operations to control aggregate and MatCon Binder feed rates, process temperatures, and production continuity and quality consistency is essential. The transfer of the MatCon HMA to transport vehicles and its haul to the job site must be performed without aggregate segregation or temperature loss below specifications.

4.2 Area Specific Quality Control Measures

4.2.1 Mix-design

With the entire MatCon HMA mix-design being performed at an offsite reputable laboratory and well in advance of full-scale MatCon installation, and the implementation of ASTM, USEPA, or other accepted standardized methods, the role of laboratory Quality Assurance/Quality Control is mostly self-imposed by the laboratory itself. The use of calibration methods, duplicates/replicates, method blanks, and spikes and other well established QA/QC procedures need not be discussed in detail in this Program Plan. However, the laboratory that performs the mix-design, must have all the approved QA/QC procedures in place that are followed by qualified analysts and technicians experienced with the methods that are performed. Further, all data and reports generated and prepared by the laboratory will be critically examined by Wilder MatCon professionals that are technically and operationally knowledgeable in historic data and performance patterns of MatCon. Any anomalies found in the mix-design data from the established data base will be carefully reviewed and the laboratory work evaluated for validity.

The output of the mix design for use by Wilder includes:

- Formula verification of the MatCon Binder
- Evaluation of local aggregates and asphalt binder qualities

- Development of the Job Mix Formula for MatCon HMA
- Verification of hydraulic conductivity as a function of the final JMF
- Density/Voids vs. Hydraulic Conductivity relationships for full-scale construction QC of compaction
- Resilient modulus and other test parameters important for assurance of durability, longevity and other site specific performance criteria.

4.2.2 Hot-Mix Asphalt Facility (HMAF)

4.2.2.1 HMAF Selection

Fully qualified and reputable HMAF's must be selected for potential MatCon HMA manufacture. Traditionally, the company providing HMA capabilities is also a qualified paving contractor. This is a preferred combination as hot-mix production and lay-down at the job site requires careful planning and integrated coordination. Other key selection criteria include:

- Proximity to the job site
- Experience in manufacturing modified HMA per Federal or applicable State DOT QC specifications
- Production capacity to service project demands
- Quality and gradation of aggregates
- Overall QC of HMAF operations, including process settings.

As part of the selection process, the facility must be inspected and examined to ensure it has the ability to manufacture MatCon HMA in accordance with the JMF and the MatCon Guide Specifications.

4.2.2.2 HMAF - MatCon HMA Manufacture

A QC technician will be posted at the HMAF to monitor and track the following information. Any parameters that are outside of the JMF and the MatCon Guide Specifications performance criteria may result in rejected MatCon HMA before it is hauled from the HMAF to the project job site. Areas to be inspected for QC compliance include:

- Aggregate and MatCon Binder Monitoring of gages, scales, and other instrumentation.
- HMA Blending Operations: temperature, production rates, asphalt content.
- MatCon HMA Product:
  - gradation; asphalt content; temperature; Rice density, at chute by time/date
  - temperature and tonnage by haul vehicle number by time and date.
- Weights and Measure - verify certified calibration records per State DOT.

As part of the QC plan, samples of MatCon Binder, aggregates, and MatCon HMA will be collected for analysis, testing, and archive. Additional information such as temperature, volumes and weights, and other process setting data will be documented.

The following Sampling and Testing Matrix (Table 1) is provided for use in determining and archiving the quality of MatCon HMA prepared by the HMAF.

Table 1. Sample and Testing Matrix Table, Hot-Mix Asphalt Facility.

Hot-Mix Asphalt Facility - Sample and Testing Matrix **MatCon Construction Quality Control**			
Sample Matrix	**Sample Location**	**Parameter**	**Frequency**
Aggregate	Feed hopper or bin	Gradation	1 per 500 tons mix, or per 0.5 acres, or minimum of 3-4 per day
MatCon binder	Delivery truck	Temperature Quantity	Each truck delivered to storage tank, Plus 1 quart sample per truck for archive
MatCon binder	Storage tank at HMAF	Temperature	Hourly Plus 1 quart for archive daily
MatCon HMA	Chute or truck	Gradation Binder content Rice max. density Temperature	1 per 500 tons mix, or per 0.5 acres, or minimum of 3-4 per day
MatCon HMA	Haul Truck	Temperature Tonnage	Every truck-load Record truck tag or ID number
NOTES: 1) All samples collected in duplicate. 2) All samples sent to laboratory under Chain-of-Custody protocol. 3) One (1) sample for testing + one (1) sample for archive, unless noted.			

4.2.3 Protocols

Table 2 is a summary of the test standards utilized in the design, testing, and evaluation of MatCon Binder and HMA. All tests are not required for all projects. Tests and results are proprietary to Wilder Construction Company. Deliverable results are limited to core sample thickness and permeability only.

Table 2. Summary of QC/QA Testing and Evaluation Procedures.

Parameter	Test Method		Notes
1. Materials Evaluation			
• Aggregate quality	ASTM	C 127 C 128 C 131 D 2419 D 4791 D 5821	• Acceptance of aggregates may be based on certification by supplier, but is based on these tests.
• Aggregate gradation	ASTM AASHTO	C 136 T 304	
• Aggregate sampling	ASTM	D 75	
2. Mixture Preparation			
• Mix design	ASTM AASHTO ASTM	D 1559 T 283 D 2726 D 3203 D 4123 D 5084	• Combined with some features of Superpave methods are proprietary evaluation/criteria. These tests are used to develop a Job Mix Formula (JMF).
• Mixing plant	MatCon Guide Specifications and ASTM D 995 (optional)		• Certification by Wilder Construction Company.
• Mix quality	AASHTO TP 53 ASTM C 136		• From samples of loose mix.
3. Installation Procedures (non-destructive)			
• Density	ASTM D 2950		• Nuclear method.
• Thickness	By observation and direct measurement.		
• Permeability	By indirect comparison to mix design.		
4. Performance Criteria Tests – Quality Assurance			
• Permeability	ASTM D 5084		• Using 4" diam. core samples.
• Thickness	Direct measurement		• 4" cores or sawed sections.

MatCon® Test Methods

AASHTO Test Methods

Designation No.	Standard Test Method
TP 53	Standard Test Method for Determining the Asphalt Content of Hot Mix Asphalt (HMA) by the Ignition Method
T 283	Standard Test Method for Resistance of Compacted Bituminous Mixture to Moisture Induced Damage
T 304	Standard Test Method for Uncompacted Void Content of Fine Aggregate
	ASTM Test Methods
C 127	Standard Test Method for Specific Gravity and Absorption of Coarse Aggregate
C 128	Standard Test Method for Specific Gravity and Absorption of Fine Aggregate
C 131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
C 136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregate
D 70	Test Method for Density of Semi-Solid Bituminous Materials (Pycnometer Method)
D 75	Standard Practice for Sampling Aggregates
D 995	Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
D 1559	Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
D 2419	Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregates
D 2726	Standard Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
D 2950	Density of Bituminous Concrete in Place by Nuclear Method
D 3203	Standard Test Method for Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
D 4123	Standard Test Method for Indirect Tension Test for Resilient Modulus Bituminous Mixtures
D 4791	Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
D 5084	Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
D 5821	Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate

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4.3 Responsibilities and Authority for QC Related Corrective Action

A trial strip with minimum dimensions of 1,000 square feet will be constructed for the purpose of establishing construction procedures on site and for calibration of the Nuclear Density Meter (NDM). The results form the test strip shall be submitted to the Project Technical Manager and approved before commencement of the main works.

A QC technician will be posted at the HMAF as previously indicated.

4.4 Project Reporting

At the completion of the MatCon installation, a final construction QC report will be prepared. It will include:

- A summary of the mix data pertinent to density and hydraulic conductivity
- HMAF inspection form
- Summary of MatCon HMA data including: tonnage, temperature minimum, and MatCon Binder content ranges
- Laboratory permeability test data summaries of samples.

All work sheets, field notes, and laboratory data will be used in preparing the final summary report for the project. Proprietary and sensitive confidential MatCon technology supporting information will be maintained in archive by Wilder Construction Company, or submitted if under mutually acceptable protective legal cover.

Attachment A
Guide Specifications

WILDER

WILDER CONSTRUCTION COMPANY

ATTACHMENT A

Guide Specifications

For

MatCon™ Impermeable Asphalt

Prepared By:

WILDER CONSTRUCTION COMPANY

"This Guide Specification for MatCon™ Impermeable Asphalt, furnished by Wilder Construction Company (Wilder) of Everett, WA, including all text, tables, and forms, shall not be published, duplicated, used or disclosed in whole or in part for any purpose other than to evaluate MatCon for a specific site application or to manufacture and install MatCon™ for the specific project for which this specification has been submitted. Information contained in this document is strictly confidential and the proprietary property of Wilder. Any breach in this restriction will result in significant and substantial material loss to WCC. The information subject to this restriction is contained on all sheets of this document."

April 2006

CONTENTS

1.0 INTRODUCTION **3**

2.0 MATCON® PRODUCTION **3**

2.1 Description 3

2.2 Materials for MatCon production 3

2.3 Methods for MatCon production 5

2.4 Weighing Equipment 11

2.5 Quality Control 13

3.0 MATCON® TRANSPORT **16**

3.1 Transport Equipment 16

3.2 Methods 16

3.3 Quality Assurance 16

4.0 SURFACE PREPARATION **16**

4.1 Material 16

4.2 Preparation of Existing Surfaces 16

4.3 Quality Control 17

5.0 PLACEMENT AND COMPACTION **17**

5.1 Equipment for Placement and Compaction 17

5.2 Methods for placement and compaction 18

5.3 Quality Control of placement and compaction 20

TABLES

Table 1 Recommended Aggregate Gradation for Dense and Open Graded MatCon Mixture 5

Table 2 Recommended Quality Control Sampling and Testing 15

Table 3 Recommended Quality Control Sampling and Testing 17

Table 4 MatCon Quality Assurance Matrix Table 21

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MatCon®

GUIDE SPECIFICATIONS
For Construction of the
LANL Airport Landfill Impermeable MatCon Cap

1.0 INTRODUCTION

These guidelines have been adapted from specifications for constructing conventional hot mix asphalt pavements. An essential feature of MatCon® is that the materials and placement can be accomplished using equipment and procedures readily available throughout the U.S. and normally used for producing Hot Mix Asphalt (HMA).

2.0 MATCON® PRODUCTION

2.1 Description

This work shall consist of one course of dense graded MatCon placed on a prepared aggregate base in accordance with these Specifications and in conformity with the lines, grades, thicknesses, and typical cross-sections shown in the Plans or established by the Engineer.

MatCon shall be composed of MatCon Binder and aggregate which, with or without the addition of mineral filler and blending sand as may be required, shall be mixed in the proportions specified to provide a homogeneous, stable, and workable mixture.

2.2 Materials for MatCon production

Materials shall meet the requirements of the following sections:

- MatCon Binder
- Anti-Stripping Additive
- Aggregates
- Blending Sand
- Mineral Filler

2.2.1 MatCon Binder

Wilder Construction will provide the MatCon binder to the project plant. The binder will be pumped into empty storage tanks meeting the requirements of all plants as defined later in this section.

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2.2.2 Anti-Stripping Additive

When directed by the Engineer, an anti-stripping additive shall be added to the MatCon binder. If anti- strip is normally specified for local mixes made from the same aggregate, MatCon will require anti-strip

2.2.3 Aggregates

Aggregates used in MatCon shall be manufactured from ledge rock, talus, or gravel. The material from which they are produced shall meet the following test requirements:

ASTM C 131 LA Wear	30% max loss
ASTM C 127 SPG & Absorb Coarse Agg.	2% max absorption
ASTM C 128 SPG & Absorb Fine Agg	2% max absorption
ASTM D 2419 Sand Equivalent	40 min

Aggregates shall be uniform in quality, substantially free from wood, roots, bark, extraneous materials, and adherent coatings. The presence of a thin, firmly adhering film of weathered rock will not be considered as coating unless it exists on more than 50 percent of the surface area of any size between consecutive laboratory sieves.

The fracture requirements are at least one fractured face on 75 percent of the material retained on each specification sieve size U.S. No. 10 and above, if that sieve retains more than 5 percent of the total sample.

When material is being produced and stockpiled for use on a specific contract the fracture and sand equivalent requirements shall apply at the time of stockpiling. When material is used from a stockpile that has not been tested as provided above, the requirements for fracture and sand equivalents shall apply at the time of its introduction to the cold feed of the mixing plant.

Aggregate removed from deposits contaminated with various types of wood waste shall be washed, processed, selected, or otherwise treated to remove sufficient wood waste, so that the oven-dried material retained on a ¼ -inch square sieve shall not contain more than 0.1 percent by weight of material with a specific gravity less than 1.

2.2.4 Blending Sand

In the production of aggregate for MatCon, there is often a deficiency of material passing the U.S. No. 40. When this occurs, blending sand in an amount specified by the Engineer may be used to make up this deficiency, provided that a satisfactory final mix is produced, including fracture requirements.

Blending sand shall be clean, hard, sound material (either naturally occurring sand or crusher fines) and must be material which will readily accept an MatCon binder coating. Blending sand shall have a minimum value in the Sand Equivalent test (ASTM D 2419) of 40.

2.2.5 Mineral Filler

Mineral filler, when used in MatCon mix, shall conform to the requirements of AASHTO M 17.

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2.2.6 Gradation

The Contractor may furnish aggregates for use on the same contract from a single stockpile or from multiple stockpiles. The gradation of the aggregates shall be such that the completed mixture complies in all respects with the pertinent requirements of this section. Acceptance of the aggregate gradation shall be based on samples taken from the final mix.

The materials of which MatCon is composed shall be of such sizes, gradation, and quantities that, when proportioned and mixed together, they will produce a well-graded dense impermeable mixture or an open graded very permeable drainage layer within the requirements listed in the table that follows. All sieve testing shall be in accordance with ASTM C 136 Sieve Analysis of Fine and Course Aggregates

Table 1. Recommended Aggregate Gradation for Dense and Open Graded MatCon Mixture

Sieve size	% Passing Based on Total wt. of aggregate	
	Dense	Open
(3/4 inch)	100	70-100
(1/2 inch)	100	25-40
(3//8 inch)	85-100	5-15
No. 4 sieve	60-80	0-2
No. 8 sieve	40-60	0-1
No. 16 sieve	25-40	0-1
No. 30 sieve	15-25	0-1
No. 50 sieve	11-20	0-1
No. 100 sieve	7-15	0-1
No. 200 sieve	3-8	0-1

2.3 Methods for MatCon production

2.3.1 Stockpiling aggregates

This work shall consist of placing the specified aggregates in the stockpiles at the sites and in the amounts as shown in the Plans or as approved by the Engineer. This section also includes the requirements pertaining to the removal of aggregates from stockpiles.

2.3.2 Construction of Stockpiles

Stockpiles in excess of 200 cubic yards shall be built up in layers not more than 4 feet in depth. Stockpile layers shall be constructed by trucks, clamshells, or other methods approved by the Engineer. Pushing aggregates into piles with a bulldozer will not be permitted. Each layer shall be completed over the entire area of the pile before depositing aggregates in the succeeding layer. The aggregate shall not be dumped so that any part of it runs down and over the lower layers in the stockpile. The method of dropping from a bucket or spout in one location to form a cone shaped pile will not be permitted. Any method of placing aggregates in stockpiles, which in the opinion of the Engineer, breaks, degrades, or otherwise damages the aggregate, will not be permitted. Stockpiles of less than 200 cubic yards shall be piled in a manner to prevent segregation of the various sizes of material.

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No equipment other than pneumatic tired equipment shall be used in constructing the stockpiles of processed or manufactured aggregates.

Stockpiles of different types or sizes of aggregate shall be spaced far enough apart, or separated by suitable walls or partitions, to prevent the mixing of the aggregates. Aggregate shall not be deposited where traffic, vehicles, or Contractor's equipment will either run over or through the piles, or in any way cause foreign matter to become mixed with the aggregates.
Removing Aggregates from Stockpiles

Aggregates shall be removed from stockpile in a manner to avoid separation of sizes or admixture of dirt or foreign material. The Engineer will approve the method and equipment used for loading.

No equipment other than pneumatic tired equipment shall be used on stockpiles of processed or manufactured aggregates in removing the materials from the stockpiles. When removing materials from the face of the stockpile, the equipment shall be operated in a manner to face-load from the floor to the top of the stockpile to obtain maximum uniformity of material.

2.3.3 Preparation of Aggregates

The aggregates shall be removed from stockpile(s) in a manner to ensure a minimum of segregation when being moved to the MatCon plant for processing into the final mixture.

2.3.4 Mix Design

The Contractor shall obtain representative samples from mineral aggregate stockpiles and blend sand sources to be used for MatCon production, submitting them to Wilder Construction for development of a mix design and job mix formula.

The Contractor shall allow 30 working days for approval of the mix design once the material has been received by Wilder Construction. Additional time may be required if the proportions will not make an adequate design as determined by Wilder Construction. The Contractor is also advised that production of MatCon shall not commence until the job mix design has been established. Expedited mix designs may be performed provided arrangements are made in advance with Wilder Construction Company.

The properties of the aggregate in a preliminary mix design for MatCon shall be such that, when it is combined and mixed in the laboratory or in the field, with the MatCon binder, mixtures with the following test values can be produced:

Permeability Coefficient, k	$<1x10^{-8}$ cm/sec*	(ASTM D 5084)
Air Voids %	<3% max*	(ASTM D2041/3203)
Modified Lottman Stripping Test ,TSR	> 80%	(ASTM 4867/4867M)

**MatCon dense graded only.*

Typical regulatory standards require $<1x10^{-7}$ cm/sec. However, to achieve this minimum standard the target value is $<1x10^{-8}$ cm/sec*.

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2.3.5 Mixing Plant

Sufficient storage space shall be provided for each size of aggregate. The different aggregate sizes shall be kept separated until they have been delivered to the cold elevator feeding the plant except that aggregates produced meeting the requirements of Section 3-01.8 need not be separated. The storage yard shall be maintained neat and orderly and the separate stockpiles shall be readily accessible for sampling.

Plants used for the preparation of MatCon shall conform to all requirements of this section except that scale requirements shall apply only where weight proportioning is used. In addition, batch plants shall conform to the requirements of given for batch plants and rotary drum plants shall conform itemized for rotary drum plants.

2.3.6 Requirements for All Plants

All plants shall meet the following requirements:
The asphalt plant shall have a minimum capacity rating by the manufacture as follows:

- For projects involving 5,000 tons or more:
  - Batch plants — 2,000 lbs. per batch.
  - Continuous mix and rotary drum plants — 100 tons per hour.
- For projects involving less than 5,000 tons:
  - Batch plants — 1,000 lbs. per batch.
  - Continuous mix and rotary drum plants — 45 tons per hour.

Plant and truck scales shall meet the requirements defined later in this section for weighing equipment.

1. Equipment for preparation of MatCon binder: Tanks for the storage MatCon material shall be equipped to heat and hold the material at the required temperatures. Typical storage temperatures for the MatCon binder range between 310 F and 360 F. Steam coils, electricity, other approved means, shall accomplish the heating so that no flame shall be in contact with the tank. The circulating system for the binder material shall be designed to ensure proper and continuous circulation during the operating period. Provision shall be made for measuring the binder in the storage tank and a valve shall be placed in the supply line to the mixer for sampling the material.
2. Feeder for drier or drum mixer: The plant shall be provided with accurate mechanical means for uniformly feeding the aggregate into the drier so that uniform production and uniform temperature will be obtained. The feeder for blending sand, when required shall be capable of providing a consistent, uniform flow in the amount designated by the Engineer.
3. Screens: Plant screens, capable of screening all aggregates to the specified sizes and proportions and having normal capacities in excess of the full capacity of the mixer, shall be provided when batch plants are used.
4. Bins: The plant shall include storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Bins shall be arranged to ensure separate and adequate

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storage of appropriate fractions of the aggregates. Separate dry storage shall be provided for mineral filler when used and the plant shall be equipped to feed such material into the mixer. Each bin shall be provided with overflow pipes, sized and located to prevent material backing up into other compartments or bins. Each compartment shall be provided with an outlet gate, constructed so there shall be no leakage when closed. The gates shall close quickly and completely. Bins shall be constructed so samples can be readily obtained. Bins shall be equipped with adequate telltale devices to indicate the level of the aggregates in the bins at the lower quarter points.

5. Binder control unit: Satisfactory means, either by weighing or metering, shall be provided to obtain the proper amount of MatCon binder in the mix. Means shall be provided for checking the quantity or rate of flow of MatCon binder into the mixer.
6. The binder may also be proportioned by a device which sprays the material into the mixer through six or more nozzles, and which weighs or proportions the material for each batch by a positive rotating meter which is calibrated in pounds. The metering device shall have an established background of service and shall be approved by the Engineer
7. Thermometric equipment: An armored thermometer of adequate range in temperature reading shall be fixed in the MatCon binder feed line at a suitable location near the charging valve at the mixer unit.
8. The plant shall also be equipped with either an approved dial-scale, a mercury actuated thermometer, an electric pyrometer, or other approved thermometric instrument placed at the discharge chute of the drier to automatically register or indicate the temperature of the heated aggregates. This device shall be in full view of the plant operator. The Engineer may require replacement of any thermometer with an approved temperature-recording apparatus for better regulation of the temperature of aggregates.
9. Dust collector: The plant shall be equipped with a dust collector constructed to waste or return uniformly to the hot elevator all or any part of the material collected.
10. When a bag house is used for dust control, the Contractor shall be able to introduce the material returned from the bag house into the mixture at a uniform and continuous rate. Accurate mechanical means shall be provided for uniformly feeding the fines into the aggregate stream. To accomplish this, the Contractor shall provide a surge hopper with a holding capacity sufficient to accumulate the bag house fines or shall have a variable speed mechanical feed interlocked to the plant which will prevent any variance in feed into the aggregate stream. Either method shall provide uniform and continuous return of the well-graded fine materials and be provided with a method of withdrawing the surplus fines independently for disposal.
11. Burner fuel: The plant burner fuel shall be restricted to the use of propane, butane, natural gas, methane, coal, No. 1 or No. 2 fuel oil, or other acceptable burner fuel as determined by the Engineer.
12. Compliance: Hot-mix asphalt plants shall be in compliance with all local, state, and federal operating permits, licenses, air quality and other applicable regulations.

2.3.7 Requirements for Batch Plants

In addition to the requirements listed earlier in this section, batch plants shall meet the following requirements:

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1. The plant shall include a drier or dryers which continuously agitate the aggregate during the heating and drying process, and be capable of preparing aggregates to specification requirements.
2. Weigh box or hopper: The equipment shall include a means for accurately weighing each size of aggregate in a weigh box or hopper suspended on scales and of ample size to hold a full batch without hand raking or running over. The gate shall close tightly so that no material is allowed to leak into the mixer while a batch is being weighed.
3. MatCon binder control: The equipment used to measure the binder shall be accurate to plus or minus 0.5 percent. The binder bucket shall be a non-tilting type with a loose sheet metal cover. The length of the discharge opening or spray bar shall be not less than 75 percent of the length of the mixer and it shall discharge directly into the mixer. The binder bucket, its discharge valve or valves and spray bar shall be adequately heated. Steam jackets, if used, shall be efficiently drained and all connections shall be constructed so they will not interfere with the efficient operation of the asphalt scales. The capacity of the binder bucket shall be at least 15 percent in excess of the weight of binder material required in any batch. The plant shall have an adequately heated quick-acting, non-drip, charging valve located directly over the asphalt material bucket. The indicator dial shall have a capacity of at least 15 percent in excess of the quantity of binder material used in a batch. The controls shall be constructed so they may be locked at any dial setting and will automatically reset to that reading after the addition of binder material to each batch. The dial shall be in full view of the mixer operator. The flow of binder material shall be automatically controlled so it will begin when the dry mixing period is over. All of the binder material required for one batch shall be discharged in not more than 15 seconds after the flow has started. The size and spacing of the spray bar openings shall provide a uniform application of binder material the full length of the mixer. The section of the binder line between the charging valve and the spray bar shall be provided with a valve and outlet for checking the meter when a metering device is substituted for an binder material bucket.
4. Mixer: The batch mixer shall be an approved type capable of producing a uniform mixture meeting the requirements of these Specifications. If not enclosed, the mixer box shall be equipped with a dust hood to prevent loss of dust.
5. Clearance of the blades from all fixed and moving parts shall not exceed 1 inch unless the maximum diameter of the aggregate in the mix exceeds 1 1/2 inches, in which case the clearance shall not exceed 1 1/2 inches
6. Mixing time: The plant shall be capable of regulation of the mixing time as specified in Section 2-01.3(10) in 5 second increments
7. Automatic controls: All projects using a batch mixer involving 5,000 tons or more of MatCon shall conform to the following provisions. Automatic control of batch mixing operations may be used providing the requirements of this section are met.
8. The proportioning and timing devices shall be automatic to the extent that the only manual operation required for the proportioning and mixing of materials for one batch shall be a single operation of a switch or starter. The mixing plant shall be equipped with automatic weight proportioning devices to monitor and control the weights of the several components of aggregates and of the asphalt. The mixing plant shall also contain timing lock devices to monitor and control the position of the aggregate weigh hopper dump gate, the asphalt bucket discharge valve, and the mixer discharge gate.

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9. Withdrawal from the aggregate bins and the discharge of the weigh hopper shall be so interlocked that the weigh hopper cannot discharge until the required quantity of aggregate from each bin has been deposited therein. The weigh hopper may be a single compartment, individual weight control type, or of the divided compartment, preset volume type. When the single compartment, individual weight control type is used, the automatic scale weight system shall discharge and weigh material from one bin at a time. When the preset volume weigh hopper is used, the automatic control system shall check the total weight of each aggregate batch and provision shall be made to allow the Engineer to check easily and quickly the individual aggregate weights at any time.
10. The opening of the aggregate weigh hopper dump gate shall actuate the timing lock devices. They shall lock the asphalt bucket discharge valve until preset dry mixing time is expired and shall lock the mixer discharge gate throughout the preset dry and wet mixing periods. The control of the timing shall be flexible and capable of being set at intervals of not more than 5 seconds throughout cycles up to 60 seconds.
11. The dials of the timing locks and automatic weighing controls shall be so arranged that the time interval and mass proportion controls may be locked by the Engineer.

2.3.8 Requirements for Rotary Drum Plants

In addition to the requirements listed earlier in this section, rotary drum plants shall meet the following requirements:

1 The plant shall have a feeder capable of uniformly introducing the aggregate into the drum. The aggregate feeder shall be synchronized with the MatCon binder material feed. Satisfactory means shall be provided to afford positive interlocking control between each aggregate cold feed bin, aggregate feed, and the asphalt feed so the plant will automatically activate a warning device if the feed of either aggregate or asphalt is interrupted.
2 The plant shall have the mixing capability to provide a uniform mixture meeting the requirements of these Specifications.
3 The asphalt material feed shall have positive recording capabilities so the amount of asphalt incorporated into the mix during any given period of time may be read directly.

2.3.9 Heating of MatCon Binder

The MatCon binder shall be heated to a range between 310F and 360F as determined by the mix design. The asphalt shall be heated in a manner that will avoid local overheating and provide a continuous supply of asphalt material to the mixer at a uniform temperature plus or minus 10°F from the mix design temperature.

2.3.10 Anti-Stripping Additive

When directed by the Engineer, heat-stable liquid anti-stripping additive shall be added to the asphalt mix. At the option of the Contractor, the anti-stripping additive can be either added to the liquid asphalt or sprayed on the aggregate on the cold feed. Once the process and type of anti-stripping additive proposed by the Contractor have been approved by Wilder, the process, brand, grade, and amount of anti-stripping additive shall not be changed without approval of the Engineer.

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When liquid anti-stripping additive is added to the liquid asphalt, the amount will be designated by Wilder.

The use of another process or procedure for adding anti-stripping additive to the asphalt mix will be considered based on a proposal from the Contractor.

2.3.11 Mixing

The prepared aggregates shall be combined in the mixer in the amount of each fraction of aggregates as specified or as directed by the Engineer. The asphalt material shall be measured or gauged and introduced into the mixer in the amount determined by the Engineer.

After the required amounts of aggregate and asphalt material have been introduced into the mixer, unless otherwise specified, the materials shall be mixed until a complete and uniform coating of the particles and a thorough distribution of the asphalt material throughout the aggregate is ensured. Wet mixing time shall be sufficient to produce 95 percent coated particles. When discharged, the temperature of the mix shall not exceed the mix design temperature. A maximum water content of 2 percent in the mix, at discharge, will be allowed providing the water causes no problems with handling, stripping, or flushing. In this case, the moisture content shall be reduced as directed by the Engineer.

Storing or holding of the asphalt concrete mixture in approved storage facilities will be permitted during the daily operation but in no event shall the materials be held for more than 2 hours, unless approved by Wilder. Materials held for more than 2 hours after mixing may be rejected and disposed of by the Contractor at no expense to the Contracting Agency. The storage facility shall have a visible device located at the top of the cone or about the third point to indicate the amount of material in storage. No material shall be accepted from the storage facility when the material in storage is below the top of the cone of the storage facility, except at the end of the working day.

2.4 Weighing Equipment

2.4.1 General Requirements for Weighing Equipment

The Contractor shall provide, set up, and maintain the scales or use permanently installed, certified, commercial scales.

Scales shall:

- Be accurate to within one-half of 1 percent throughout the range of use;
- Not include spring balances;
- Include beams, dials, or other reliable readout equipment;
- Be arranged so that operators and inspectors can safely and easily see the dials, beams, rods, and operating scale mechanisms;
- Be built to prevent scale parts from binding, vibrating, or being displaced and to protect all working parts from falling material, wind, and weather; and

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- Be carefully maintained, with (a) bunkers and platforms kept clear of accumulated materials that could cause errors and (b) knife edges given extra care and protection.
- Be calibrated in accordance with standard specifications for the state where work is performed and per manufacturers' specifications.

At each batching and platform scale location, the Contractor shall have available not less than 10 standard 50-pound weights for scale calibration and testing. If the Engineer has approved other calibration and testing equipment, the Contractor may substitute it for these weights.

2.4.2 Specific Requirements for Batching Scales

Qualified operators employed by the Contractor shall weigh all materials proportioned by weight on an accurate, approved scale

Each scale shall be designed to support a weighing hopper. The arrangement shall make it convenient for the operator to remove material from the hopper while watching readout devices. Any hopper mounted on a platform scale shall have its center of gravity directly over the platform centerline.

Marked intervals on the readout device shall be spaced evenly throughout and shall be based on the scale's nominal rated capacity. These intervals shall be at least 1 pound, but shall not exceed one-tenth of 1 percent of nominal rated capacity.

An agent of the scale manufacturer shall test and service any batch scale before its use at each new site and then at 6-month intervals. The Contractor shall provide the Engineer a copy of the final results after each test. Whenever the Engineer requests, the Contractor's operator(s) shall test the scale while the inspector observes.

The MatCon binder shall be weighed on a scale not used for other materials.

2.4.3 Specific Requirements for Platform Scales

The Contractor shall provide the platform scales and any tickets required for self-printing scales. Each weigh or load ticket shall contain gross, net, and tare weight. It shall also identify the weighed material. A tare weight shall be taken of each hauling vehicle at least twice a day.

If commercial scales are used, the Contractor shall:

- Provide the scale operator with approved load tickets;
- Provide duplicate, legible copies to the Material Receiver at the delivery point; and
- Guarantee permission for an agent of the Engineer to observe the weighing and to check and compile the daily scale weight record.

Each commercial weigher shall test the scales at least daily. Test methods and procedures for recording test results and tare weight shall be approved in advance by the Engineer. Before use at a new site and then at 6-month intervals, the scale shall be serviced and tested with at least 10,000 pounds by an agent of its manufacturer. In any case, the Contractor shall provide the

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Engineer with a copy of the final test results. Scales to be certified in accordance with accepted calibration methods.

2.5 Quality Control

2.5.1 Plant inspection

Prior to commencement of production the mixing faculties shall undergo a full inspection to ensure compliance with the requirements of this specification. This inspection shall be conducted by Wilder quality control staff at least one-week before production commences.

2.5.2 Acceptance Sampling and Testing

The MatCon dense graded mixtures will be evaluated for quality of gradation and binder content.

The MatCon open graded mixtures will be evaluated for quality of gradation based on samples taken from the cold feed or from samples of the MatCon mixture.

2.5.3 Aggregates

Aggregates will be accepted for sand equivalent and fracture based on their conformance to the following requirements.:
The MatCon mixture will be accepted based on its conformance to the project job mix formula (JMF). For the determination of a project JMF, the Contractor shall submit to Wilder, representative samples of the various aggregate and blend sand, to be used along with the gradation data showing the various aggregate stockpile averages and the proposed combining ratios and the average gradation of the completed mix. Based on this submittal from the Contractor, Wilder will determine the MatCon binder content, anti-strip requirement, and MatCon binder retention factor in the mix design process. Using the representative samples submitted and proposed proportion of each, trial mix tests will be run to determine the percentage of MatCon binder, by weight, to be added. The JMF thus established shall be changed only upon order of Wilder.

The intermingling of MatCon mixtures produced from more than one JMF is prohibited. Each paver path of MatCon mixture placed during a working shift shall conform to a single job mix formula established for the class of MatCon mixture specified unless there is a need to make an adjustment in the JMF.

No mixture shall be produced for use on the project until the amount of MatCon binder and anti-strip additive to be added has been established.

2.5.4 MatCon Mixture

2.5.4.1 Sampling

(1) A sample will not be obtained from either the first or last 25 tons of mix produced in each production shift.

(2) Samples for compliance of gradation and asphalt cement content will be obtained on a random basis from the hauling vehicle.

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2.5.4.2. Definition of Sampling: Sampling and testing for acceptance shall be performed on a random basis at a minimum frequency of one sample for each sublot of 500 tons, or a minimum of 3 to 4 per day.

2.5.4.3 Reject Mixture

(1) Rejection by Contractor: The Contractor may, prior to sampling, elect to remove any defective material and replace it with new material at no expense to the Contracting Agency. Any such new material will be sampled, tested, and evaluated for acceptance.

(2) Rejection without Testing: The Engineer may, without sampling, reject any batch, load, or section of the cap or liner that appears defective in gradation or MatCon binder content. Material rejected before placement shall not be incorporated into the work. Any rejected section of the work shall be removed.

2.5.5 Job Mix Formula Tolerances and Adjustments

Tolerances. After the JMF is determined, the several constituents of the mixture at the time of acceptance shall conform to the following tolerances:

Constituent of Mixture	**Tolerance Limits**[1]
Aggregate passing ¾ ", 5 / 8 ",1 /2 ", and 3 /8 "sieves	Broad band specification
Aggregate passing No. 4sieve	±5%
Aggregate passing No. 8 sieve	±4%
Aggregate passing No. 16 sieve	±4%
Aggregate passing No. 30 sieve	±4%.
Aggregate passing No. 50 sieve	±3%
Aggregate passing No. (100) sieve	±3%
Aggregate passing No. (200) sieve	±2%
MatCon Binder	±0.3%
Temperature of Mixing	±25°F

2.5.6 Aggregates Adjustments.

Upon written request from the Contractor, the Project Engineer, with Wilder concurrence may approve field adjustments to the JMF including the Contractor's proposed combining ratios for mineral aggregate stockpiles and blend sand. The maximum allowed gradation change shall be 2 percent for the aggregate retained on the No. 8 sieve and above, 1 percent for the aggregate passing the No. 16, No. 30 and No. 50 sieves, and 0.5 percent for the aggregate passing the No. 100 and No. 200 sieve. The Project Engineer may make these field adjustments to the JMF provided the change will produce material of equal or better quality. The above adjustments and/or any further adjustments as ordered by the Engineer will be considered as a new JMF. Adjustments beyond these limits will require development of a new JMF. The adjusted JMF plus or minus the allowed tolerances shall be within the range of the broad band specifications.

[1] The tolerance limit for each mix constituent shall not exceed the broad band specification limits.

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2.5.7 Gradation

The Contractor may furnish aggregates for use on the same contract from a single stockpile or from multiple stockpiles. The gradation of the aggregates shall be such that the completed mixture complies in all respects with the pertinent requirements.

Recommended frequency of testing of the various stages of MatCon production and given in Table 2 below. Variations are permitted, subject to approval by Wilder Quality Control staff if deemed necessary for safety and/or production reasons. All sampling shall be witnessed by Wilder staff and Wilder staff will be responsible for shipping samples to be used for external compliance testing. Wilder staff members shall establish a Chain of Custody form for each sample produced which will include labeling and shipping details to the certified test laboratory. Completed records for COC will be maintained as part of the permanent quality control record.

Table 2. Recommended Quality Control Sampling and Testing

MatCon Quality Assurance – Production					
PHASE ON/OFF SITE	**DESCRIPTION**	**LOCATION**	**TEST PARAMETERS**	**TIMING/ FREQUENCY**	**COMMENTS**
MatCon Binder Formulation Off Site	MatCon Modifier Compatibility	Asphalt Laboratory	Per Wilder	1-2 weeks prior to MatCon Laydown	Wilder to prepare Binder data for submittal to Binder Blending Facility
MatCon Mix-Design Off Site	Prepare MatCon JMF	Asphalt Laboratory	Per Wilder	Within one week prior to MatCon Laydown	Wilder to prepare JMF and submit to Contractor
MatCon Binder Blending/ Delivery to HMAF Off Site	Prepare MatCon Binder	Binder Blending Facility	Per Wilder	Immediately before/during MatCon Laydown	Wilder to Approve MatCon Binder
	Sample & Test MatCon Delivery Trucks to HMAF	HMAF	1) Temperature 2) Quality	Each delivered truck load	Wilder to submit samples to lab for testing
	Sample & Test MatCon in HMAF Storage Tank(s)	HMAF Storage Tanks	Temperature	Hourly	All Data on appropriate QC Form
MatCon HMA Off Site	Sample & Test MatCon Hot-Mix Asphalt at HMAF prior to Haul to Site	Chute or Haul Truck at HMAF	1) Gradation 2) Binder Content 3) Rice Max. Density 4) Temperature	1 per 500 tons mix, or 1 per 0.5 acres, or minimum of 3-4 per day, 1 Rice Density per Day	All Data on appropriate QC Form

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3.0 MATCON® TRANSPORT

3.1 Transport Equipment

Trucks used for transport/hauling MatCon mixtures shall have tight, clean, smooth metal beds which have been thinly coated with a minimum amount of paraffin oil, or other approved material to prevent the mixture from adhering to the beds. Each truck shall have a cover of canvas or other suitable material of sufficient size to protect the mixture from the weather.

3.2 Methods

When dump truck beds are sprayed with oil, the excess oil shall be drained prior to filling with the asphalt mixture. For hopper trucks, the conveyer shall be in operation during the process of oiling the bed.

3.3 Quality Assurance

Visual inspection records and temperatures shall be recorded by the Contractors staff. Each load shall be visually inspected as the load leaves the plant.

The temperature of the load shall be taken upon the start and completion of transportation. Material outside the acceptable range as defined by the mix design and the corresponding temperature tolerance shall be rejected.

4.0 SURFACE PREPARATION

4.1 Material

Materials shall be submitted to Wilder in advance of construction for approval. Due to the highly variable nature of sites and standard specification is not available for materials.

The surface shall be firm and unyielding condition. Typically this can be characterized as having a dynamic stiffness of 80MPa or greater with little or no potential for settlement.

4.2 Preparation of Existing Surfaces

Before construction of a MatCon liner or cap system, the existing surface will be constructed to plan subgrade elevations with a tolerance of +/- one half inch, and brought to a firm and unyielding condition as evidenced by proof rolling with a loaded tandem rear-axle dump truck. Further, the surface must be capable of maintaining its smooth and unyielding condition when loaded repeatedly by the MatCon mixture delivery trucks.

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4.3 Quality Control

Recommended frequency of testing of the various stages of MatCon surface preparation are given in Table 3 below. Variations are permitted, subject to approval by Wilder Quality Control staff if deemed necessary for safety and/or production reasons. All sampling shall be witnessed by Wilder staff and Wilder staff will be responsible for shipping samples to be used for external compliance testing.

Table 3. Recommended Quality Control Sampling and Testing

MatCon Quality Assurance Matrix Table – Surface Preparation					
PHASE ON/OFF SITE	**DESCRIPTION**	**LOCATION**	**TEST PARAMETERS**	**TIMING/ FREQUENCY**	**COMMENTS**
***Site Preparation* On-Site**	Examine prepared grade for suitability for MatCon Pavement Installation	Surface for Paving	1) firm and unyielding 2) >1.5% grade 3) +/- 1/2" tolerance	Prior to MatCon Paving	Wilder may accept or reject all or part of grade prior to MatCon paving
Evaluation with PRIMA LWD	Evaluation of dynamic stiffness of soil	Surface for Paving	E > 80 MPa	Prior to MatCon Paving 100 ft grid	No standard covers this method currently.

5.0 PLACEMENT AND COMPACTION

5.1 Equipment for Placement and Compaction

5.1.1 Pavers

MatCon pavers shall be self-contained, power-propelled units, provided with an activated screed or strike-off assembly, heated if necessary, and capable of spreading and finishing courses of MatCon in panel widths applicable to the specified typical section and thicknesses shown in the Plans.

The screed or strike-off assembly shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, segregating, or gouging the mixture. Any bolt on or hydraulic extensions shall produce the same results including ride, density, and surface texture as the screed or strike off assembly. Hydraulic extenders without screeds, augers, and vibration shall not be used.

When laying mixtures, the paver shall be operated at a uniform forward speed consistent with the plant production rate and roller train capacity to result in a continuous operation. The auger speed and flight gate opening shall be adjusted to coordinate with the operation.

The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent. The paver shall be equipped with automatic feeder controls, properly adjusted to maintain a uniform depth of material ahead of the screed.

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5.1.2 Rollers

Rollers shall be of the steel wheel, vibratory, or pneumatic tire type, in good condition, capable of reversing without backlash, and shall be operated at speeds slow enough to avoid displacement of the mixture. The number and weight of rollers shall be sufficient to compact the mixture as required in Section 2.01.3(12). The use of equipment, which results in excessive crushing of the aggregate, will not be permitted. Rollers producing pickup, washboard, uneven compaction of the surface or other undesirable results will be rejected. Compaction, in areas too small for the use of conventional sized rollers, shall be achieved using vibratory plate compactors or other approved equipment.
The following specifications shall apply to the various types of rollers:

5.1.3 Vibratory Rollers

- Variable amplitude will be required, with at least 2 settings.
- A variable frequency with a 2,000 VPM minimum.
- The maximum rate of travel under vibration shall be limited to 3 mph.
- Pneumatic propulsion on surface courses shall be limited to smooth tires that will not leave visible tracks.

5.1.4 Pneumatic Tired Rollers

- The maximum rate of travel shall be limited to 5 mph.
- Skirts shall be firmly affixed to the perimeter of the roller and shall uniformly extend to within 1 inch of the pavement surface

5.1.5 Steel Wheel Rollers

- The maximum rate of travel shall be limited to 4 mph.

5.2 Methods for placement and compaction

5.2.1 Spreading and Finishing

The mixture shall be laid upon an approved surface, spread, and struck off to the grade and elevation established. Asphalt pavers complying with this section shall be used to distribute the mixture. Unless otherwise directed by the Engineer or specified in the Plans or in the Special Provisions, the nominal compacted depth of any layer or lift of any course shall not be less than the following depths:

MatCon Dense Graded	4 inches
MatCon Open Graded	4 inches

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the paving may be done with other equipment or by hand. When the MatCon mixture is being produced by more than one plant, the material produced by each plant shall be placed by separate spreading and compacting equipment.

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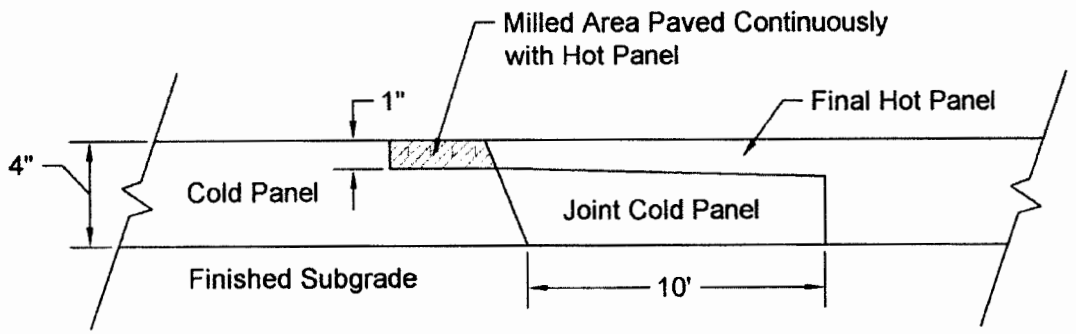
5.2.2 Joints

The construction of dense graded MatCon requires the elimination of nearly all-cold joints. This is accomplished by keeping the paving panels short enough, that when the paver is set back to start another panel, the joint being placed against is still hot and not yet compacted. Once placement of the adjacent panel has started, the hot joint between the two panels can be compacted, resulting in a seamless connection. When a prolonged break is anticipated, such as the end of a work shift, the Cold Joint Panel will have the following configuration, (See drawing below). The inside of the panel which is adjacent to the previously laid hot panel will be approximately, three (3) inches compacted; however the outer edge of this last (cold joint) panel will be approximately two (2) inches thick after compaction creating a tapered joint panel. Prior to placing the Overlay Hot Panel a tack coat shall be applied over the entire cold joint panel and milled area at the rate of 0.1 gallons per square yard, or at a rate determined by Wilder. The Overlay Hot Panel will be laid a minimum of one (1) foot wider than the Cold Joint Panel.



Cross Section

Notes:

1. Milled area removed from tapered cold joint panel with narrow milling machine to depth of adjacent joint panel surface.
2. Milled surface broomed clean.
3. Surface of all cleaned cold panels heavily tacked with modified asphalt.
4. Overlay hot panel paved and compacted against milled edge.
5. Final surface seam sealed with modified asphalt.
6. Drawing not to scale.

5.2.3 Compaction

Immediately after MatCon has been spread, struck off, and surface irregularities adjusted, it shall be thoroughly and uniformly compacted. The completed course shall be free from ridges, ruts, humps, depressions, objectionable marks, or irregularities and in conformance with the line, grade, and cross-section shown in the Plans or as established by the Engineer.

Compaction shall take place when the mixture is in the proper condition so that no undue displacement, cracking, or shoving occurs. All compaction units shall be operated at the speed, within specification limits, that will produce the required compaction. Areas inaccessible to large compaction equipment shall be compacted by mechanical or hand tampers. Any MatCon

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that becomes loose, broken, contaminated, shows an excess or deficiency of MatCon binder, or is in any way defective, shall be removed and replaced at no additional cost with fresh MatCon which shall be immediately compacted to conform with the surrounding area.

The type of rollers to be used and their relative position in the compaction sequence shall generally be the Contractor's option, provided specification densities are attained.

Coverages with a vibratory or steel wheel roller may proceed pneumatic tired rolling.
Vibratory rollers shall not be operated in the vibratory mode when the internal temperature of the mix is less than 225 F without permission of the Engineer. In no case shall a vibratory roller be operated in a vibratory mode when checking or cracking of the mat occurs at a greater temperature.

5.2.4 Weather Limitations

MatCon shall not be placed on any wet surface, or when the average surface temperatures are less than those specified in the following table, or when weather conditions otherwise prevent the proper handling or finishing of the bituminous mixtures:

Surface Temperature Limitations for both Cap and Liner Courses: 35 F min

5.3 Quality Control of placement and compaction

The quantity represented by each density lot will be no greater than a single day's production or approximately 500 tons, whichever is less.

At the start of paving, a compaction test section shall be constructed, as directed by the Engineer, to determine the compactability of the mix design. Compactability shall be evaluated as the ability of the mix to attain a quality level of 97 percent of the maximum density determined by AASHTO T 209

Following determination of compactability, the Contractor is responsible for the control of the compaction effort. .

5.3.1 Samples

The Engineer reserves the right to have samples cut or cored from the completed project or as MatCon is being placed. Additionally, the Engineer may take samples of the uncompressed MatCon mixtures as well as all materials incorporated in the work. Where samples have been taken from the uncompressed MatCon, new material shall be placed and compacted to conform with the surrounding area at no additional expense to the Contracting Agency.

5.3.2 Surface Smoothness

The completed dense MatCon surface shall be of uniform texture, smooth, uniform as to crown and grade, and free from defects of all kinds. The primary purpose of a MatCon surface is to achieve the required impermeability and surface drainage. Site configuration, obstructions and contours do not always allow sufficiently long runs for paving equipment. For that reason, typical highway surface smoothness requirements are generally not applicable for most project sites.

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To the extent practicable, the surface smoothness of the finished MatCon surface shall meet the requirements of US Army Corps of Engineers Specification 02551, Sections 1.6 and 3.14. After completion of final rolling, the compacted surface will be tested by the Contractor with a 12-foot straightedge. Any joint or mat surface area deviation which exceeds the tolerances given in paragraph 1.6, GRADE AND SURFACE-SMOOTHNESS REQUIREMENTS, by more than 40 percent shall be corrected to meet specification requirements.

Table 4: MatCon Quality Assurance Matrix Table

PHASE ON/OFF SITE	DESCRIPTION	LOCATION	TEST PARAMETERS	TIMING/ FREQUENCY	COMMENTS
***MatCon HMA* On-Site**	Sample & Test MatCon at Haul Truck on Site	Each Haul Truck at Site prior to off-load	1) Temperature 2) Tonnage	1-2) on each weigh ticket by truck number & grid	All Data on appropriate QC Form
***MatCon HMA Lay-down and Compaction* On-Site**	Sample and Test MatCon as placed/compacted	As paved onsite	1) Temperature	Each site grid as placed	All Data on appropriate QC Form
			2) Thickness	Each site grid as placed	
		As compacted	1) Temperature	1 ea per grid as compacted	1-3) All Data to Wilder on appropriate QC Forms
			2) Thickness	1 ea per grid as compacted	
			3) In-place Density	5 ea per grid as compacted	
		Post compaction and cooling to ambient	4" diameter full-depth core sample – one sample per 20,000 sf of asphalt placed	Per Specification clause 3.13 of contract specification	Samples to Wilder
***MatCon Surface During Construction* On-Site**	Site Construction Map	MatCon Surface as Paved	Locate all grids and sample locations	Prepare prior to paving, use during construction	Wilder to utilize during QA Tracking
***Final MatCon Surface* Off Site**	As-built Site Plan	MatCon Paved Surface and Appurtenances/ Structures	Locate all grids, sample locations, and appurtenances	Prepare from Site Construction Map	Wilder to submit with Final QA Report to OWNER or ENGINEER

NOTES:

1) The paving contractor is responsible for all costs for construction Quality Control of their contracted work per MatCon Guide Specifications
2) Wilder to provide Quality Assurance on the paving contractor's entire MatCon installation process
3) All samples to be collected in duplicate, unless noted (one for testing + one for archive by Wilder)
4) All samples to be handled in accordance with strict Chain-of-Custody protocol
5) Grid system to be established prior to paving and submitted with paving and rolling plan (Recommended grid system = 10 feet (paver width) x 200 ft = 2000 SF ~/= 500 tons for 4 inch nominal thickness)
6) All laboratory testing to be performed in accordance with USEPA SW-846 or ASTM test methods and procedures.
7) Construction and installations that fail to meet MatCon Guide Specifications to be corrected by Contractor

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Attachment B
Forms

WILDER

WILDER CONSTRUCTION COMPANY

FORM 1
MatCon™ Subbase/Aggregate Base Acceptance Form

Construction Contractor Information

Name: _____

Contact: _____

Address : _____

City, state, zip : _____

Telephone: _____ Fax: _____

Aggregate Base Requirements

Yes	*No*	The aggregate base:
1. ☐	☐	Extends laterally beyond the edges of the surface to receive MatCon™ by approximately five (5) to ten (10) feet in each direction (or up to a hard paved pre-existing surface)
2. ☐	☐	Is firm and unyielding when proof rolled by a loaded tandem-axle dump truck
3. ☐	☐	Has a grade that conforms to the contours of the final MatCon™ surface, less the nominal four (4) inch thickness of the MatCon™ to be installed, for water drainage
4. ☐	☐	Has a minimum slope of no less than 1.5% and no greater than 3:1 (H:V) with a surface grade tolerance of ± ½ inch
5. ☐	☐	Is staked for grade and survey control points with grade breaks clearly marked on the finished grade
6. ☐	☐	Was constructed using soil density vs. moisture content curves established for the material used in this construction
7. ☐	☐	Was constructed using a calibrated nuclear densometer for field measurements. If yes, who will maintain the data? Attach a copy to this form.

Field Density Data Custodian:

Name: _____ Firm: _____

Address: _____

City, state, zip_____

Phone: _____ Fax: _____E-mail_____

8. ☐ ☐ Was a survey performed that identifies the surface area prepared and its final contours?

9. ☐ ☐ Did the project OWNER/ENGINEER for the project approve the final subbase surface contours?

What corrective actions, if any, were taken to bring final surface contours into compliance with project plans?

PROOF-ROLLING: Locations to be noted on map, survey or site plan

Date performed: _____

Equipment used: _____

Wilder Inspector: _____

Notes

1. **Site Map Attached with:**

   - Field Nuclear Density test locations and results noted (if performed)
   - Surface area included in this inspection specified
   - Locations of proof-rolling marked

2. **Note any necessary corrective action to bring the following items into compliance for acceptance by Wilder Construction Company**

   - Surface area of subbase to be extended 5-10 feet beyond footprint of surface area to be paved with MatCon™

   - Grade tolerance of ± 0.5 inch

   - Firm and unyielding surface conditions

   - Slope is greater than 1.5%, unless previously approved and less than 3:1 (H:V)

   - Grading and survey control stakes are installed and labeled to OWNER/ENGINEER'S satisfaction with grade breaks clearly marked on final surface

   - Structure insertions, pipes, vaults, catch-basins, utility conduits are all installed in subbase grade

3. Other comments:

Inspected by: _____ Initials: _____ Date: _____

Accepted or Rejected by: _____ Date: _____
(*circle one*) Print Name

_____
Signature

_____
Title

Wilder Construction Company
1525 E. Marine View Drive
Everett, WA 98201-1927
(425) 551-3100

WILDER

WILDER CONSTRUCTION COMPANY

FORM 2
MatCon™ HMA Facility Initial Inspection Form

Wilder Project No.: _____ **Client Name:** _____

Project Name: _____

Project Address

Street: _____

City: _____ **State:** ____ **Zip:** _____

Hot-Mix Facility Owner: _____

Facility Address

Street: _____

City: _____ **State:** ____ **Zip:** _____

Facility Phone Number/Fax: _____/_____

Facility Manager: _____ **Direct Phone No.:**_____

Facility Operator: _____ **Direct Phone No.:**_____

EMERGENCY FACILITY CONTACT: _____

Phone No.: _____ **Mobile Cell No.:** _____

Facility is in compliance with local, state, and federal permits, licenses, and other regulations?

( ) **Yes, facility is currently operating without infractions or permit violations.**

( ) **No, facility is currently in violation of applicable permits, licenses or regulations as listed on attached form.** Include copy of letters, correspondence, that address the infraction. Provide a statement from the facility discussing its corrective action plan.

MatCon Binder Storage Tanks

Yes	*No*	
☐	☐	Tanks are equipped to heat and hold material at 310-345°F using steam coils, electricity or other approved means so that no flame is in contact with the storage tank.
☐	☐	Binder material is totally and continuously circulated during the operation period
☐	☐	The binder is able to be measured while in the tank
☐	☐	The supply line to the mixer contains a valve for sampling

_____tons **Project MatCon Hot-Mix Tonnage**

Projects involving 5000 TN or more

Yes	*No*	*N/A*	
☐	☐	☐	Minimum Capacity of 2000 Lbs./Batch (Batch Facilities)
☐	☐	☐	Minimum Capacity of 100 TN/hr (Continuous Mix/Rotary Drum Facilities.)

Projects involving < 5000 TN

Yes	*No*	*N/A*	
☐	☐	☐	Minimum Capacity of 1000 Lbs./Batch (Batch Facilities)
☐	☐	☐	Minimum Capacity of 45 TN/hr (Continuous Mix/Rotary Drum Facilities)

Facility and Truck Scales

Yes	***No***	
☐	☐	Tolerance = ± 0.5% Throughout range of use
☐	☐	Not to include spring balances
☐	☐	Includes beams, dials, or other reliable readout equipment
☐	☐	Dials, beams, rods, and scale mechanisms are safely/easily viewed

Name of Inspector:_____Initials:_____Date:_____

Company Name:_____

Facility and Truck Scales (continued)

Yes	*No*	
☐	☐	Scale is located and built to prevent vibrating, binding of parts, and displacement
☐	☐	All working parts of scale are protected from falling material, wind, and weather
☐	☐	Knife edges/load cells are given extra care and protection
☐	☐	Scale is calibrated in accordance with standard specifications for the state where work is to be performed and per manufacturers specifications. ATTACH COPY OF MOST RECENT CALIBRATION CERTIFICATION

Batching Scales

Yes	*No*	
☐	☐	Approved scales operated by qualified person(s) employed by the contractor
☐	☐	Each scale designed to support a weighing hopper
☐	☐	Designed to allow convenience of operator to remove material from hopper while watching read-out devices
☐	☐	If hopper mounted on platform scale, the center of gravity of the hopper is directly over the platform centerline

Feeder for Drier or Drum Mixer

Yes	*No*	
☐	☐	There is an accurate, mechanical means for uniformly feeding the aggregate to the drier in order to obtain uniform production and temperature
☐	☐	The feeder for blending sand provides consistent and uniform flow in the amount designated by the engineer

Storage Bins

Yes	*No*	
☐	☐	Each bin is provided with overflow pipes sized to prevent material from backing up into other components or bins

Dust Collector

Yes	*No*	
☐	☐	The facility is equipped with a dust collector constructed to waste, or return uniformly to the hot elevator, all or any part of material collected

Name of Inspector:_____Initials:_____Date:_____

Company Name:_____

Dust Collector, (continued)

Yes	*No*	
		If a baghouse is used:
☐	☐	The material is returned from the baghouse into the mixture at a uniform, continuous rate and is provided with a method of withdrawing the surplus independently for disposal

Burner Fuel

Yes	*No*	
☐	☐	Burner fuel is restricted to propane, butane, natural gas, methane, coal, No. 1 or No. 2 fuel oil or other as accepted by the state Department of Transportation

Temperature

Temperature can be monitored on a continuous and instantaneous basis(± 0.5 ° F) at the following areas

Yes	*No*	
☐	☐	Aggregate feed bins
☐	☐	Aggregate drier
☐	☐	Mix chamber
☐	☐	Hot mix at discharge chute
☐	☐	Binder tank

Additional Requirements for Batch Facilities

MatCon Binder Bucket

Yes	*No*	
☐	☐	Bucket is non-tilting type with loose sheet metal cover
☐	☐	Discharge opening or spray bar is not less than 75% of the length of the mixer and discharges directly to the mixer
☐	☐	The bucket, valves, and/or spray bar are appropriately heated (If steam jackets are used, all connections are constructed as to not interfere with asphalt scale operation
☐	☐	Bucket capacity is at least 15% in excess of the weight of binder material required in any batch

Name of Inspector:_____Initials:_____Date:_____

Company Name:_____

MatCon Binder Bucket, (continued)

Yes	*No*	
☐	☐	There is an adequately heated, quick acting, non-drip charging valve directly over the asphalt material bucket (The indicator dial has a capacity of at least 15% of the quantity of binder material used in a batch)
☐	☐	The controls may be locked at any dial setting and will automatically reset to that reading after each batch
☐	☐	The dial is in full view of the operator
☐	☐	The flow of binder material is automatically controlled and will begin when the dry mixing period is complete
☐	☐	All binder material required for one batch is discharged in not more than (fifteen 15) seconds after the flow has started
☐	☐	The size and spacing of the binder material flow provides a uniform application the full length of the mixer

Mixer

Yes	*No*	
☐	☐	Mixer is capable of producing a uniform mix meeting requirements of the project specifications
☐	☐	The mixer is enclosed or equipped with a dust hood to prevent loss of dust
☐	☐	Clearance of the mixer blades from all fixed or moving parts does not exceed one (1) inch when the maximum diameter of aggregate is < one and one-half (1.5) inches. When maximum diameter of the aggregate is > one and one-half (1.5) inches, blade clearance does not exceed one and one-half (1.5) inches
☐	☐	The facility is capable of regulating mixing time in five (5) second increments
☐	☐	All proportioning and timing devices are automatic for projects 5000 TN or larger

Additional Requirements for Rotary Drum Facilities

Facility Feeder

Yes	*No*	
☐	☐	The feeder is capable of uniformly introducing aggregate to the drum
☐	☐	The aggregate feeder is synchronized with the MatCon binder material feeder
☐	☐	If feed of aggregate of asphalt is interrupted, a warning is automatically activated

Name of Inspector:_____Initials:_____Date:_____

Company Name:_____

WILDER

WILDER CONSTRUCTION COMPANY

FORM 3
MatCon™ Job Mix Formula Summary Form
MatCon Construction Quality Control

NOTE: Each asphalt laboratory utilizes their own Job Mix Formula (JMF) form.

The form to be inserted will be provided by the laboratory performing the mix-design.

Data contained on this form is strictly confidential.

Data to be presented on this form is generated during the mix-design. It contains information critical to MatCon HMA manufacture and includes:

1. Aggregate gradation
2. Percent aggregate by HMAF stockpile or bin
3. MatCon Binder content
4. Other additives required such as anti-strip
5. Water sensitivity/TSR
6. Recommended mixing temperature
7. Recommended compaction temperature at lay-down

Laboratory Approval of JMF
Wilder Representative Approval Signature and Date

HMA Facility - Aggregates
MatCon Construction Qualilty Control

HMAP - Aggregates	Job:_____			Date:_____		
Activity	**Time**	**Time**	**Time**	**Time**	**Time**	**Time**
Aggregate stockpile construction is consistent with specs (*Note 1)						
	Time	**Time**	**Time**	**Time**	**Time**	**Time**
Observe removal of aggregates from stockpiles (*Note 2)						
	Time	**Time**	**Time**	**Time**	**Time**	**Time**
Test and verify aggregate gradation (*Note 3)						
	Once prior to plant approval					
Inspect aggregate screens at Batch Plants (*Note 4)	Notes:					
	Once prior to plant approval					
Inspect aggregate/mineral storage bins (*Note 5)	Notes:					
	Time/Temp	**Time/Temp**	**Time/Temp**	**Time/Temp**	**Time/Temp**	**Time/Temp**
Check temp. at discharge chute of drier (*Note 6)						

***Note 1:** Stockpile construction - standard state department of transportation specification compliant
***Note 2:** Removal of aggregate from stockpiles shall be performed per standard state department of transportation specification compliant.
***Note 3:** Assure uniformity in size distribution using applicable state approved method
***Note 4:** Verify screens are capable of screening all aggregates to specified sizes and proportions and have capacities in excess of the full capacity of the mixer
***Note 5:** Storage bins will be of sufficient capacity to supply the mixer when operating at full capacity. Bins will be arranged to ensure separate and adequate storage of appropriate fractions of aggregates. Separate, dry storage shall be provided for mineral filler. Bins to incorporate an outlet gate with no leakage when closed quickly and completely. Bins shall be equipped with adequate, telltale devices to indicate the level in the bin has reached the lower quarter point and be constructed so that samples can be readily obtained.

***Note 6:** The plant shall be equipped with an approved thermometer placed at the discharge chute of the drier in full view of the operator to automatically register or indicate the temperature of the heated aggregates.

Inspector's Notes:

QC Technician: _____ _____ **Date:** _____
Print Name **Signature**

Firm: _____ **Wilder Representative:** _____ **Date**_____

HMA Facility - MatCon Binder Monitoring
MatCon Construction Quality Control

HMAF+A19 - MatCon Liquid Binder **JOB:** _____ **DATE:** _____

Empty storage tank free of residuals prior to binder delivery.
Two 1 qt. samples (lab & archive) collected from each binder delivery truck.
Take binder temperature of each load as delivered.

Activity	Time/Temp	Time/Temp	Time/Temp	Time/Temp	Time/Temp	Time/Temp
MatCon binder storage tank temperature *Note 1						
	Time	Time	Time	Time	Time	Time
MatCon binder sample taken, circulation of binder varified *Note 2						
	Time/Level	Time/Level	Time/Level	Time/Level	Time/Level	Time/Level
MatCon binder level in tank						
	Time/Rate	Time/Rate	Time/Rate	Time/Rate	Time/Rate	Time/Rate
MatCon binder flow rate to mixer *Note 3						

***Note 1:** An armored thermometer of adequate range shall be fixed in the MatCon binder feed line near the charging valve. Temperature range should be between _____ and _____ degrees F. *(temperature range determined during mix design)*

***Note 2:** A valve shall be placed in the supply line to the mixer for sampling

***Note 3:** Satisfactory means, by weighing or metering, shall be provided to obtain the proper amount of MatCon binder in the mix. Means shall be provided for checking the flow rate of MatCon binder into the mixer.
The MatCon binder may also be proportioned by a device which sprays the binder into the mixer using six (6) or more nozzles. In this case, the proportion or weight of MatCon binder material for each batch will be determined incorporating a positive rotating meter which is calibrated in pounds. The metering device shall have an established background and the approval of the Engineer.

Percent Anti-strip additive used _____% Brand _____ Type _____

Inspector's Notes:

QC Technician: _____ _____ **Date:** _____
Print Name Signature

Firm: _____ **Wilder Representative:** _____

HMA Facility - Scales and Weights
MatCon Construction Quality Control

HMAF - Scales and Weights	Job:_____				Date_____	
Activity	**Time**	**Time**	**Time**	**Time**	**Time**	**Time**
Inspect scale bunkers and platforms (*Note 1)						
	Time/Wt	**Time/Wt**	**Time/Wt**	**Time/Wt**	**Time/Wt**	**Time/Wt**
Test Batching scales (*Notes 2&3)						
	Time/Wt	**Time/Wt**	**Time/Wt**	**Time/Wt**	**Time/Wt**	**Time/Wt**
Test Platform scales (*Notes 2&3)						
	Time	**Time**	**Time**	**Time**	**Time**	**Time**
Inspect Platform scale load ticket (*Note 3)						
If commercial platform scale is used	**Contractor to provide load tickets in accordance with *Note 3. See also Note 2**					
	Tare weight 1			**Tare weight 2**		
Tare weight of haul vehicle (Twice Daily)	**Truck #**	**Weight**	**Time**	**Weight**	**Truck #**	**Time**

***Note 1:** Bunkers and platforms will be kept clear of accumulated material/debris that may cause errors

***Note 2:** At each batching and platform scale location, the contractor shall have available not less than 10 standard 50-pound weights or other approved equipment for scale calibration and testing. All scales shall be calibrated and certified per applicable state department of transportation requirements.

For batching scales, An agent of the scale manufacturer shall test and service any scale before its use at any new site and then at 6 month intervals. At the Engineer's request, the contractor will test the scale using available, approved weight standards or other equipment while the inspector observes.

For platform scales, before use and then at 6 month intervals, the scale will be tested with at least 10,000 lbs. by an agent of it's manufacturer. The contractor will provide the Engineer with a copy of all final test results. (If a **commercial** platform scale is used, all test requirements apply and the contractor shall provide the scale operator with approved load tickets and the Material Receiver with legible, duplicate copies. The Engineer will also have guaranteed permission to observe the weighing and to check and compile the daily scale weight record.)

***Note 3:** Each weigh or load ticket shall contain gross, net, and tare weight and will identify the weighed material. A tare weight of each hauling vehicle shall be taken at least twice per day.

Inspector's Notes:

QC Technician: _____ _____ **Date:** _____

Print Name **Signature**

Firm: _____ **Wilder Representative:** _____**Date**_____

HMA Facility Monitoring Information and Test Data

MatCon Construction Quality Control

NOTE: This form to be provided by the HMA Facility that will manufacture MatCon HMA.

MatCon HMA Delivery Tracking Form
MatCon Construction Quality Control

Date:_____
Job:_____

	Time Onsite	Weigh Tag #	Temperature (°F) at Delivery	Lbs. Delivered	Panel/Grid ID Placement Location	Time Placed	Temperature (°F) Placed	Comments
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
			Total Lbs.					
			Total Tons					

General Notes / Comments:

QC Technician: _____ _____Date:_____
Print Name Signature

Firm: _____ Wilder Representative: _____

Attached: Truck Weigh Tickets
Attached: Map / Site Plan

MatCon Daily Density Summary Report
MatCon Construction Quality Control

Date:_____
Job:_____

						Test Results		
	Time	Pass/Panel #	Station Location	Test Location	Lbs/CF	% Density	% Air Voids	Comments
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
				Average				

General Notes / Comments:

QC Technician: _____ _____ Date:_____
Print Name Signature

Firm: _____ Wilder Representative: _____

Attached: Nuclear Density Calibration (per instrument manufacturer) data
Attached: Map / Site Plan
Attached: Field Form

Note: Correlation between air voids and hydraulic conductivity was established during mix design

MatCon Panel Placement and Compaction
MatCon Construction Quality Control

Panel Placement and Compaction	**Job:**_____		**Date:**_____	
Activity	**Time/Width/Thickness**	**Time/Width/Thickness**	**Time/Width/Thickness**	**Time/Width/Thickness**
Verify panel is within specifications (*Note 1)				
	Time/Results	**Time/Results**	**Time/Results**	**Time/Results**
Verify uniform and thorough compaction (*Note 2)				
	Panel/Time/Density	**Panel/Time/Density**	**Panel/Time/Density**	**Panel/Time/Density**
Field density of compacted panel (*Note 3)				
	Time/Results	**Time/Results**	**Time/Results**	**Time/Results**
Inspect cold joints (if any) (*Note 4)				

***Note 1:** Unless otherwise directed by WILDER or specified in the plans, the nominal compacted depth of dense or open graded MatCon shall be four (4) inches. The panel width shall be as specified in the plans or approved by Wilder.
***Note 2:** The compacted course shall be smooth, in conformance with the line, grade, and cross-section shown in the plans or as directed by Wilder, and free of irregularities. Roller compaction shall prevent thinning near panel edges.
***Note 3:** The field density of the compacted MatCon shall be measured using a nuclear gage in accordance with ASTM D2950. The nuclear density shall be within specifications as directed by Wilder. Air void percentage shall be three (3) percent or less, or as approved by Wilder.
***Note 4:** Cold joints are to be avoided by keeping paving panels short enough so that the start of a new panel is placed against a joint that is still hot and not yet compacted. At the end of a work shift or when a break in paving activity is anticipated, the cold joint shall be configured, constructedand finished as directed by Wilder or as specified in the plans. All cold joints shall be located on the site lay-out plan with coordinates identified for future identification. Cold joint cross-section sketch shall be provided below.

Inspector Notes:

QC Technician: _____ _____ Date: _____
Print Name Signature

Firm: _____ Wilder Representative: _____Date_____

MatCon® Cap Operation and Maintenance Plan For Installation of an Impermeable MatCon® Modified Asphalt Cap at Los Alamos National Laboratory Airport Landfill

Prepared by:

Wilder Construction Company
1525 East Marine View Drive
Everett, WA 98221

April 15, 2006

WILDER
WILDER CONSTRUCTION COMPANY

"This data, furnished in connection with this submittal, shall not be disclosed outside the Client and shall not be duplicated, used, or disclosed in whole or in part for any purpose other than to evaluate or implement this MatCon Operation and Maintenance Plan. The Client shall have a right to duplicate, use, or disclose this data to the extent provided in the contract. This restriction does not apply to the Client for its submittal of this document to the regulatory agency(ies) for their evaluation, but does apply to the regulatory agency(ies) as related to their duplication, disclosure and use of the data. The data subject to this restriction is contained on all sheets of this submittal."

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CONTENTS

1. PURPOSE AND SCOPE 4

2. STANDARD SITE OPERATION AND OPERATIONAL LIMITATIONS 4

2.1 Loading 4

2.2 Chemical Resistance 4

2.3 General Guidelines for Operations 4

2.3.1 Acceptable Operations and Surface Traffic 5

2.4 Typically Proposed Operations 6

3. VISUAL INSPECTION AND EVALUATION 6

3.1 Inspection and Evaluation Schedule 6

3.2 Inspection Requirements 7

3.3 Inspection Procedures 8

3.4 Types of Distress 8

3.5 Hydraulic Conductivity Monitoring 11

3.6 Overall Assessment of Performance 11

4. RECOMMENDED MAINTENANCE AND REPAIR PROCEDURES 11

4.1 Crack Sealing 12

4.2 Fog Seal 13

4.3 Patching and Overlay 13

4.4 Traffic Control striping 14

4.5 Sealing to Concrete Slabs and Structures 15

4.6 Sealing Penetrations 15

Attachment A—Load Equivalency Factors

Attachment B—Forms

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FIGURES

1. Cross Section of Crack Sealing 16

2. Typical Patching Configurations. 16

3. Shallow Patch to Repair Surface Defect. 17

4. Full Depth Patch to Repair Crack. 17

5a. Sealing the edge of MatCon HMA placed against existing concrete structure. 18

5b. Sealing the edge of MatCon HMA placed in a "step" in the concrete structure. 18

6. Sealing Full-Depth Penetration in a MatCon Cap. 19

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1. PURPOSE AND SCOPE

The primary purpose of this document is to provide guidelines for the ongoing operation and maintenance of the MatCon® cap at the Los Alamos Airport Landfill. The operation and maintenance requirements are necessary to prolong the integrity and performance of the installation and assure that any failure or potential failure of the low permeability barrier system is discovered and repaired. As a secondary objective, this plan outlines operations and maintenance requirements that are necessary to the care and use of the MatCon cap as a surface suitable for light aircraft taxi, parking, vehicle traffic, materials storage, and various staging activities.

2. STANDARD SITE OPERATION AND OPERATIONAL LIMITATIONS

The site shall be operated such that its use does not conflict with the essential purpose of the cap. "Normal use" of a MatCon cap is defined in the first order as a RCRA cap with a low hydraulic conductivity coefficient of <1.0 x 10-8 cm/sec. Second order use permits controlled light aircraft taxi and parking, vehicular traffic and parking, storage of equipment and materials, placement of light structures such as aircraft hangars as well as recreation and additional cover materials such as soil and vegetation. It is essential that those who manage, direct, utilize, or actually perform work on the surface during ongoing facility operations and those who may plan and/or implement future modified uses for the site realize that the primary intended use of the MatCon cap is as a long-term barrier and containment system of low permeability to environmental contaminants beneath the surface. It is, therefore, paramount that all current and future use of the installation be carefully considered and controlled so as to not penetrate, gouge, or otherwise inflict damage to the surface of the system, either mechanically, statically, or chemically. Penetrations may be made for site improvement such as anchor points, building tie-downs, utility poles and bollards if the penetrations are designed to prevent water build-up around the penetration and sealed as specified in this document. Specific precautionary considerations are as follows:

2.1 Loading

The MatCon cap surface is readily resistant to normal operations of rubber-tired vehicles and some heavier equipment. Care should be taken to avoid unnecessary point loads, gouging, or otherwise penetrating the surface with standing or moving loads.

2.2 Chemical Resistance

Although the MatCon Hot Mix asphalt (HMA) material is resistant to most chemicals, it is not immune to damage caused by petroleum solvents, such as gasoline, diesel fuel, lube oils, transmission fluid, or hydraulic fluid, etc. When inadvertent spills occur, they must be immediately blotted using industrial absorbents and then water flushed and vacuumed to remove any standing fluids. This cleaning should take place as soon as possible to minimize any damage to the MatCon cap. It is recognized that a minor spill may occur over a weekend or other non-work period and may not be discovered for up to several days, however in no cases shall the spill be allowed to remain uncleaned longer than 24 hours after discovery.

2.3 General Guidelines for Operations

Wilder Construction Company provides the following acceptable and unacceptable operational uses for MatCon cap installations. If unacceptable operations are conducted on the MatCon surface, such action will nullify the warranty in entirety.

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2.3.1 Acceptable Operations and Surface Traffic

- Automobiles
- Light aircraft
- Trucks and other vehicles of legal highway loading (not requiring special permits) such as 18-wheel semi truck/trailer, and fuel trucks.
- Repeated loading (accumulated) traffic of up to 500,000 ESALs (See: Section B.4).
- Pneumatic tired loaders, fork lifts, stackers, etc., with tire-to- MatCon HMA contact pressures of less than 100 psi*
- Single layer or stacked, empty or loaded ship containers with flat bottoms that impart combined contact pressures to the MatCon capof less than 100 psi
- Storage of "dry" materials such as sand and gravel directly on the MatCon cap
- Storage of other materials if on wood pallets and contact pressure is less than 100 psi
- Light buildings with spread footings

The following OPERATIONS may be detrimental and need to be reviewed with Wilder

- Vehicles with greater than legal highway loading
- Studded or other cold weather traction tires/devices of all types
- Vehicles, loaders, forklifts, stackers, etc. with hard tires imparting contact pressure greater than 100 psi
- Steel (lugged, crawler-type) tracked vehicles (with rubber pads may be acceptable)
- Ship containers or equipment with foot pads, stacking pegs/lugs, rails or other protrusions that come in contact with the MatCon surface
- Excessive point loads and impact loads such as from dropping corners of portable storage containers, heavy equipment bucket teeth, etc.
- Any load imparting contact pressure in excess of 100psi
- Excessive heavy traffic concentrated in a narrow path (pathways can be varied, however)
- Long-standing water (ponding)
- Liquid chemicals (solvents) stored or spilled directly on the MatCon cap. This would include the fueling of aircraft parked on the MatCon surface. Such fueling operations would be best done at a less critical location.
- General abuse caused by scraping and gouging with heavy equipment buckets and other equipment.

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***NOTE:** Tire air pressure (psig) is usually less than the tire-to-MatCon HMA contact pressure of 100 psi because of the stiffening effect of truck tire sidewalls. Light aircraft tires generally do not have this characteristic and the tire pressure is equal to the contact pressure.

2.4 Typically Proposed Operations

In addition to light aircraft, vehicles and aircraft hangars, operations on this site may include parking of automobiles, semi-trailers, light traffic, light industrial operations, and storage uses. If the loads are expected to be heavy, there should not be excessive repetitions. Because this use has the potential to inflict damage on the cap surface, precautions should be taken to reduce the opportunity for damage. Rutting or depressions resulting from concentrated heavy use is beyond the MatCon cap's warranty, but such damage can be readily repaired in accordance with the requirements in this plan. Note that such damage may not in itself reduce the permeability of the MatCon surface. It is suggested that a sacrificial layer of high quality conventional asphalt pavement applied directly on the MatCon surface be utilized wherever heavy or excessive use is expected or where operations may damage the surface.

Although the MatCon cap is designed primarily for environmental containment, the surface will carry considerable repetitions of highway-type vehicles. The MatCon cap is warranted for up to 500,000 18,000 lb. Equivalent Single Axle Loads (ESALs) before requiring structural repair and/or overlay consideration within the warranty period. The accumulated number of ESALs over a given surface area or access driveway can be calculated from the data in Table A-1 (Attachment A) similar to the following example:

Example: A fully loaded panel truck with a single front axle (10,000 lb.) and a tandem rear axle (40,000 lb.).

- Front axle Load equivalency factor (from Table 1) = 0.0877
- Rear axle Load equivalency factor (from Table 1) = 2.0800
- Number of 18,000 lb. ESAL per operation = 2.1677.

This vehicle entering and leaving each day for 5 days per week over the same surface area results in (2.1677 ESALs x 2 passes x 5 days/week x 52 days per year) 1,127 ESALs per year on that particular surface area. Note that the heaviest traffic will usually be the driveway entrance to the site.

An assessment of the affect on the MatCon cap of any proposed changes in the use of the facility shall be made prior to implementing such changes. Heavy and/or prolonged use of the facility in concentrated areas, or changes in use of the facility should also trigger interim or more frequent inspections and evaluations.

An inspection of all affected areas of the cap shall also be performed at any time a site incident, activity, or atypical weather event may have caused reason to suspect potential damage to the MatCon system.

3. VISUAL INSPECTION AND EVALUATION

3.1 Inspection and Evaluation Schedule

The inspection process is a key part of evaluating and maintaining the MatCon cap's performance. When the MatCon cap is exposed, it is relatively easy to make required routine and regular inspections. There will be three types of inspections as follows:

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a. **Annual.** Wilder Construction Company will perform a thorough evaluation at the conclusion of construction, and again at each 1-Year anniversary of construction thereafter during the 5-year warranty period. Similar annual inspections, providing a detailed assessment of the MatCon cap, shall be conducted by the owner/operator at one-year intervals thereafter. Any inspections performed at times corresponding to any regulatory agency planned reviews should be coordinated with and accomplished prior to or as part of this annual review. The owner, U.S. EPA and/or state or local regulators can be alerted at least 30 days prior to all annual inspections, to allow them for their participation, should they so choose.

b. **Quarterly.** The owner/operator shall make routine and regular inspections monthly during the design life.

c. **Special.** Interim inspections shall be made of all affected areas of the cap, at any time a site incident, activity, or atypical weather event may have caused reason to suspect potential damage to the MatCon system. Such inspections shall also be made if there are changes in use of the facility or if the site is subject to heavy and/or prolonged use in concentrated areas.

Since Wilder Construction, designed the MatCon hot mix asphalt, provided the binder material and quality assurance during construction and has warranty responsibilities, they shall be afforded an opportunity to participate in all inspections during the warranty period. In addition, Wilder may request the results of any inspections made by the owner/operator during the warranty period. Wilder reserves the right to make more frequent inspections to facilitate proper operation and maintenance, as it feels necessary.

3.2 Inspection Requirements

A visual inspection will require a careful walking of the entire surface and careful documentation of any notable features and surface uses. Although the distress types to be considered, (as noted in Section C.4, below), are most important, the inspection record shall also include the following information:

- Name, position and employer of inspector(s)
- Date, time, and weather conditions at time of inspection.
- Carefully prepared scale map of the facility such as an as-built drawing, to note location and type of any distress, and/or activity (storage, new structures, etc.) using GPS coordinates.
- Description of use since last inspection and comments on any planned changes
- Photographs, including overall views showing current use and condition as well as close-up views of any distress such as cracking, ponding, and referenced to any descriptive notes.
- Vital information such as when the cap was constructed, the contractor, previous maintenance, or etc.
- Location and extent of any areas not inspected due to temporary storage items obscuring visibility.
- Location and condition of any penetrations such as tie-downs and the condition of the mastic seal material, including the possible need to re-seal.

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3.3 Inspection Procedures

Inspector(s) shall review as-built drawings and previous MatCon cap inspection reports prior to the inspection to familiarize themselves with the purpose and current status of the cap. The inspection will require a carefully planned walking inspection of the entire cap surface. All notable features shall be carefully documented in the report, on the data form (Attachment B) and on the site drawing. Any accumulated sediment and /or vegetation discovered on the surface shall be removed. Any contact between the MatCon cap and concrete or any other non-MatCon materials shall be inspected for separation or cracking,

A standardized procedure shall be used for the inspection by trained professionals so that results can be compared consistently to previous inspections. The standardized procedure for both monthly and annual inspections shall utilize the "MatCon Cap Monthly Inspection Report" form attached as Attachment B.

At the time of construction, Wilder will instruct the owner/operator of the site in the techniques and reporting operations when they make the "as-built" evaluation. The monthly report requires only observations of operations and any observed distress and noting their location using GPS co-ordinates. If distress such as a crack is observed, only the reporting of it is required by the owner/operator of the site, without interpreting the cause and/or mitigation, unless the cause of the distress is actually known. Wilder may follow up with a more detailed evaluation as needed either at the time of the next annual inspection or immediately if warranted by the situation. Such reports and associated communications shall become part of the performance record. Suspected warranty problems or defects should be reported within 48 hours of discovery. Since many such problems or defects may be discovered during an inspection, an annual, monthly or special inspection report that indicates a problem or defect that may be a potential warranty issue shall be considered acceptable warranty notification.

3.4 Types of Distress

There are several types of distress that may affect the MatCon surface that may be observed during inspections. The following discussion is intended to provide a general understanding of the types and causes of possible MatCon material deterioration with use and time. It is important, if observed, that they are noted in the monthly and/or annual inspection. An experienced pavement engineer can often determine the cause of distress through analysis of the nature, location, type, and severity of the observed distress, and thus determine the best repair solution.

In order to ascertain responsibility for maintenance or repair under Wilder's warranty, it is helpful to classify the distress types as to their origin and probable cause.

<u>Distress to the MatCon cap that is covered by warranty.</u>

- Excessive weathering or disintegration
- Thermal cracking (non load-associated)
- Fatigue cracking (load-associated), if it occurs prior to the 500,000 ESAL limitation within the warranty period and is not related to underlying materials.

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Distress to the MatCon cap that is not covered by warranty.

- Abrasions, scuffing, or surface wear caused by equipment use.
- Settlement, subsidence, ponding of water caused by changing of underlying materials.
- Deformation or rutting caused by localized traffic or storage loading.
- Fatigue cracking (load-associated), unless it occurs prior to the 500,000 ESAL limitation within the warranty period and is not related to underlying materials.

The terminology used in environmental cap and cover facilities is different from that utilized to describe work, storage, traffic and other pavement surfaces. A clear understanding of the terms used in this plan is essential its proper implementation. The following is, therefore, established:

- **Remedy Failure.** The condition where the entire MatCon cap no longer performs as a RCRA cap under the first order use of the site. It is unlikely that this condition could exist as a MatCon cap can always be repaired.
- **Secondary Failure.** The condition where the entire site no longer performs as a suitable work surface under the second order use of the site.
- **Distress.** An impact to an area of the MatCon cap that may require repair, replacement, or other corrective actions so that either the primary or secondary uses of the site are continued.
- **Localized Distress.** A state of distress present with certain definable surface areas of the MatCon cap that compromises permeability, and thus the first order of use as a RCRA cap, and is beyond routine maintenance repairs requiring corrective fog sealing, patching, overlay, and/or subgrade or base repair. Localized failures can be repaired, replaced, or managed to allow both first and second order use.

Distress mechanisms such as thermal cracking are readily apparent when they occur. But other forms of distress such as weathering or disintegration can affect permeability, but are less obvious and some regular sampling and testing is required. Most distress can be managed through maintenance and repair actions so that impermeability is maintained. Most distress that may recur is likely to be localized, e.g., a soft spot in the underlying soil causes a crack. Another example would be fatigue cracking in the driveway, where truck traffic is focused. These and even occasional thermal cracks are localized "distress" rather than failure. Remedy failure would imply the need to replace or overlay the entire MatCon cap, and would be highly unlikely under any circumstances.

The following discussion is a general overview and description of distress types and can be used in conjunction with the inspections made monthly.

- **Surface deterioration.** Weathering, abrasion, scuffing, raveling, or surface wear that might be attributed to either environmental exposure or possible traffic. Comparison to unexposed or untrafficked areas during the inspections is helpful. If weathering is noted, consider the possible need for a restorative fog seal.

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- **Settlement, subsidence, ponding of water.** These situations are most likely caused by changing conditions of the underlying soil or waste rather than the MatCon cap. Localized differential settlement may cause some cracking, while widespread subsidence or consolidation most likely will not. Ponding of water may need to be corrected by overlaying to change the surface grade. Note the location and extent as well as depth. Spray paint demarcation on the MatCon surface will facilitate future inspections and spot relocation.

- **Deformation or rutting.** If heavy use such as equipment storage or truck traffic or parking has caused deformation, this should be noted separately from that caused by general settlement or consolidation. For example, repeated passes of heavy trucks may cause broad localized deformation that, in turn, results in cracking of the MatCon surface. Any distress will need to be repaired, but assessment of the cause and appropriate corrective measures are important to future performance. Minor deformation without cracking is tolerable and to be expected.

- **Cracking.** The two main types of cracking that may be observed are fatigue (caused by repeated heavy loads or "load-associated") or thermal (caused by low temperature and temperature fluctuations or "non load-associated").

  Although it is possible to get fatigue failure on a MatCon cap serving as a RCRA cap, it may also be an indication of abuse of the intended use. Fatigue or "alligator" cracking may be associated with repeated deflections under truck traffic.

  Thermal cracking is of most concern in broad expanses of asphalt pavements. Wide changes in air temperature, both long term (summer vs. winter), or short term (diurnal) are detrimental to the integrity of these facilities. As the temperature decreases, asphalt cools and wants to shrink, but is restrained by friction at the interface between the asphalt and underlying base material, and tensile stress builds up. If the temperature changes slowly, there is time for stress to be relieved in the asphalt binder (called stress relaxation), since it is viscoelastic. But if the change is rapid, such as overnight, there may not be time for stress to relax and it builds to a level that exceeds the strength, hence a crack.

  The design and materials used in MatCon HMA reduce the tendency to crack compared to conventional or standard asphalt. MatCon HMA is stronger and more elastomeric (stretches further without breaking). However, extreme situations may still cause cracking, such as thermal stress in combination (additive) with differential settlement. Often in conventional asphalts, thermal cracks do not penetrate a full 4-in. thickness, but start on the surface and progress only a short distance into the mat, then stop. Full depth cracking in the MatCon cap, if encountered, will need to be repaired, while surface checking may be corrected by a seal coat. Note the length (on map), depth, and width of cracks so that an estimate of required repairs may be made without re-surveying them.

- Performance of prior repairs. If present, a careful look at previously repaired cracks, core holes, sealing around pipes, foundations, patches, etc., needs to be made to assess how well they are doing. Any gaps or cracks caused by shrinkage or loss of adhesion should be noted, and close-up photographs taken so that comparison can be made to previous inspections. These MatCon cap repairs are made with modified binders, and paved or placed hot, so some shrinkage may occur and will need to be assessed to determine if follow-up repair is needed. Under no circumstances should the MatCon cap be repaired using conventional hot-mix asphalt or conventional asphalt binder. Use of MatCon hot-mix or binder is always preferred as that is the material that produces the impermeability and flexural properties.

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3.5 Hydraulic Conductivity Monitoring

Wilder may collect two (2) core samples during each annual inspection of the MatCon cap during the five (5) year material warranty, with the first set obtained immediately upon installation of the MatCon cap, and the remaining four sets collected annually thereafter. Samples will be analyzed for hydraulic conductivity by a reputable laboratory in accordance with ASTM D5084, Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials using Flexible Wall Permeameter. This will continue at annual inspections thereafter.

The two core samples will be taken from locations that appear to be representative of the site. The need to minimize perforations of the MatCon surface to maintain integrity is essential to long-term performance. Therefore, core sampling should be confined to a non-critical area, outside of traffic zones, whenever possible. Backfilled core holes may become a point of stress concentrations under loading.

If the tests on the core samples show the coefficient of permeability to be less than 1x10-8 cm/sec, no action would be required. If the test results show that the permeability is greater than 1x10-8 cm/sec, or if the trend from past tests show increasing permeability with time, Wilder may elect to fog seal the area as a preventative measure. It is difficult to predict the scenarios that may occur in future years. But if the core sample testing shows marginal permeability results or there is concern because of adverse testing to define the extent and severity of increased permeability, Wilder may elect to perform additional sampling and testing to define the extent and severity of increased permeability. At Wilder's option, all of the MatCon surface or only selected areas may receive a fog seal to reduce the permeability, while still meeting the warranted performance. Increased permeability can also be addressed by implementing changes in the surface operations and maintenance. This same procedure is required for the time period beyond Wilder's warranty as part of this maintenance plan. Wilder reserves the right to analyze the core samples for other test parameters at its discretion. All permeability data will be presented in the annual inspection report.

3.6 Overall Assessment of Performance

The inspection report shall summarize the general condition of the MatCon cap by checking the appropriate rating on the MatCon Cap Monthly Inspection Report form included as Attachment B. Annual inspections shall also provide a narrative discussion that includes the inspector's reasoning and any special conditions not already covered. Most important - the report shall make recommendations as to what to do and when. Photographs and the site drawing shall be attached. Finally, the inspector shall discuss the evaluation and recommendations with the owner or operations manager before leaving the site. A copy of all monthly reports shall be sent to Wilder Construction Company. Additional copies shall be maintained by the OWNER, the ENGINEER, and/or sent to the applicable regulatory agency as required. Upon review of the report, and in conjunction with the OWNER/Operator, Wilder shall make recommendations as to the determination and timing of any required corrective action(s).

4. RECOMMENDED MAINTENANCE AND REPAIR PROCEDURES

All deficiencies identified in the inspection report shall be corrected or repaired in accordance with this plan. Once these corrections or deficiencies are complete a Corrective Action Report shall be prepared documenting the repair activities. A copy of this report shall be sent to Wilder Construction Company, the OWNER, the manager of the facilities operations, and the applicable regulatory agency as required.

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4.1 Crack Sealing

Any crack that is at least one inch deep shall be routed out rather than sawed or cut because better control can be achieved. A cross-section configuration as shown in Figure 1 is recommended because it provides both a reservoir for sealant and additional sealing at the lips of the crack. A vertical-spindle router is least damaging and most maneuverable to follow random cracking. Rotary-impact routers may be more productive, but also tend to cause more damage along the edges.

Following routing, air blasting is required to remove dust, debris, and any loosened fragments. Hot air blasting with a compressed-air lance or heat lance is required to help remove any moisture and it aids in improving the bonding of hot-applied sealant. The sealant shall be applied immediately following hot air blasting.

Hot-applied thermoplastic crack sealer can be applied using an asphalt distributor, but it is much better to use an asphalt kettle/melter. Modified asphalt material must be heated to a higher temperature than can be achieved and maintained with a distributor. Application can be done using a dish-shaped attachment at the end of the crack filling wand for one- step application. However, to assure that the crack and routed reservoir are uniformly filled, it may be best to use two steps: first fill the crack with the application wand and immediately shape the top using a 'U' - shaped industrial squeegee. Blotting with sand is probably not required with modified asphalt and since it is unlikely to be trafficked, as in a highway. The selection of type and grade of material will be approved by Wilder Construction to assure compatibility with the MatCon surface.

Contact the manufacturer Wilder Construction Company, 1525 East Marine View Drive, Everett, WA 98221, phone (800) 377-0954 for acceptable crack sealers.

A few days following crack sealing, the work should be inspected and any defects re-sealed.

Routine crack sealing of occasional or sporadic cracking will be adequate to maintain the MatCon cap's primary function as a low permeability RCRA cap. A few days following crack sealing, the project should be inspected and any imperfections touched up. Previously sealed cracks will be inspected on a monthly schedule, and re-sealed as necessary. It is unlikely that cracking would extend over a wide area or the entire project, and is more likely to be localized. However, if non load-associated cracking increases with time, consideration should be given to alternative repairs. For example, if cracking caused by differential settlement or thermal conditions extends or increases such that crack spacing is less than 5 feet within the localized area, consideration should be given to patching or overlaying that area. The decision is one of economics, since both repair methods will maintain low permeability. Crack sealing is a low cost option, so more extensive repairs will need to be carefully considered before a decision is made to replace or overlay the MatCon cap.

Regardless of cost considerations, the accumulation of a total 100 linear feet of cracks that are repaired by sealing within a 320 sq.ft. area, shall trigger either of the following actions:

1. Exclude and isolate the repaired area from any surface traffic, use or loading, by means of permanent fences or barriers; or

2. Remove the distressed area and replace with new MatCon HMA using proper cold joint methods. Such replacement may also require underlying base course material removal and reconstruction prior to reinstallation of MatCon HMA.

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With either alternative, the MatCon cap's low permeability and performance as a RCRA cap will be maintained. The presence of 100 linear feet of cracks within the 320 sq.ft. of the MatCon cap does not constitute a failure as a RCRA cap, however, it does establish a limit for the use of the cap as a work, storage, or traffic area, unless it is replaced.

The 100 linear feet limit of repaired cracks is based upon the size of the unaffected MatCon cap areas and their collective stability within the area when subjected to a surface load. The 320 square feet surface area is consistent with the dimensions of an eight (8) feet wide by forty (40) feet long semi-truck and trailer, or ship container. Even if properly repaired cracks exceed the 100 linear feet per 320 sq.ft. surface area limit, the repaired MatCon cap will still serve the primary intended purpose as a RCRA cap. However, subsequent surface use and loading may further distress the area beyond cost beneficial and effective repair.

4.2 Fog Seal

A fog seal is a uniformly sprayed application of a specially prepared modified-asphalt emulsion. It is applied with a distributor for most areas and for close quarters or adjacent to structures, pipes, etc., a wand with a single spray nozzle is best used.

Cleaning prior to seal coating can generally be accomplished using a power broom and/or truck mounted vacuum cleaner to remove dirt and loose debris. In some instances, water jets may be required to loosen dirt or mud that is adhered to the MatCon surface.

The surface must be dry and above 60°F at the time of application. Warm weather is required for the emulsion to 'break' and cure properly. Application rate should be approximately 0.50 gallon per square yard. The actual rate may be adjusted and fine-tuned at the beginning of the project to account for surface texture and curing rate. The selection of type and grade of material will be approved by Wilder Construction to assure compatibility with the MatCon surface.

For this site, Wilder Construction Company must be consulted prior to the selection and application of any fog seal material. Site and weather conditions at the time of application will dictate the sealant to be utilized.

Wilder Construction Company
1525 East Marine View Drive, Everett, WA 98221
Contact: Mr. Jerry Thayer, MatCon Program Manager
Telephone: (425) 551-3100

4.3 Patching and Overlay

In some instances, a large crack or depressed area may need to be patched using MatCon material or other Wilder approved material. Patches may range from a few square yards to much larger areas. These materials and construction procedures will follow the same high standards and protocols required for the original MatCon cap installation.

An advantage of patching a MatCon cap is that, in most instances, the original MatCon surface will not be cut out and removed. Rather, the patch, or overlay, can be shaped to cover the crack and tapered at the edges to provide a smooth transition. An example is shown in Figure 2. A patch can also be used to correct the grade and drainage of the surface (ponding, for example) when localized subsidence has changed the profile. Any cracks will be sealed prior to patching. Thickness of the overlay may be variable, but in critical areas should not be less than four (4) inches. Multiple overlays (layered) may be

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required to correct extreme settlement. All edges, tapers, and surfaces of the patch should be fog sealed at the time of construction.

For areas that are cracked and no differential settlement has occurred, crack repair may require more elaborate procedures as shown in Figures 3 and 4. Shallow cracks or gouges can be repaired after milling out about 1 inch as shown in Figure 3. If a crack extends through the entire MatCon surface, then all the material adjacent to the crack should be removed by sawing. A multi stage operation providing a step configuration, such as a MatCon cap cold joint, is preferred.

For areas such as driveways or aisles where heavy traffic is concentrated, fatigue cracking may occur and will require special repair techniques. Fatigue or alligator cracking of the MatCon cap is caused by repeated flexure of the mat. The material can accommodate accumulated repetitions whether they are caused by excessive wheel loading, or by soft underlying foundation materials; but it does not know the source. A typical area of fatigue distress would be a driveway 10 feet wide, with 5% of the area (i.e., wheel paths) exhibiting alligator cracking.

A wheel path exhibiting fatigue cracking is often accompanied by a depression, or rut, within the wheel path. By definition, if the maximum depression (measured with a straight edge across the wheel path) is less than ¼ inch, the fatigue cracking is caused by loading alone. If the depression (rut) is greater than ¼ inch, the cracking is also caused by repeated strain, but in turn, higher strain is induced because of soft or consolidating underlying foundation materials.

Any fatigue cracking discovered during an annual (or monthly) inspection and evaluation must be repaired, following the method for patching. If the accompanying rut or depression is greater than ¼ inch deep, it is caused by changing foundation materials, and is not covered by warranty. If the rut or depression is less than ¼ inch deep, it is more likely caused by traffic loading and falls under the 500,000 ESAL limitation. And accounting is made of all vehicular traffic using the "traffic path or pattern" by mutual agreement between the operator/owner of the Los Alamos Airport Cap. If at any time during the warranty period the cumulative ESALs have exceeded 500,000, the repair is not covered by the warranty. Corrective action following repair would include review and modifications to surface use operations. Subgrade failure distress mechanisms (e.g., upheaval, settlement, etc.) that impact the MatCon cap's integrity must be mitigated and repaired prior to any MatCon HMA replacement.

The selection of type and grade of material will be approved by Wilder Construction to assure compatibility with the MatCon surface. If the approved material(s) are unavailable, contact the manufacturer Wilder Construction 1525 East Marine View Drive, Everett, WA 98221, phone (800) 377-0954 for acceptable substitutes and the EPA for approval.

4.4 Traffic Control striping

The basic concept is to reduce the reflectance or albedo of the stripe to a value near that of the MatCon surface itself. The reason for this is that the MatCon HMA expands and contracts at a different rate under the stripe because of different reflectance during hot sunny days and cool nights. The result may be surface cracking along the edge of the stripe due to this repeated heating and cooling. One may observe this phenomenon yourself at crosswalks, etc.

Ideally, Wilder would like a black colored stripe (similar to that often used on portland cement concrete). This will work after a year or so when the surface has turned gray, providing sufficient contrast for parking delineation. But since newly paved surfaces will still be black, a higher contrast stripe is required. Conventional striping paint materials will suffice, with the following comments and recommendations:

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1. Paint should be water-based so that it can be thinned or reduced with water. This will eliminate the solvents used in other types, and will reduce any possible damage to the MatCon Binder. An example would be Fast Drying Water Reducible Acrylic, available from LaFarge Road Marking (www.lafargeroadmarking.com). But there are others on the market that will be familiar to the local paint applicators.

2. Yellow or white color is acceptable. Some other color such as green or blue is also ok.

3. Reduce the paint with water sufficiently to reduce the coverage to no more than one-third of what is normally used. This thinned paint should be applied at the same forward speed of the striping machine as is normally used, in order to achieve the lighter coverage. When painters use this procedure, the tendency is to slow down to apply more paint so that it looks like what they are accustomed to doing.

4. The idea is to reduce the density of color to less than one-third that of a solid stripe. The result will be stripes that look like they have been down for two or three years instead of new, but will still serve to provide guidance to drivers.

4.5 Sealing to Concrete Slabs and Structures

A seal is required at joints where the MatCon HMA abuts concrete structures. Typically, the concrete slab should be in place prior to paving with MatCon HMA. The exposed concrete slab edge should be coated with a heavy asphalt tack coat or MatCon Mastic (a highly modified, hot-applied asphalt based sealer provided by Wilder Construction Company). The MatCon HMA paving operation should be completed within 24 hours of coating the edge. After the paving operation is completed, the surface joint is further sealed with another coat at the joint line as in a fillet.

Two common options to seal are (a) straight abutment, and (b) step design. Figure 5A shows the details of the abutment with a concrete structure such as a foundation or slab, and should be prepared with mastic as described above. Figure 5B shows an option where an exceptionally good seal is needed, such as in a pond that will hold standing water. The foundation or wall is designed with a step, so that the MatCon HMA has a larger area of contact as well as a direct bearing on the concrete step, decreasing the likelihood for leakage.

4.6 Sealing Penetrations

Penetrations are often needed to add features such as fence posts light standards or tie-downs. It is advantageous to pave the entire site prior to installing penetrations whenever possible, because the density, voids, and permeability are better controlled. Penetrations can be saw-cut or core-drilled, resulting in smooth sides. Jack hammering is not recommended. The hole should be about1-inch oversized (1/2-in minimum space for penetration of sealant) and hot MatCon Mastic applied in the resulting void. Assure full penetration to seal the opening around the feature. After cooling, the mastic should be topped up as shown in Figure 6 in the form of a "fillet" to assure a tight seal and to prevent water from standing at the joint.

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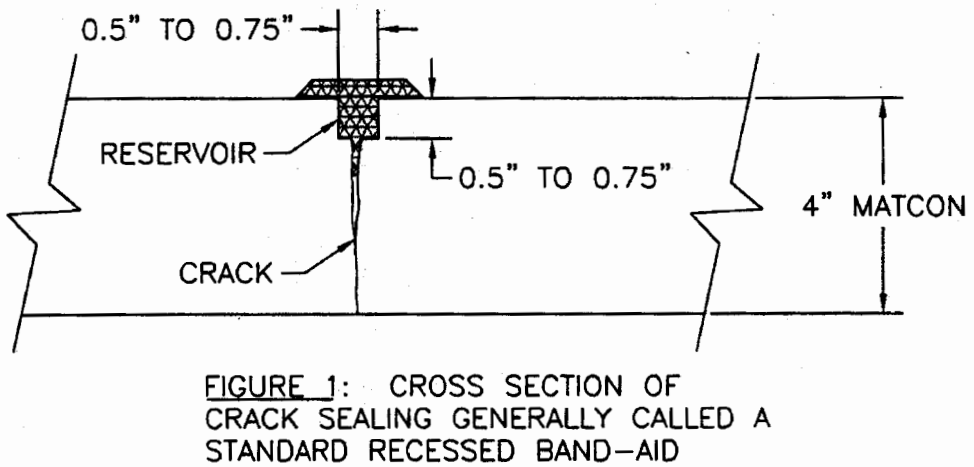
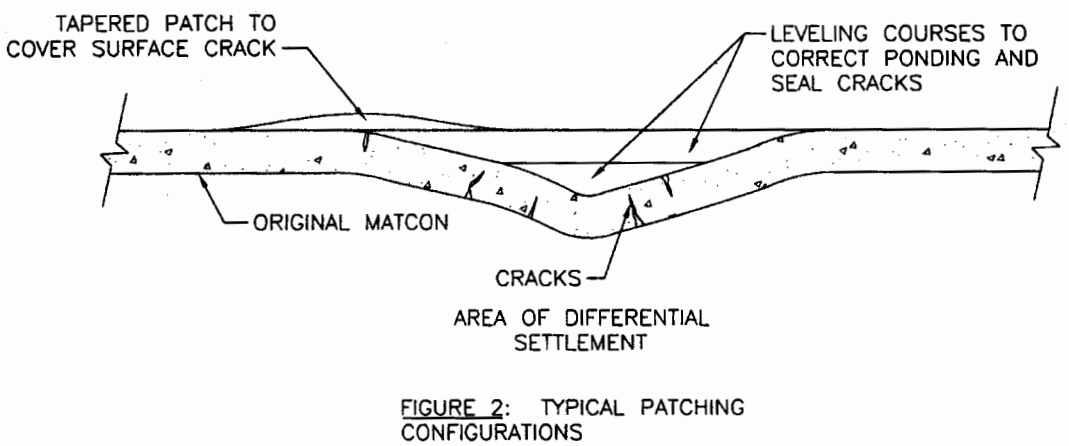


Not to scale

Figure 1. Cross Section of Crack Sealing.



Not to scale

Figure 2. Typical Patching Configurations.

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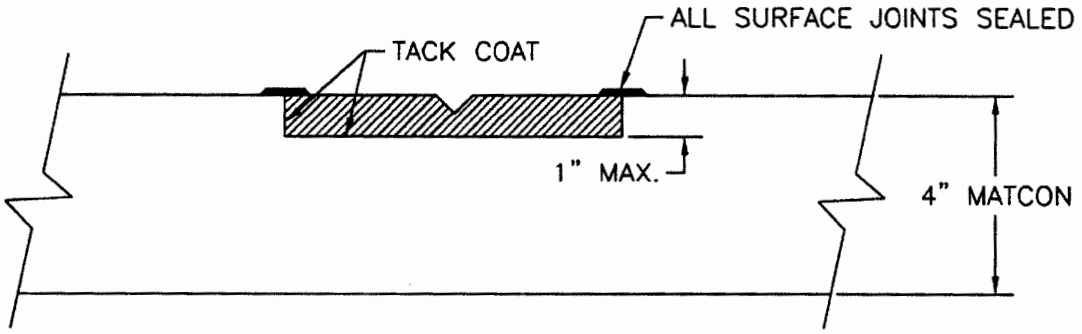

FIGURE 3: SHALLOW PATCH TO REPAIR SURFACE DEFECT. MILL OUT AREA TO BE PATCHED TO A DEPTH NOT TO EXCEED 1". INLAY WITH HIGH QUALITY MATCON MIXTURE AFTER APPLYING HEAVY TACK COAT. SEAL ALL EDGES.

Figure 3. Shallow Patch to Repair Surface Defect.

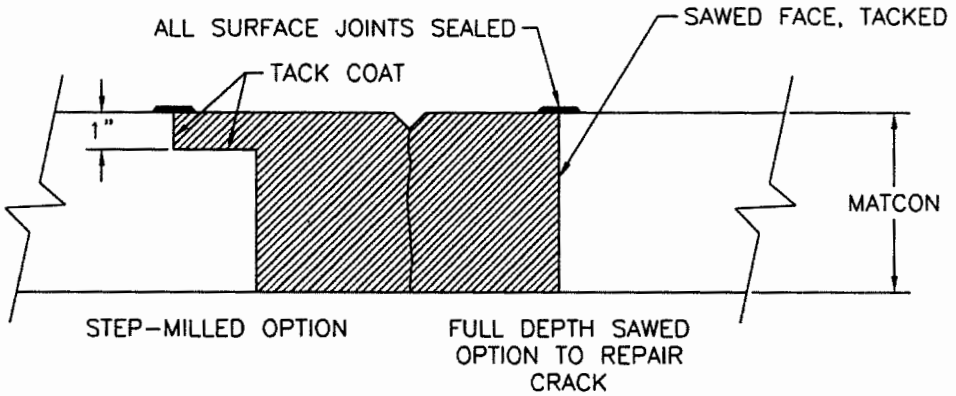

FIGURE 4: FULL DEPTH PATCH TO REPAIR CRACK. REMOVE MATCON BY SAWING OR MILLING IN SEVERAL PASSES TO MINIMIZE DAMAGE TO ADJACENT MATCON. TACK COAT ALL SURFACES. PLACE MATCON PATCH MIXTURE IN TWO LIFTS - BOTTOM LIFT PLACED, THEN IMMEDIATELY FOLLOWED BY TOP LIFT AND COMPACTED. SEAL ALL EDGES.

Figure 4. Full Depth Patch to Repair Crack.

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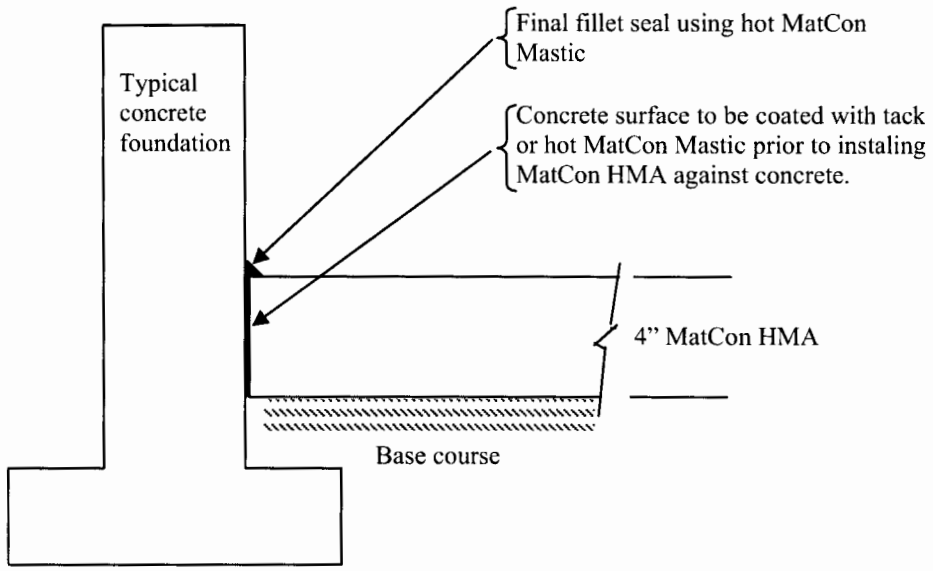

Figure 5a. Sealing the edge of MatCon HMA placed against existing concrete structure. Concrete shouuld be dry and clean before applying tack or MatCon Mastic. Compaction equipment should "pinch" the MatCon HMA against concrete structure as tight as conditions will allow. Final seal should be a "fillet" of MatCon Mastic in the corner of intersection as shown.

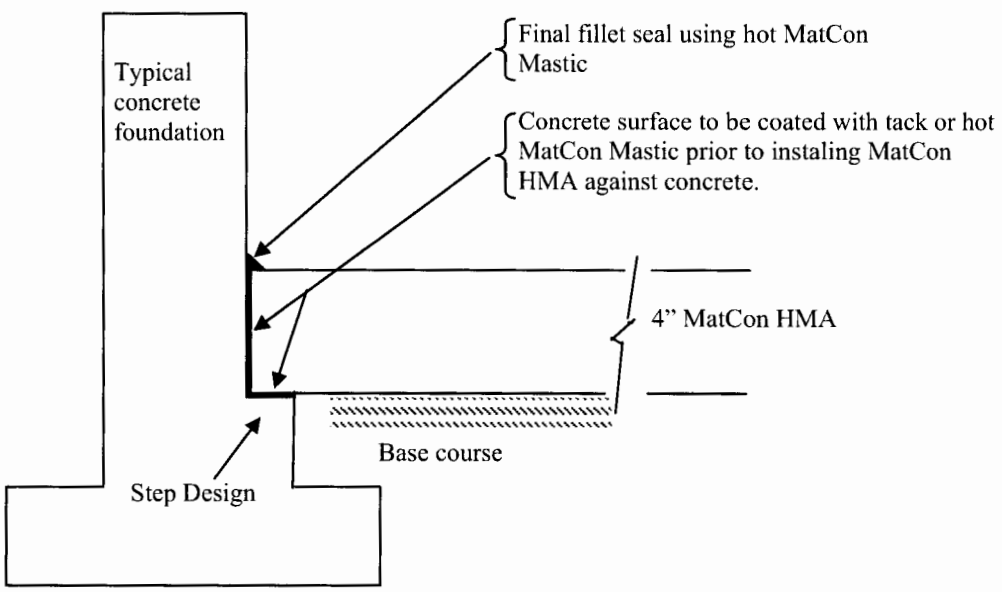

Figure 5b. Sealing the edge of MatCon HMA placed in a "step" in the concrete structure. This design provides a larger surface area for sealing and seating the MatCon HMA. See Figure 5.a. for additional notes.

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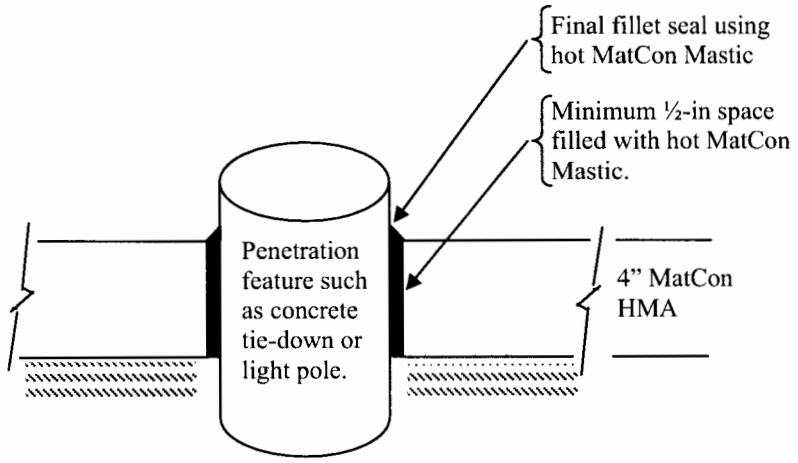

Figure 6. Sealing Full-Depth Penetration in a MatCon Cap. Remove MatCon HMA by sawing or core drilling. Alow space for hot MatCon Mastic sealant of at least ½-in. Apply hot MatCon Mastic using a melter and hot lance normally used to fill cracks (See Fig 1). When the mastic has cooled "top up" around the edges by applying a "fillet" of hot mastic.

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Attachment A
Load Equivalency Factors

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Table A-I. Load Equivalency Factors.

Gross Axle Load		Load Equivalency Factors		Gross Axle Load		Load Equivalency Factors	
kN	lb	Single Axles	Tandem Axles	kN	lb	Single Axles	Tandem Axles
4.45	1,000	0.00002		182.5	41,000	23.27	2.29
8.9	2,000	0.00018		187.0	42,000	25.64	2.51
13.35	3,000	0.00072		191.3	43,000	28.22	2.75
17.8	4,000	0.00209		195.7	44,000	31.00	3.00
22.25	5,000	0.00500		200.0	45,000	34.00	3.27
26.7	6,000	0.01043		204.5	46,000	37.24	3.55
31.15	7,000	0.0196		209.0	47,000	40.74	3.85
35.6	8,000	0.0343		213.5	48,000	44.50	4.17
40.0	9,000	0.0562		218.0	49,000	48.54	4.51
44.5	10,000	0.0877	0.00688	222.4	50,000	52.88	4.86
48.9	11,000	0.1311	0.01008	226.8	51,000		5.23
53.4	12,000	0.189	0.0144	231.3	52,000		5.63
57.8	13,000	0.264	0.0199	235.7	53,000		6.04
62.3	14,000	0.360	0.0270	240.2	54,000		6.47
66.7	15,000	0.478	0.0360	244.6	55,000		6.93
71.2	16,000	0.623	0.0472	249.0	56,000		7.41
75.6	17,000	0.796	0.0608	253.5	57,000		7.92
80.0	18,000	1.000	0.0773	258.0	58,000		8.45
84.5	19,000	1.24	0.0971	262.5	59,000		9.01
89.0	20,000	1.51	0.1206	267.0	60,000		9.59
93.4	21,000	1.83	0.148	271.3	61,000		10.20
97.8	22,000	2.18	0.180	275.8	62,000		10.84
102.3	23,000	2.58	0.217	280.2	63,000		11.52
106.8	24,000	3.03	0.260	284.5	64,000		12.22
111.2	25,000	3.53	0.308	289.0	65,000		12.96
115.6	26,000	4.09	0.364	293.5	66,000		13.73
120.0	27,000	4.71	0.426	298.0	67,000		14.54
124.5	28,000	5.39	0.495	302.5	68,000		15.38
129.0	29,000	6.14	0.572	307.0	69,000		16.26
133.5	30,000	6.97	0.658	311.5	70,000		17.19
138.0	31,000	7.88	0.753	316.0	71,000		18.15
142.3	32,000	8.88	0.857	320.0	72,000		19.16
146.8	33,000	9.98	0.971	325.0	73,000		20.22
151.2	34,000	11.18	1.095	329.0	74,000		21.32
155.7	35,000	12.50	1.23	333.5	75,000		22.47
160.0	36,000	13.93	1.38	338.0	76,000		23.66
164.5	37,000	15.50	1.53	342.5	77,000		24.91
169.0	38,000	17.20	1.70	347.0	78,000		26.22
173.5	39,000	19.06	1.89	351.5	79,000		27.58
178.0	40,000	21.08	2.08	356.0	80,000		28.99

**From AASHTO Interim Guide for Design of Pavement Structures, 1972, American Association of State Highway and Transportation Officials, Washington, D.C. 1974; Flexible Pavement.*

Note: kN converted to lb are within 0.1 percent of lb shown.

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Attachment B
Forms

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ATTACHMENT B

WILDER
WILDER CONSTRUCTION COMPANY

Wilder Construction Company

Page ___of ____

MatCon® Cap Inspection Report[1] ☐ Monthly ☐ Annual

No.:_____

Project Name: Los Alamos Airport Landfill Number:_____

Location: Los Alamos Airport, Los Alamos, New Mexico Date Constructed: _____

Name of Inspector (s):_____ Position:_____

_____

_____

Date of Inspection:_____ Time: _____Start _____Stop: _____

Weather Conditions:_____

Discussion: (Include purpose, scope, and any features or conditions specific to this inspection)

_____

_____

_____

Information to be provided for each section of MatCon surface. Divide entire project into areas of different use, location, etc. and note or sketch them on attached site map. Note location of observed distress, attached photographs, or other features on the site map. Use additional sheets as needed.

Section No.	Site Use	Observed Distress[2]
Determine logically different areas based on use, location etc. and assign a number on the sitemap. Use GPS to define areas	Describe Current use of each section. Note any changes since last report	0. None 1. Alligator Cracking 2. Block or Thermal Cracking 3. Depression or Settlement 4. Standing Water 5. Rutting 6. Raveling/Weathering/ Surface Blemish 7. Hydrocarbon/Chemical Spill
		For each section indicate: ☐ Type of distress ☐ Locate distress on site map ☐ Provide GPS coordinates ☐ Attach Photo if appropriate ☐ Provide additional description / dimension
		GPS Location: Long.:_____ Lat.:_____Alt.: _____ Observed Distress: _____ Dimension: Length: _____Width:_____Depth:_____ **Notes:**

[1] Submit report to Wilder Construction Company.
[2] Refer to Operations and Maintenance Manual for information on distress.

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Section No.	Site Use	Observed Distress3
		GPS Location: Long. _____ Lat. _____Alt. _____ Observed Distress: _____ Dimension: Length _____ Width _____Depth: _____ **Notes:**
		GPS Location: Long. _____Lat. _____ Alt. _____ Observed Distress: _____ Dimension: Length _____Width _____ Depth:_____ **Notes:**

[3] Refer to Operations and Maintenance Manual for information on distress.

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Summary Sheet Page ___of _____

Condition of MatCon Cap:

ق Excellent – No maintenance required.

ق Good – Some minor wear or distress, but fully serviceable.

ق Fair – Will need some minor maintenance during next year.

ق Poor – Needs maintenance as recommended below.

Narrative:

_____
_____
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Action Taken:

ق None Required
ق Contacted Wilder Construction Co.
ق Corrective action initiated / implemented
ق Result of action attached
ق Report sent to Wilder Construction Co.

ق Needs Attention

Inspector Name: _____ Signature: _____Date: _____

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TENSAR Earth Technologies, Inc.

5883 Glenridge Drive
Suite 200
Atlanta, GA 30328
Tel. 404•250•1290
Fax. 404•250•9185

May 24, 2006

Michael Bolender
North Wind, Inc.
1425 Higham Street
Idaho Falls, Idaho 83402

Subject: **Los Alamos Site Office TA-73 Airport Landfills**
Mechanically Stabilized Earth wall systems
Los Alamos, NM
TET Project No. D06602

Dear Michael,

Tensar Earth Technologies, Inc. (TET) is pleased to present you the design for Mechanically Stabilized Earth (MSE) wall systems for the LASO TA-73 Airport Landfills project. The design package including Design Calculations and Construction Drawings is enclosed.

The enclosed design has been performed under direct supervision of Brendan Sheppard in the absence of our New Mexico registered Professional Engineer (the EOR), who is currently out of the country. Mr. Sheppard is registered Professional Engineer in the state of Georgia and several other jurisdictions but is not currently registered in New Mexico. Prior to construction, this design will be reviewed and signed and sealed by the EOR. Any modifications that the EOR may require would be resubmitted for approval. However, we believe that any modifications are likely to be minor and would be noted clearly on the plans at the time of submittal in order to expedite the review process. In the interim, we ask that you accept this design and submit it for approval prior to the EOR's review. We currently anticipate that you will be able to receive signed and sealed drawings on May 31, 2006.

We appreciate the opportunity to work with you and look forward to help make this project successful for all parties. If you have any questions pertaining to this design, feel free to contact us at (404) 250-1290.

Sincerely,

Tensar Earth Technologies, Inc.

GEORGIA REGISTERED No. PE 028466 PROFESSIONAL ENGINEER BRENDAN R. SHEPPARD

Weslie Ross
Staff Engineer

Brendan Sheppard, PE
Manager-Engineering Operations

Encl: Construction Drawings
Design Calculations

TENSAR Earth Technologies, Inc.

5883 Glenridge Drive
Suite 200
Atlanta, Georgia 30328
Tel: 404-250-1290
Fax: 404-250-9185

DESIGN CALCULATIONS

Prepared for

Los Alamos Site Office TA-73 Airport Landfills

W.O. NO. 13104.002.001.7000

Los Alamos County, New Mexico

TET#D06602

May 24, 2006

TABLE OF CONTENTS

	PAGE
DESIGN ASSUMPTIONS	2
DESIGN CALCULATIONS	5
SIERRASCAPE RETAINING WALL SYSTEM INSTALLATION GUIDE	60
GEOGRID SPECIFICATION: UX1400HS, UX1500HS AND UX1600HS	66

CALCULATED BY: CANDANCE CAMPBELL
CHECKED BY: WESLIE ROSS

WR 5/25/06

DESIGN ASSUMPTIONS

Project Name:	LASO TA-73 Airport Landfills Los Alamos County, NM	**Date:**	5/24/06
Project Number	D06602	**Engineer:**	CLC

THE FOLLOWING ASSUMPTIONS HAVE BEEN ADOPTED BY TET FOR THE PURPOSE OF DEVELOPING A FINAL DESIGN. ALL ASSUMPTIONS MUST BE VERIFIED BY OTHERS PRIOR TO CONSTRUCTION.

1. Design Methodology

In general accordance with AASHTO Standard Specifications for Highway Bridges 2002

2. Soil Properties

Soils	*Unit Weight γ, PCF*	*Friction Angle ϕ', degrees*	*Cohesion PSF*
Reinforced Soil	130	32	0
Retained Soil	100	35.5	0
Foundation Soil	130	32	4000

NOTE: ALL SOIL PROPERTIES MUST BE VERIFIED BY A GEOTECHNICAL ENGINEER PRIOR TO CONSTRUCTION.

3. Geometry

- General Information
  - Three Mechanically Stabilized Earth (MSE) walls with the following geometry:

Walls	*Length, ft*	*Maximum Design Height, ft*	*Top & Toe slope*
Wall 2	347.0	26.5	4:1 Top Slope Level Toe slope
Wall 3	56.5	6.0	4:1 Top Slope Level Toe slope
Wall 4	50.0	7.0	4:1 Top Slope Level Toe slope

- MSE Walls are superimposed at the following stations:
  - Wall 2 and Wall 4:
    - Wall 2 from Sta. 1+00.0 to Sta. 1+35.7 and Wall 4 from Sta. 1+00.0 to 1+50.0
  - Wall 2 and Wall 3:
    - Wall 2 from Sta. 4+00.7 to Sta. 4+47.0 Wall 3 from Sta. 1+00.0 to Sta. 1+34

4. Facing

SierraScape galvanized baskets with stone facing and a setback of 1.5" to achieve 1H:12V face batter.

5. Loading

Traffic Loading	= 250 psf
Design Seismic Acceleration	= 0.262 g

6. Geogrid Reinforcement

Type	*Creep Limited Strength, Lbs/ft*	*Reduction Factor* RF_{ID}/RF_D	*Working Strength, Lbs/ft*
UX1400MSE	2170	1.10/1.0	1973
UX1500MSE	3255	1.10/1.0	2959
UX160MSE	4308	1.10/1.0	3917

Soil-geogrid interaction coefficient	= 0.8
Percent coverage of geogrid	= 94 %
Design life	= 75 years

7. Stability Analysis

	Static	Static
Internal Stability		
Minimum factor of safety for geogrid pullout	= 1.5	= 1.1
Minimum factor of safety for geogrid strength	= 1.5	= 1.1
Minimum factor of safety for direct sliding at geogrid	= 1.5	= 1.1
Minimum factor of safety for connection	= 1.5	= 1.1
External Stability	**Static**	
Minimum factor of safety for direct sliding at base	= 1.5	= 1.1
Maximum eccentricity, e/L	= 1/6	= 1/3

NOTE: Global stability is beyond the scope of this design.

8. Maximum Applied Bearing Pressure = 3915 psf (Static)

= 6056 psf (Seismic)

9. Hydraulic Conditions

Groundwater/phreatic surfaces were not considered in this design. Water surfaces assumed to be sufficiently below the base of the MSE walls as not influence the internal and external stability of the MSE walls.

10. Notes

A. The design presented herein is based on the information provided to Tensar Earth Technologies, Inc. Tensar Earth Technologies, Inc. accepts no liability for the information or verification of information.

B. The owner or owner's representative is responsible to review and verify the design parameters prior to construction.

C. Tensar Earth Technologies, Inc. assumes no liability for interpretation of subsurface conditions, suitability of soil design parameters, and subsurface groundwater conditions.

D. Evaluation of foundation bearing capacity and global stability are the responsibility of the owner or owner's representative. Tensar Earth Technologies, Inc., accepts no responsibility or liability for the evaluation of global stability and foundation bearing capacity.

E. Total and differential settlement and their effects on this system are the responsibility of the owner or owner's representative. Tensar Earth Technologies, Inc. accepts no responsibility or liability for the evaluation of settlements.

F. Flood conditions and rapid drawdown have not been considered in the design.

11. References

For references see Section 9.0 on sheet 2 of 11, Construction Requirements, of the construction drawings.

SIERRASCAPE®
RETAINING WALL SYSTEMS

AASHTO DESIGN METHOD
LASO TA-73 Airport Landfills

PROJECT IDENTIFICATION

Title:	LASO TA-73 Airport Landfills
Project Number:	D06602
Client:	Slaton Bros SW
Designer:	CLC
Station Number:	1+35.7-4+00.7

Description:

Wall 2_DH=26.5'_EXTERNAL

Company's information:

Name: Tensar Earth Technologies, Inc.
Street: 5883 Glenridge Drive
Suite 200
Atlanta, GA 30328
Telephone #: (404) 250-1290
Fax #: (404) 250-9185
E-Mail: ccampbell@tensarcorp.com

Original file path and name: k:_d\D06602\Final\Design\Design without Wall 1\Wall1an.....
.....ndWall2_26.5'_EX.BEN

Original date and time of creating this file: May 22, 2006

PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ	130.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	32.0 °

RETAINED SOIL

Unit weight, γ	100.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	35.5 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	130.0 lb/ft ^{3}
Equivalent internal angle of friction, $\phi_{equiv.}$	32.0 °
Equivalent cohesion, $c_{equiv.}$	4000.0 lb/ft ^{2}

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3073 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ = 61.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.2866 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 35.49 N γ = 30.21

SEISMICITY

Maximum ground acceleration coefficient, α_o = 0.131
Kae (α_o > 0) = 0.4015 Kae (α_o = 0) = 0.2486 Δ Kae = 0.1529 (see eq. 37 in DEMO 82)
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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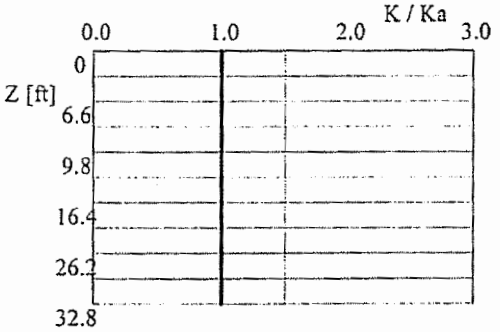
INPUT DATA: Geogrids
(Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	3974.1	4796.3	7811.2	9866.7	11990.8
Durability reduction factor, RFd	1.00	1.00	1.00	1.00	1.00
Installation-damage reduction factor, RFid	1.10	1.10	1.10	1.10	1.10
Creep reduction factor, RFc	2.34	2.21	2.40	2.29	2.22
Fs-overall for strength	N/A	N/A	N/A	N/A	N/A
Coverage ratio, Rc	0.940	0.940	0.940	0.940	0.940
Friction angle along geogrid-soil interface, ρ	26.56	26.56	26.56	26.56	26.56
Pullout resistance factor, F*	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ
Scale-effect correction factor, α	1.0	1.0	1.0	1.0	1.0

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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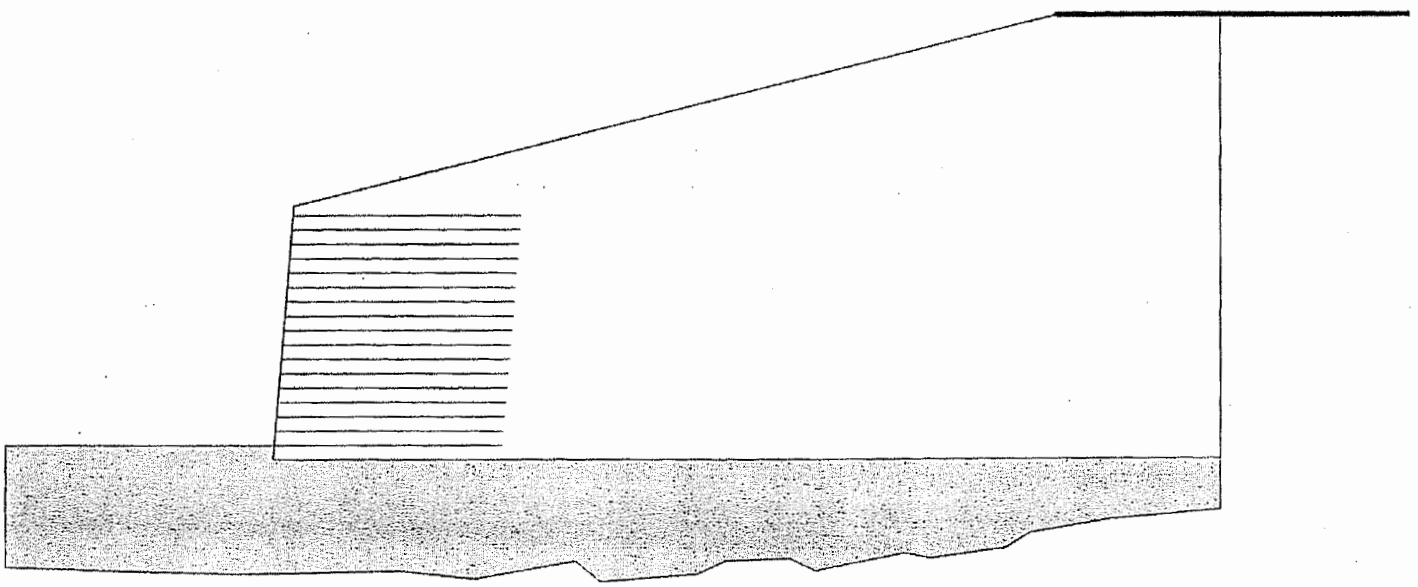
INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd	26.50	[ft]	{ Embedded depth is E = 1.50 ft, and height above top of finished bottom grade is H = 25.00 ft }
Batter, ω	4.8	[deg]	
Backslope, β	14.0	[deg]	
Backslope rise	20.0	[ft]	Broken back equivalent angle, I = 14.04° (see Fig. 25 in DEMO 82)

UNIFORM SURCHARGE
Uniformly distributed dead load is 0.0 [lb/ft ²]

OTHER EXTERNAL LOAD(S)
[S1] Strip Load, Qv-d = 0.0 and Qv-l = 250.0 [lb/ft ²].
Footing width, b=150.0 [ft]. Distance of center of footing from wall face, d = 155.0 [ft] @ depth of 0.0 [ft] below soil surface.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10[ft]

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ANALYSIS: CALCULATED FACTORS (Static conditions)

N/A

Bearing capacity, Fs = ~~48.65~~, Meyerhof stress = 3860 lb/ft².

Foundation Interface: Direct sliding, Fs = 3.969, Eccentricity, e/L = 0.0135, Fs-overturning = 7.96

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.00	24.00	4	4.77	4.32	4.321	95.511	3.223	0.0135	UX1600MSE-SS
2	1.50	24.00	4	2.48	2.25	2.249	47.088	3.364	0.0086	UX1600MSE-SS
3	3.00	24.00	4	2.62	2.38	2.380	46.569	3.519	0.0038	UX1600MSE-SS
4	4.50	24.00	3	1.62	1.91	1.909	45.510	3.687	-0.0008	UX1500MSE-SS
5	6.00	24.00	3	1.72	2.03	2.034	44.310	3.871	-0.0053	UX1500MSE-SS
6	7.50	24.00	3	1.85	2.18	2.177	43.149	4.074	-0.0096	UX1500MSE-SS
7	9.00	24.00	3	1.97	2.34	2.342	42.013	4.299	-0.0139	UX1500MSE-SS
8	10.50	24.00	3	2.03	2.53	2.534	40.886	4.548	-0.0182	UX1500MSE-SS
9	12.00	24.00	3	2.09	2.76	2.760	39.818	4.826	-0.0225	UX1500MSE-SS
10	13.50	24.00	3	2.17	3.03	3.030	38.799	5.138	-0.0270	UX1500MSE-SS
11	15.00	24.00	3	2.27	3.36	3.359	37.824	5.490	-0.0318	UX1500MSE-SS
12	16.50	24.00	3	2.39	3.77	3.768	36.959	5.889	-0.0371	UX1500MSE-SS
13	18.00	24.00	3	2.55	4.29	4.290	36.221	6.342	-0.0431	UX1500MSE-SS
14	19.50	24.00	3	2.75	4.98	4.981	35.646	6.859	-0.0504	UX1500MSE-SS
15	21.00	24.00	3	3.04	5.94	5.936	35.389	7.446	-0.0597	UX1500MSE-SS
16	22.50	24.00	3	3.45	7.35	7.346	35.636	8.102	-0.0726	UX1500MSE-SS
17	24.00	24.00	3	4.13	9.63	9.632	36.831	8.799	-0.0920	UX1500MSE-SS
18	25.50	24.00	3	4.83	12.46	12.456	35.937	9.422	-0.1257	UX1500MSE-SS

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

N/A

Bearing capacity, Fs = ~~38.56~~, Meyerhof stress = 4673 lb/ft².

Foundation Interface: Direct sliding, Fs = 2.180, Eccentricity, e/L = 0.0928, Fs-overturning = 3.72

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.00	24.00	4	3.49	3.72	3.724	55.886	1.770	0.0928	UX1600MSE-SS
2	1.50	24.00	4	2.09	2.08	2.081	31.774	1.866	0.0789	UX1600MSE-SS
3	3.00	24.00	4	2.20	2.20	2.197	31.297	1.972	0.0658	UX1600MSE-SS
4	4.50	24.00	3	1.51	1.76	1.765	30.446	2.091	0.0534	UX1500MSE-SS
5	6.00	24.00	3	1.61	1.88	1.876	29.493	2.225	0.0416	UX1500MSE-SS
6	7.50	24.00	3	1.72	2.00	2.003	28.554	2.376	0.0305	UX1500MSE-SS
7	9.00	24.00	3	1.83	2.15	2.148	27.618	2.549	0.0199	UX1500MSE-SS
8	10.50	24.00	3	1.88	2.32	2.316	26.672	2.748	0.0099	UX1500MSE-SS
9	12.00	24.00	3	1.95	2.51	2.511	25.743	2.980	0.0004	UX1500MSE-SS
10	13.50	24.00	3	2.02	2.74	2.744	24.819	3.253	-0.0087	UX1500MSE-SS
11	15.00	24.00	3	2.11	3.02	3.023	23.889	3.577	-0.0176	UX1500MSE-SS
12	16.50	24.00	3	2.22	3.37	3.366	22.980	3.970	-0.0265	UX1500MSE-SS
13	18.00	24.00	3	2.37	3.80	3.797	22.082	4.451	-0.0355	UX1500MSE-SS
14	19.50	24.00	3	2.55	4.35	4.353	21.187	5.050	-0.0453	UX1500MSE-SS
15	21.00	24.00	3	2.80	5.10	5.102	20.329	5.807	-0.0567	UX1500MSE-SS
16	22.50	24.00	3	3.17	6.16	6.161	19.507	6.769	-0.0710	UX1500MSE-SS
17	24.00	24.00	3	3.75	7.77	7.775	18.728	7.956	-0.0915	UX1500MSE-SS
18	25.50	24.00	3	4.34	9.64	9.643	16.911	9.193	-0.1257	UX1500MSE-SS

N/A*

* see internal stability analysis

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AASHTO DESIGN METHOD
LASO TA-73 Airport Landfills

PROJECT IDENTIFICATION

Title: LASO TA-73 Airport Landfills
Project Number: D06602
Client: Slaton Bros SW
Designer: CLC
Station Number: 1+35.7-4+00.7

Description:

Wall 2_DH=26.5'_INTERNAL

Company's information:

Name: Tensar Earth Technologies, Inc.
Street: 5883 Glenridge Drive
Suite 200
Atlanta, GA 30328
Telephone #: (404) 250-1290
Fax #: (404) 250-9185
E-Mail: ccampbell@tensarcorp.com

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Original date and time of creating this file: May 22, 2006

PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ		130.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	32.0 °

RETAINED SOIL

Unit weight, γ		100.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	35.5 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$		130.0 lb/ft ^{3}
Equivalent internal angle of friction,	$\phi_{equiv.}$	32.0 °
Equivalent cohesion, $c_{equiv.}$		4000.0 lb/ft ^{2}

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3073 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ = 61.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.2866 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 35.49 N γ = 30.21

SEISMICITY

Maximum ground acceleration coefficient, α_o = 0.262
Kae (α_o> 0) = 0.6339 Kae (α_o= 0) = 0.2486 Δ Kae = 0.3853 (see eq. 37 in DEMO 82)
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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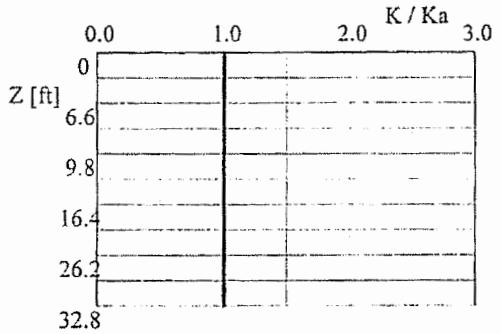
INPUT DATA: Geogrids
(Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	3974.1	4796.3	7811.2	9866.7	11990.8
Durability reduction factor, RFd	1.00	1.00	1.00	1.00	1.00
Installation-damage reduction factor, RFid	1.10	1.10	1.10	1.10	1.10
Creep reduction factor, RFc	2.34	2.21	2.40	2.29	2.22
Fs-overall for strength	N/A	N/A	N/A	N/A	N/A
Coverage ratio, Rc	0.940	0.940	0.940	0.940	0.940
Friction angle along geogrid-soil interface, ρ	26.56	26.56	26.56	26.56	26.56
Pullout resistance factor, F*	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ
Scale-effect correction factor, α	1.0	1.0	1.0	1.0	1.0

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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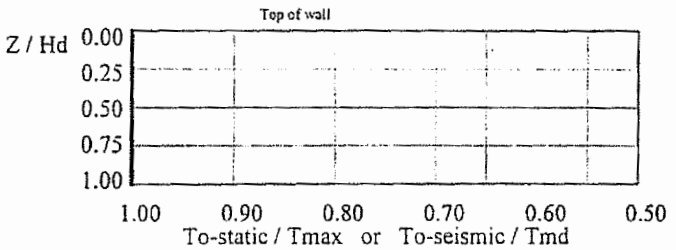
INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.48/1.48 ft. Horizontal distance to Center of Gravity of block is 0.74 ft.
Average unit weight of block is $\gamma r = 114.58$ lb/ft ^{3}

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ (1)	CRult (2)	σ	CRult	σ	CRult	σ	CRult	σ	CRult
0.0	1.00	0.0	1.00	0.0	1.00	0.0	0.38	0.0	0.38
						1200.9	0.44	1200.9	0.44
						2999.0	0.53	3600.5	0.56
						6000.1	0.68	7198.9	0.74

Geogrid Type #1 (3)		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr
0.0	0.15	0.0	0.15	0.0	0.15	0.0	0.38	0.0	0.38
480.3	0.20	480.3	0.20	599.4	0.21	1200.9	0.44	1200.9	0.44
1200.9	0.27	1200.9	0.27	1800.3	0.33	2999.0	0.53	3600.5	0.56
2399.6	0.39	2399.6	0.39	3600.5	0.51	6000.1	0.68	7198.9	0.74

(1) σ = Confining stress in between stacked blocks [lb/ft ^{2}]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

In seismic analysis, long term strength is reduced to 100% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	UX1100MSE..	UX1400MSE..	UX1500MSE..	UX1600MSE..	UX1700MSE..
Connection strength reduction factor, RFd	1.10	1.10	1.10	1.10	1.10
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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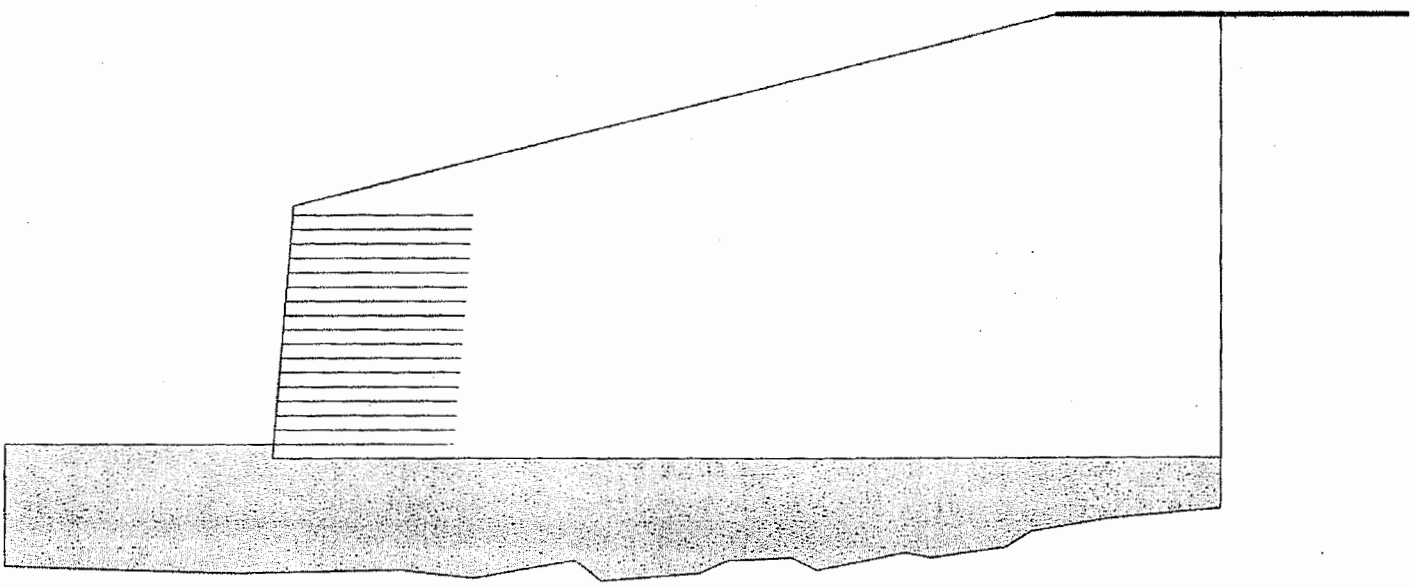
INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd	26.50	[ft]	{ Embedded depth is E = 1.50 ft, and height above top of finished bottom grade is H = 25.00 ft }
Batter, ω	4.8	[deg]	
Backslope, β	14.0	[deg]	
Backslope rise	20.0	[ft]	Broken back equivalent angle, I = 14.04° (see Fig. 25 in DEMO 82)

UNIFORM SURCHARGE
Uniformly distributed dead load is 0.0 [lb/ft ²]

OTHER EXTERNAL LOAD(S)
[S1] Strip Load, Qv-d = 0.0 and Qv-l = 250.0 [lb/ft ²].
Footing width, b=150.0 [ft]. Distance of center of footing from wall face, d = 155.0 [ft] @ depth of 0.0 [ft] below soil surface.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10[ft]

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ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = ~~44.42~~ N/A, Meyerhof stress = 3970 lb/ft².

Foundation Interface: Direct sliding, Fs = 3.315, Eccentricity, e/L = 0.0392, Fs-overturning = 5.54

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.00	19.00	4	4.77	4.32	4.321	73.047	2.692	0.0392	UX1600MSE-SS
2	1.50	19.00	4	2.48	2.25	2.249	35.960	2.818	0.0317	UX1600MSE-SS
3	3.00	19.00	4	2.62	2.38	2.380	35.356	2.957	0.0246	UX1600MSE-SS
4	4.50	19.00	3	1.62	1.91	1.909	34.220	3.110	0.0179	UX1500MSE-SS
5	6.00	19.00	3	1.72	2.03	2.034	32.954	3.278	0.0115	UX1500MSE-SS
6	7.50	19.00	3	1.85	2.18	2.177	31.677	3.466	0.0054	UX1500MSE-SS
7	9.00	19.00	3	1.97	2.34	2.342	30.428	3.675	-0.0005	UX1500MSE-SS
8	10.50	19.00	3	2.03	2.53	2.534	29.190	3.909	-0.0061	UX1500MSE-SS
9	12.00	19.00	3	2.09	2.76	2.760	27.948	4.174	-0.0116	UX1500MSE-SS
10	13.50	19.00	3	2.17	3.03	3.030	26.745	4.476	-0.0170	UX1500MSE-SS
11	15.00	19.00	3	2.27	3.36	3.359	25.566	4.821	-0.0225	UX1500MSE-SS
12	16.50	19.00	3	2.39	3.77	3.768	24.402	5.221	-0.0282	UX1500MSE-SS
13	18.00	19.00	3	2.55	4.29	4.290	23.307	5.687	-0.0344	UX1500MSE-SS
14	19.50	19.00	3	2.75	4.98	4.981	22.284	6.233	-0.0416	UX1500MSE-SS
15	21.00	19.00	3	3.04	5.94	5.936	21.353	6.878	-0.0507	UX1500MSE-SS
16	22.50	19.00	3	3.45	7.35	7.346	20.639	7.634	-0.0631	UX1500MSE-SS
17	24.00	19.00	3	4.13	9.63	9.632	20.302	8.492	-0.0824	UX1500MSE-SS
18	25.50	19.00	3	4.83	12.46	12.456	18.548	9.330	-0.1181	UX1500MSE-SS

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = ~~16.99~~ N/A*, Meyerhof stress = ~~9252 lb/ft²~~ N/A*.

Foundation Interface: Direct sliding, Fs = ~~1.214~~ N/A*, Eccentricity, e/L = ~~0.2934~~ N/A*, Fs-overturning = ~~1.57~~ N/A*

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.00	19.00	4	2.76	3.28	3.282	33.873	0.986	0.2934	UX1600MSE-SS
2	1.50	19.00	4	1.82	1.94	1.941	21.099	1.042	0.2579	UX1600MSE-SS
3	3.00	19.00	4	1.92	2.05	2.049	20.649	1.106	0.2244	UX1600MSE-SS
4	4.50	19.00	3	1.43	1.65	1.650	19.884	1.178	0.1928	UX1500MSE-SS
5	6.00	19.00	3	1.52	1.75	1.753	19.038	1.261	0.1632	UX1500MSE-SS
6	7.50	19.00	3	1.62	1.87	1.870	18.181	1.355	0.1355	UX1500MSE-SS
7	9.00	19.00	3	1.73	2.00	2.004	17.334	1.465	0.1098	UX1500MSE-SS
8	10.50	19.00	3	1.78	2.16	2.159	16.486	1.594	0.0859	UX1500MSE-SS
9	12.00	19.00	3	1.84	2.34	2.340	15.627	1.748	0.0637	UX1500MSE-SS
10	13.50	19.00	3	1.92	2.55	2.554	14.777	1.934	0.0434	UX1500MSE-SS
11	15.00	19.00	3	2.01	2.81	2.810	13.925	2.163	0.0246	UX1500MSE-SS
12	16.50	19.00	3	2.12	3.12	3.124	13.060	2.452	0.0072	UX1500MSE-SS
13	18.00	19.00	3	2.25	3.52	3.517	12.203	2.827	-0.0090	UX1500MSE-SS
14	19.50	19.00	3	2.43	4.02	4.023	11.343	3.328	-0.0246	UX1500MSE-SS
15	21.00	19.00	3	2.68	4.70	4.699	10.465	4.027	-0.0402	UX1500MSE-SS
16	22.50	19.00	3	3.03	5.65	5.647	9.590	5.045	-0.0577	UX1500MSE-SS
17	24.00	19.00	3	3.58	7.08	7.076	8.700	6.577	-0.0803	UX1500MSE-SS
18	25.50	19.00	3	4.15	8.75	8.746	7.353	8.689	-0.1178	UX1500MSE-SS

N/A*

*See external stability analysis

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AASHTO DESIGN METHOD
LASO TA-73 Airport Landfills

PROJECT IDENTIFICATION

Title:	LASO TA-73 Airport Landfills
Project Number:	D06602
Client:	Slaton Bros SW
Designer:	CLC
Station Number:	Wall 2_4+00.7-4+21.3/ Wall 3_1+00.0-1+09.7

Description:

Tiered wall...Wall 2_DH=22.0' and Wall 3_DH=6', 10' offset_EXTERNAL

Company's information:

Name: Tensar Earth Technologies, Inc.
Street: 5883 Glenridge Drive
Suite 200
Atlanta, GA 30328
Telephone #: (404) 250-1290
Fax #: (404) 250-9185
E-Mail: ccampbell@tensarcorp.com

Original file path and name: k:_d\D06602\Final\Design\Design without Wall 1\Wall2an.....
.....ndWall3_22-6'_EX.BEN

Original date and time of creating this file: May 22, 2006

PROGRAM MODE: ANALYSIS
of SUPERIMPOSED WALL
using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight,	γ	130.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	32.0 °

RETAINED SOIL

Unit weight,	γ	100.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	35.5 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight,	$\gamma_{equiv.}$	130.0 lb/ft ^{3}
Equivalent internal angle of friction,	$\phi_{equiv.}$	32.0 °
Equivalent cohesion,	$c_{equiv.}$	4000.0 lb/ft ^{2}

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3073 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ= 61.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.2866 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 35.49 N γ= 30.21

SEISMICITY

Maximum ground acceleration coefficient, α_o = 0.131
Kae (α_o> 0) = 0.4492 Kae (α_o= 0) = 0.2866 Δ Kae = 0.1625 (see eq. 37 in DEMO 82)
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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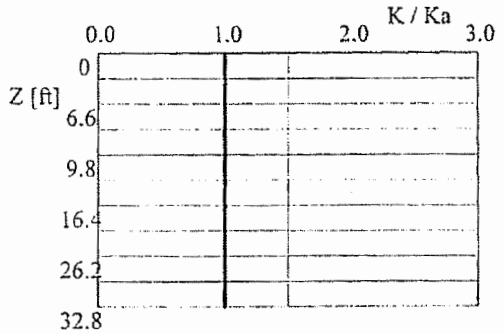
INPUT DATA: Geogrids
(Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	3974.1	4796.3	7811.2	9866.7	11990.8
Durability reduction factor, RFd	1.00	1.00	1.00	1.00	1.00
Installation-damage reduction factor, RFid	1.10	1.10	1.10	1.10	1.10
Creep reduction factor, RFc	2.34	2.21	2.40	2.29	2.22
Fs-overall for strength	N/A	N/A	N/A	N/A	N/A
Coverage ratio, Rc	0.940	0.940	0.940	0.940	0.940
Friction angle along geogrid-soil interface, ρ	26.56	26.56	26.56	26.56	26.56
Pullout resistance factor, F*	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ
Scale-effect correction factor, α	1.0	1.0	1.0	1.0	1.0

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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INPUT DATA: Geometry and Surcharge loads (of SUPERIMPOSED wall)

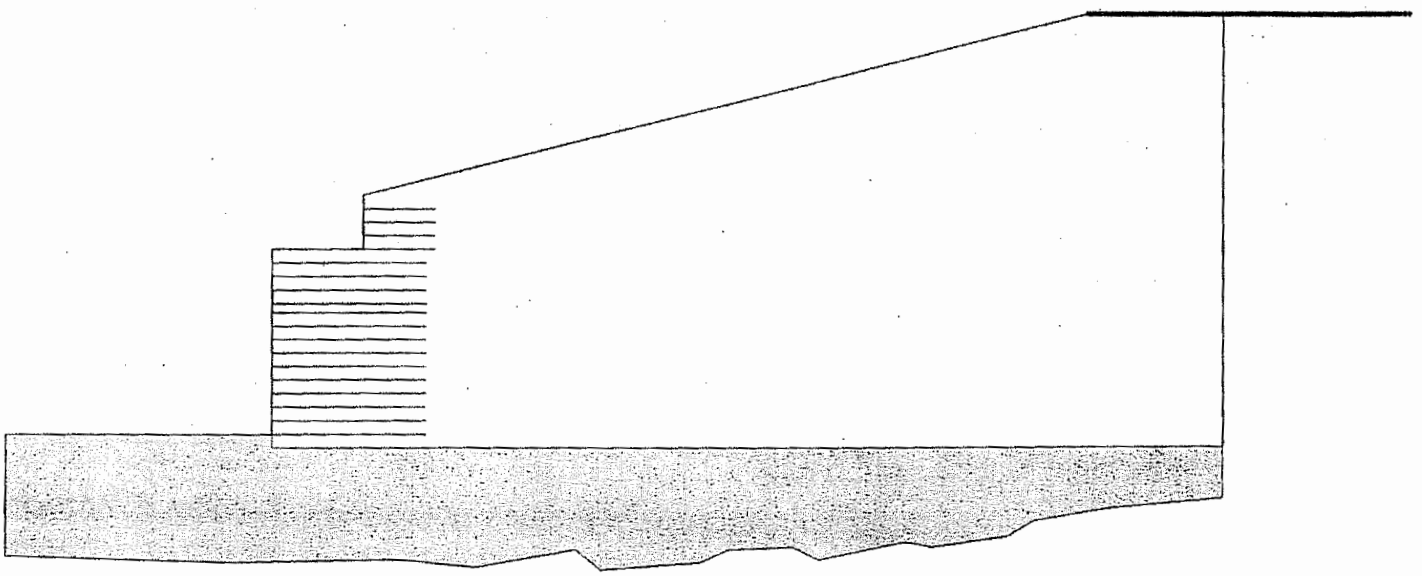
Design height, Hd	28.00	[ft]	{ Embedded depth is E = 1.50 ft, and height above top of finished bottom grade is H = 26.50 ft, where H1 = 6.00 and H2 = 20.50 }
Batter, ω	0.0	[deg]	
Backslope, β	14.0	[deg]	
Backslope rise	20.0	[ft]	Broken back equivalent angle, I = 14.04° (see Fig. 25 in DEMO 82)

Offset of upper segment from lower one, Offset = 10.0 ft, Blackslope2 = 0.0 deg. and Backslope rise, S2 = 0.0 ft.

UNIFORM SURCHARGE
Uniformly distributed dead load is 0.0 [lb/ft ²]

OTHER EXTERNAL LOAD(S)
[S1] Strip Load, Qv-d = 0.0 and Qv-l = 250.0 [lb/ft ²].
Footing width, b=150.0 [ft]. Distance of center of footing from wall face, d = 155.0 [ft] @ depth of 0.0 [ft] below soil surface.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10[ft]

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ANALYSIS: CALCULATED FACTORS (Static conditions)

N/A

Bearing capacity, Fs = ~~43.69~~, Meyerhof stress = 3915 lb/ft².

Foundation Interface: Direct sliding, Fs = 2.943, Eccentricity, e/L = 0.0646, Fs-overturning = 4.51

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.00	17.00	4	4.74	4.09	4.086	65.346	2.389	0.0646	UX1600MSE-SS
2	1.50	17.00	4	2.42	2.12	2.123	30.596	2.485	0.0527	UX1600MSE-SS
3	3.00	17.00	4	2.51	2.24	2.239	28.923	2.587	0.0410	UX1600MSE-SS
4	4.50	17.00	3	1.50	1.79	1.789	27.253	2.699	0.0294	UX1500MSE-SS
5	6.00	17.00	3	1.52	1.90	1.898	25.586	2.819	0.0178	UX1500MSE-SS
6	7.50	17.00	3	1.53	2.02	2.023	23.923	2.950	0.0062	UX1500MSE-SS
7	9.00	17.00	3	1.55	2.16	2.164	22.264	3.092	-0.0057	UX1500MSE-SS
8	10.50	17.00	3	1.57	2.33	2.327	20.611	3.246	-0.0180	UX1500MSE-SS
9	12.00	17.00	3	1.60	2.52	2.516	18.964	3.411	-0.0312	UX1500MSE-SS
10	13.50	17.00	3	1.63	2.74	2.739	17.326	3.587	-0.0456	UX1500MSE-SS
11	15.00	17.00	3	1.98	3.58	3.576	18.688	3.771	-0.0622	UX1500MSE-SS
12	16.00	17.00	3	2.04	3.89	3.888	17.707	3.894	-0.0751	UX1500MSE-SS
13	17.50	17.00	3	1.73	3.58	3.584	13.029	4.066	-0.0989	UX1500MSE-SS
14	19.00	17.00	3	1.79	4.05	4.054	11.448	4.196	-0.1322	UX1500MSE-SS
15	20.50	17.00	4	3.81	4.28	4.278	6.836	4.209	-0.1852	UX1600MSE-SS
16	22.00	8.00	2	3.73	7.67	7.666	17.577	4.278	0.0016	UX1400MSE-SS
17	23.50	8.00	2	2.00	4.45	4.453	6.561	5.067	-0.0149	UX1400MSE-SS
18	25.00	8.00	2	2.33	5.68	5.679	4.645	6.198	-0.0340	UX1400MSE-SS
19	26.50	8.00	2	2.14	5.77	5.771	1.886	7.871	-0.0643	UX1400MSE-SS

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

N/A

Bearing capacity, Fs = ~~26.59~~, Meyerhof stress = 6056 lb/ft².

Foundation Interface: Direct sliding, Fs = 1.561, Eccentricity, e/L = 0.2135, Fs-overturning = 2.03

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.00	17.00	4	3.47	3.52	3.523	38.257	1.268	0.2135	UX1600MSE-SS
2	1.50	17.00	4	2.05	1.97	1.967	20.725	1.336	0.1828	UX1600MSE-SS
3	3.00	17.00	4	2.12	2.07	2.075	19.591	1.413	0.1533	UX1600MSE-SS
4	4.50	17.00	3	1.41	1.66	1.663	18.458	1.501	0.1249	UX1500MSE-SS
5	6.00	17.00	3	1.43	1.77	1.765	17.328	1.601	0.0976	UX1500MSE-SS
6	7.50	17.00	3	1.45	1.88	1.880	16.200	1.718	0.0713	UX1500MSE-SS
7	9.00	17.00	3	1.47	2.01	2.012	15.075	2.175	0.0222	UX1500MSE-SS
8	10.50	17.00	3	1.50	2.16	2.163	13.954	2.345	0.0036	UX1500MSE-SS
9	12.00	17.00	3	1.52	2.34	2.339	12.838	2.542	-0.0150	UX1500MSE-SS
10	13.50	17.00	3	1.56	2.55	2.545	11.727	2.770	-0.0341	UX1500MSE-SS
11	15.00	17.00	3	1.88	3.28	3.280	12.286	3.033	-0.0546	UX1500MSE-SS
12	16.00	17.00	3	1.95	3.56	3.561	11.604	3.229	-0.0696	UX1500MSE-SS
13	17.50	17.00	3	1.67	3.33	3.331	8.813	3.549	-0.0960	UX1500MSE-SS
14	19.00	17.00	3	1.74	3.77	3.767	7.741	3.870	-0.1310	UX1500MSE-SS
15	20.50	17.00	4	3.38	4.05	4.053	4.852	4.092	-0.1849	UX1600MSE-SS
16	22.00	8.00	2	3.38	6.33	6.331	9.592	2.439	0.0410	UX1400MSE-SS
17	23.50	8.00	2	1.91	4.03	4.030	4.261	3.082	0.0070	UX1400MSE-SS
18	25.00	8.00	2	2.23	5.11	5.109	2.982	4.173	-0.0245	UX1400MSE-SS
19	26.50	8.00	2	2.07	5.29	5.292	1.257	6.305	-0.0620	UX1400MSE-SS

N/A*

* See internal Stability analysis

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AASHTO DESIGN METHOD
LASO TA-73 Airport Landfills

PROJECT IDENTIFICATION

Title:	LASO TA-73 Airport Landfills
Project Number:	D06602
Client:	Slaton Bros SW
Designer:	CLC
Station Number:	Wall 2_4+00.7-4+21.3/ Wall 3_1+00.0-1+09.7

Description:

Tiered wall...Wall 2_DH=22.0' and Wall 3_DH=6', 10' offset_INTERNAL

Company's information:

Name: Tensar Earth Technologies, Inc.
Street: 5883 Glenridge Drive
Suite 200
Atlanta, GA 30328
Telephone #: (404) 250-1290
Fax #: (404) 250-9185
E-Mail: ccampbell@tensarcorp.com

Original file path and name: k:_d\D06602\Final\Design\Design without Wall 1\Wall2an.....
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Original date and time of creating this file: May 22, 2006

PROGRAM MODE: ANALYSIS
of SUPERIMPOSED WALL
using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ		130.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	32.0 °

RETAINED SOIL

Unit weight, γ		100.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	35.5 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$		130.0 lb/ft ^{3}
Equivalent internal angle of friction,	$\phi_{equiv.}$	32.0 °
Equivalent cohesion, $c_{equiv.}$		4000.0 lb/ft ^{2}

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3073 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ = 61.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.2866 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 35.49 N γ = 30.21

SEISMICITY

Maximum ground acceleration coefficient, α_o = 0.262
Kae (α_o> 0) = 0.6986 Kae (α_o= 0) = 0.2866 Δ Kae = 0.4120 (see eq. 37 in DEMO 82)
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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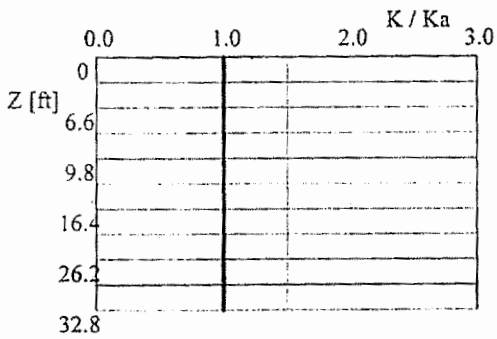
INPUT DATA: Geogrids
(Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	3974.1	4796.3	7811.2	9866.7	11990.8
Durability reduction factor, RFd	1.00	1.00	1.00	1.00	1.00
Installation-damage reduction factor, RFid	1.10	1.10	1.10	1.10	1.10
Creep reduction factor, RFc	2.34	2.21	2.40	2.29	2.22
Fs-overall for strength	N/A	N/A	N/A	N/A	N/A
Coverage ratio, Rc	0.940	0.940	0.940	0.940	0.940
Friction angle along geogrid-soil interface, ρ	26.56	26.56	26.56	26.56	26.56
Pullout resistance factor, F*	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ
Scale-effect correction factor, α	1.0	1.0	1.0	1.0	1.0

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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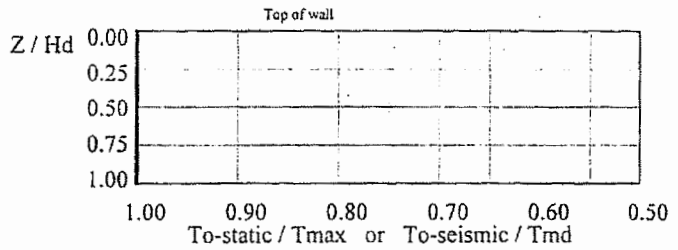
INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.48/1.48 ft. Horizontal distance to Center of Gravity of block is 0.74 ft.
Average unit weight of block is γ_f = 114.58 lb/ft ^{3}

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ (1)	CRult (2)	σ	CRult	σ	CRult	σ	CRult	σ	CRult
0.0	1.00	0.0	1.00	0.0	1.00	0.0	0.38	0.0	0.38
						1200.9	0.44	1200.9	0.44
						2999.0	0.53	3600.5	0.56
						6000.1	0.68	7198.9	0.74

Geogrid Type #1(3)		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr
0.0	0.15	0.0	0.15	0.0	0.15	0.0	0.38	0.0	0.38
480.3	0.20	480.3	0.20	599.4	0.21	1200.9	0.44	1200.9	0.44
1200.9	0.27	1200.9	0.27	1800.3	0.33	2999.0	0.53	3600.5	0.56
2399.6	0.39	2399.6	0.39	3600.5	0.51	6000.1	0.68	7198.9	0.74

(1) σ = Confining stress in between stacked blocks [lb/ft ^{2}]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

In seismic analysis, long term strength is reduced to 100% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	UX1100MSE..	UX1400MSE..	UX1500MSE..	UX1600MSE..	UX1700MSE..
Connection strength reduction factor, RFd	1.10	1.10	1.10	1.10	1.10
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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INPUT DATA: Geometry and Surcharge loads (of SUPERIMPOSED wall)

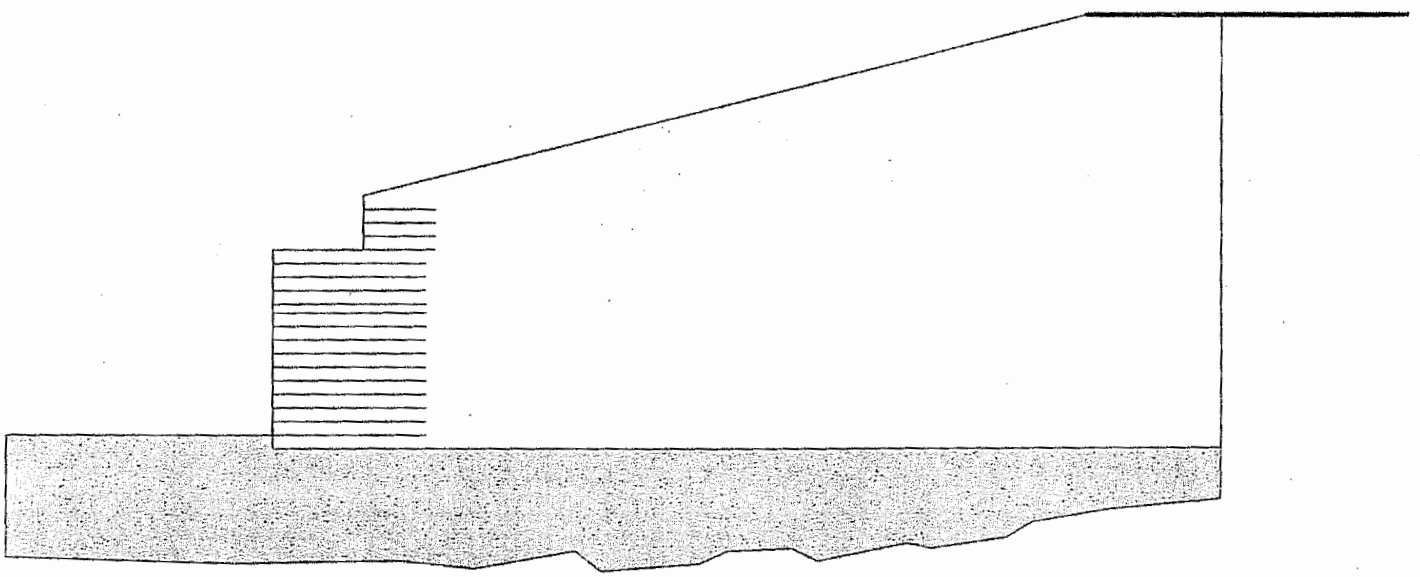
Design height, Hd	28.00	[ft]	{ Embedded depth is E = 1.50 ft, and height above top of finished bottom grade is H = 26.50 ft, where H1 = 6.00 and H2 = 20.50 }
Batter, ω	0.0	[deg]	
Backslope, β	14.0	[deg]	
Backslope rise	20.0	[ft]	Broken back equivalent angle, I = 14.04° (see Fig. 25 in DEMO 82)

Offset of upper segment from lower one, Offset = 10.0 ft, Blackslope2 = 0.0 deg. and Backslope rise, S2 = 0.0 ft.

UNIFORM SURCHARGE
Uniformly distributed dead load is 0.0 [lb/ft ²]

OTHER EXTERNAL LOAD(S)
[S1] Strip Load, Qv-d = 0.0 and Qv-l = 250.0 [lb/ft ²].
Footing width, b=150.0 [ft]. Distance of center of footing from wall face, d = 155.0 [ft] @ depth of 0.0 [ft] below soil surface.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10[ft]

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ANALYSIS: CALCULATED FACTORS (Static conditions)

N/A

Bearing capacity, Fs = 43.69, Meyerhof stress = 3915 lb/ft².

Foundation Interface: Direct sliding, Fs = 2.943, Eccentricity, e/L = 0.0646, Fs-overturning = 4.51

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.00	17.00	4	4.74	4.09	4.086	65.346	2.389	0.0646	UX1600MSE-SS
2	1.50	17.00	4	2.42	2.12	2.123	30.596	2.485	0.0527	UX1600MSE-SS
3	3.00	17.00	4	2.51	2.24	2.239	28.923	2.587	0.0410	UX1600MSE-SS
4	4.50	17.00	3	1.50	1.79	1.789	27.253	2.699	0.0294	UX1500MSE-SS
5	6.00	17.00	3	1.52	1.90	1.898	25.586	2.819	0.0178	UX1500MSE-SS
6	7.50	17.00	3	1.53	2.02	2.023	23.923	2.950	0.0062	UX1500MSE-SS
7	9.00	17.00	3	1.55	2.16	2.164	22.264	3.092	-0.0057	UX1500MSE-SS
8	10.50	17.00	3	1.57	2.33	2.327	20.611	3.246	-0.0180	UX1500MSE-SS
9	12.00	17.00	3	1.60	2.52	2.516	18.964	3.411	-0.0312	UX1500MSE-SS
10	13.50	17.00	3	1.63	2.74	2.739	17.326	3.587	-0.0456	UX1500MSE-SS
11	15.00	17.00	3	1.98	3.58	3.576	18.688	3.771	-0.0622	UX1500MSE-SS
12	16.00	17.00	3	2.04	3.89	3.888	17.707	3.894	-0.0751	UX1500MSE-SS
13	17.50	17.00	3	1.73	3.58	3.584	13.029	4.066	-0.0989	UX1500MSE-SS
14	19.00	17.00	3	1.79	4.05	4.054	11.448	4.196	-0.1322	UX1500MSE-SS
15	20.50	17.00	4	3.81	4.28	4.278	6.836	4.209	-0.1852	UX1600MSE-SS
16	22.00	8.00	2	3.73	7.67	7.666	17.577	4.278	0.0016	UX1400MSE-SS
17	23.50	8.00	2	2.00	4.45	4.453	6.561	5.067	-0.0149	UX1400MSE-SS
18	25.00	8.00	2	2.33	5.68	5.679	4.645	6.198	-0.0340	UX1400MSE-SS
19	26.50	8.00	2	2.14	5.77	5.771	1.886	7.871	-0.0643	UX1400MSE-SS

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

N/A* N/A

Bearing capacity, Fs = 11.33, Meyerhof stress = 13309 lb/ft².

Foundation Interface: Direct sliding, Fs = 1.073, Eccentricity, e/L = 0.3648, Fs-overturning = 1.31 N/A*

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.00	17.00	4	2.85	3.17	3.172	31.490	0.871	0.3648	UX1600MSE-SS
2	1.50	17.00	4	1.82	1.86	1.858	18.458	0.921	0.3163	UX1600MSE-SS
3	3.00	17.00	4	1.89	1.96	1.959	17.447	0.978	0.2698	UX1600MSE-SS
4	4.50	17.00	3	1.35	1.57	1.575	16.438	1.044	0.2254	UX1500MSE-SS
5	6.00	17.00	3	1.37	1.67	1.671	15.430	1.120	0.1830	UX1500MSE-SS
6	7.50	17.00	3	1.39	1.78	1.780	14.425	1.211	0.1425	UX1500MSE-SS
7	9.00	17.00	3	1.41	1.90	1.905	13.423	1.688	0.0502	UX1500MSE-SS
8	10.50	17.00	3	1.44	2.05	2.048	12.424	1.846	0.0254	UX1500MSE-SS
9	12.00	17.00	3	1.47	2.21	2.214	11.429	2.036	0.0014	UX1500MSE-SS
10	13.50	17.00	3	1.50	2.41	2.409	10.439	2.265	-0.0224	UX1500MSE-SS
11	15.00	17.00	3	1.81	3.08	3.076	10.750	2.545	-0.0467	UX1500MSE-SS
12	16.00	17.00	3	1.88	3.34	3.336	10.135	2.766	-0.0638	UX1500MSE-SS
13	17.50	17.00	3	1.63	3.15	3.152	7.842	3.154	-0.0928	UX1500MSE-SS
14	19.00	17.00	3	1.69	3.56	3.564	6.887	3.594	-0.1296	UX1500MSE-SS
15	20.50	17.00	4	3.10	3.89	3.889	4.449	3.983	-0.1846	UX1600MSE-SS
16	22.00	8.00	2	3.15	5.56	5.555	7.645	1.717	0.0815	UX1400MSE-SS
17	23.50	8.00	2	1.85	3.75	3.745	3.702	2.224	0.0299	UX1400MSE-SS
18	25.00	8.00	2	2.15	4.73	4.729	2.574	3.153	-0.0143	UX1400MSE-SS
19	26.50	8.00	2	2.02	4.96	4.962	1.109	5.263	-0.0595	UX1400MSE-SS

N/A*

* See external external stability analysis

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AASHTO DESIGN METHOD
LASO TA-73 Airport Landfills

PROJECT IDENTIFICATION

Title:	LASO TA-73 Airport Landfills
Project Number:	D06602
Client:	Slaton Bros SW
Designer:	CLC
Station Number:	Wall 2_4+21.3-4+47.0/ Wall 3_1+09.7-1+39.8

Description:

Tiered wall...Wall 2_DH=16.0' and Wall 3_DH=6', 10' offset_EXTERNAL

Company's information:

Name: Tensar Earth Technologies, Inc.
Street: 5883 Glenridge Drive
Suite 200
Atlanta, GA 30328
Telephone #: (404) 250-1290
Fax #: (404) 250-9185
E-Mail: ccampbell@tensarcorp.com

Original file path and name: k:_d\D06602\Final\Design\Design without Wall 1\Wall2an.....
.....ndWall3_16-6'_EX.BEN

Original date and time of creating this file: May 22, 2006

PROGRAM MODE: ANALYSIS
of SUPERIMPOSED WALL
using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ		130.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	32.0 °

RETAINED SOIL

Unit weight, γ		100.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	35.5 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$		130.0 lb/ft ^{3}
Equivalent internal angle of friction,	$\phi_{equiv.}$	32.0 °
Equivalent cohesion, $c_{equiv.}$		4000.0 lb/ft ^{2}

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3073 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ = 61.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.2866 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 35.49 N γ = 30.21

SEISMICITY

Maximum ground acceleration coefficient, α_o = 0.131
Kae (α_o > 0) = 0.4492 Kae (α_o = 0) = 0.2866 Δ Kae = 0.1625 (see eq. 37 in DEMO 82)
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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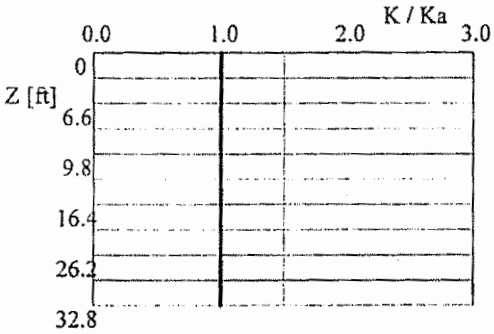
INPUT DATA: Geogrids
(Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	3974.1	4796.3	7811.2	9866.7	11990.8
Durability reduction factor, RFd	1.00	1.00	1.00	1.00	1.00
Installation-damage reduction factor, RFid	1.10	1.10	1.10	1.10	1.10
Creep reduction factor, RFc	2.34	2.21	2.40	2.29	2.22
Fs-overall for strength	N/A	N/A	N/A	N/A	N/A
Coverage ratio, Rc	0.940	0.940	0.940	0.940	0.940
Friction angle along geogrid-soil interface, ρ	26.56	26.56	26.56	26.56	26.56
Pullout resistance factor, F*	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ
Scale-effect correction factor, α	1.0	1.0	1.0	1.0	1.0

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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INPUT DATA: Geometry and Surcharge loads (of SUPERIMPOSED wall)

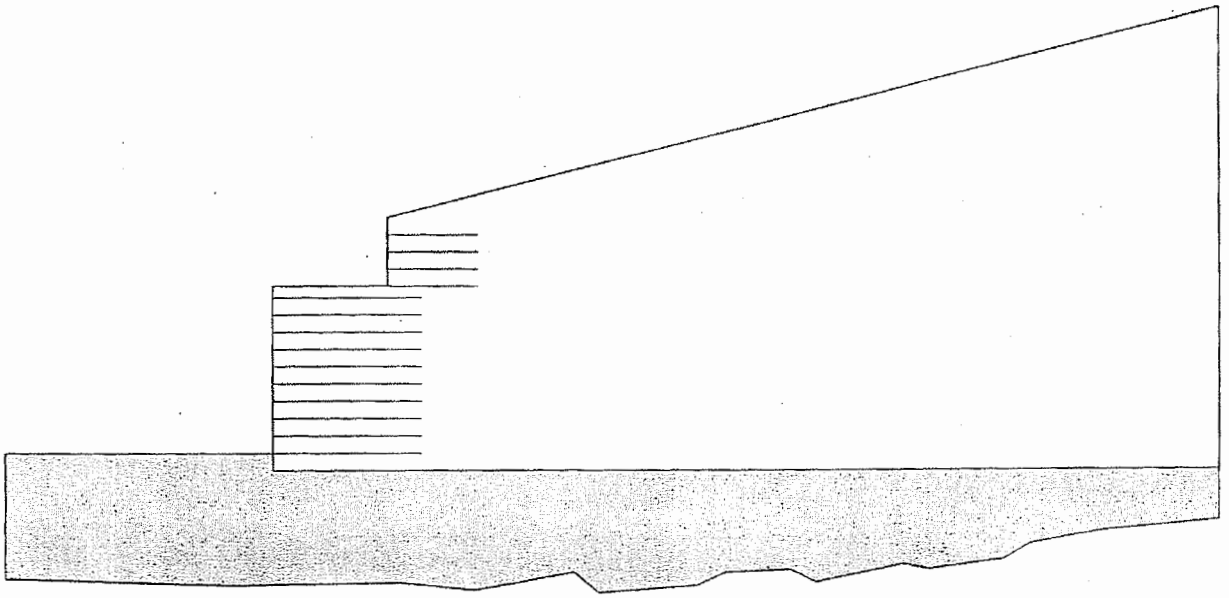
Design height, Hd	22.00	[ft]	{ Embedded depth is E = 1.50 ft, and height above top of finished bottom grade is H = 20.50 ft, where H1 = 6.00 and H2 = 14.50 }
Batter, ω	0.0	[deg]	
Backslope, β	14.0	[deg]	
Backslope rise	20.0	[ft]	Broken back equivalent angle, l = 14.04° (see Fig. 25 in DEMO 82)

Offset of upper segment from lower one, Offset = 10.0 ft, Blackslope2 = 0.0 deg. and Backslope rise, S2 = 0.0 ft.

UNIFORM SURCHARGE
Uniformly distributed dead load is 0.0 [lb/ft ²]

OTHER EXTERNAL LOAD(S)
[S1] Strip Load, Qv-d = 0.0 and Qv-l = 250.0 [lb/ft ²].
Footing width, b=150.0 [ft]. Distance of center of footing from wall face, d = 155.0 [ft] @ depth of 0.0 [ft] below soil surface.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10[ft]

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ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = ~~57.80~~ NA, Meyerhof stress = 2832 lb/ft².

Foundation Interface: Direct sliding, Fs = 2.720, Eccentricity, e/L = 0.0746, Fs-overturning = 4.17

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.00	13.00	3	3.35	4.19	4.186	52.770	2.209	0.0746	UX1500MSE-SS
2	1.50	13.00	3	1.67	2.20	2.205	24.255	2.308	0.0586	UX1500MSE-SS
3	3.00	13.00	3	1.70	2.37	2.374	22.580	2.415	0.0429	UX1500MSE-SS
4	4.50	13.00	3	1.74	2.57	2.571	20.891	2.529	0.0271	UX1500MSE-SS
5	6.00	13.00	3	1.78	2.80	2.804	19.203	2.648	0.0111	UX1500MSE-SS
6	7.50	13.00	3	1.83	3.08	3.084	17.517	2.771	-0.0058	UX1500MSE-SS
7	9.00	13.00	3	1.89	3.42	3.425	15.833	2.890	-0.0243	UX1500MSE-SS
8	10.50	13.00	3	1.97	3.85	3.851	14.153	2.992	-0.0461	UX1500MSE-SS
9	12.00	13.00	3	2.07	4.40	4.398	12.477	3.047	-0.0746	UX1500MSE-SS
10	13.50	13.00	3	2.20	5.13	5.127	10.808	2.989	-0.1182	UX1500MSE-SS
11	15.00	13.00	3	1.90	4.90	4.903	7.301	2.664	-0.2053	UX1500MSE-SS
12	16.00	8.00	2	3.99	8.20	8.199	25.911	4.278	0.0016	UX1400MSE-SS
13	17.50	8.00	2	2.17	4.82	4.817	10.230	5.067	-0.0149	UX1400MSE-SS
14	19.00	8.00	2	2.58	6.28	6.284	7.864	6.198	-0.0340	UX1400MSE-SS
15	20.50	8.00	2	2.51	6.76	6.765	3.676	7.871	-0.0643	UX1400MSE-SS

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = ~~36.17~~ N/A, Meyerhof stress = 4324 lb/ft².

Foundation Interface: Direct sliding, Fs = 1.493, Eccentricity, e/L = 0.2160, Fs-overturning = 2.01

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.00	13.00	3	3.05	3.74	3.736	32.759	1.212	0.2160	UX1500MSE-SS
2	1.50	13.00	3	1.60	2.08	2.081	16.987	1.297	0.1745	UX1500MSE-SS
3	3.00	13.00	3	1.63	2.24	2.241	15.807	1.650	0.0931	UX1500MSE-SS
4	4.50	13.00	3	1.67	2.43	2.426	14.618	1.774	0.0663	UX1500MSE-SS
5	6.00	13.00	3	1.72	2.65	2.646	13.430	1.916	0.0406	UX1500MSE-SS
6	7.50	13.00	3	1.77	2.91	2.908	12.243	2.078	0.0154	UX1500MSE-SS
7	9.00	13.00	3	1.83	3.23	3.229	11.057	2.260	-0.0101	UX1500MSE-SS
8	10.50	13.00	3	1.91	3.63	3.629	9.874	2.458	-0.0375	UX1500MSE-SS
9	12.00	13.00	3	2.01	4.14	4.143	8.694	2.651	-0.0701	UX1500MSE-SS
10	13.50	13.00	3	2.14	4.83	4.825	7.518	2.771	-0.1165	UX1500MSE-SS
11	15.00	13.00	3	1.86	4.67	4.666	5.206	2.617	-0.2051	UX1500MSE-SS
12	16.00	8.00	2	3.58	6.63	6.633	13.621	2.439	0.0410	UX1400MSE-SS
13	17.50	8.00	2	2.05	4.28	4.285	6.420	3.082	0.0070	UX1400MSE-SS
14	19.00	8.00	2	2.44	5.50	5.496	4.778	4.173	-0.0245	UX1400MSE-SS
15	20.50	8.00	2	2.39	5.96	5.965	2.269	6.305	-0.0620	UX1400MSE-SS

N/A*

* see internal stability analysis

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SIERRASCAPE®
RETAINING WALL SYSTEMS

AASHTO DESIGN METHOD
LASO TA-73 Airport Landfills

PROJECT IDENTIFICATION

Title:	LASO TA-73 Airport Landfills
Project Number:	D06602
Client:	Slaton Bros SW
Designer:	CLC
Station Number:	Wall 2_4+21.3-4+47.0/ Wall 3_1+09.7-1+39.8

Description:

Tiered wall...Wall 2_DH=16.0' and Wall 3_DH=6', 10' offset_INTERNAL

Company's information:

Name: Tensar Earth Technologies, Inc.
Street: 5883 Glenridge Drive
Suite 200
Atlanta, GA 30328
Telephone #: (404) 250-1290
Fax #: (404) 250-9185
E-Mail: ccampbell@tensarcorp.com

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Original date and time of creating this file: May 22, 2006

PROGRAM MODE: ANALYSIS
of SUPERIMPOSED WALL
using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ	130.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	32.0 °

RETAINED SOIL

Unit weight, γ	100.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	35.5 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	130.0 lb/ft ^{3}
Equivalent internal angle of friction, $\phi_{equiv.}$	32.0 °
Equivalent cohesion, $c_{equiv.}$	4000.0 lb/ft ^{2}

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3073 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ = 61.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.2866 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 35.49 N γ = 30.21

SEISMICITY

Maximum ground acceleration coefficient, α_o = 0.262
Kae (α_o > 0) = 0.6986 Kae (α_o = 0) = 0.2866 Δ Kae = 0.4120 (see eq. 37 in DEMO 82)
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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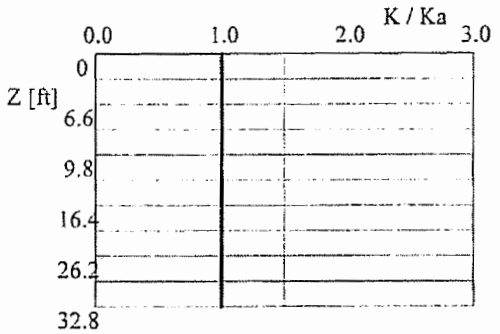
INPUT DATA: Geogrids
(Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	3974.1	4796.3	7811.2	9866.7	11990.8
Durability reduction factor, RFd	1.00	1.00	1.00	1.00	1.00
Installation-damage reduction factor, RFid	1.10	1.10	1.10	1.10	1.10
Creep reduction factor, RFc	2.34	2.21	2.40	2.29	2.22
Fs-overall for strength	N/A	N/A	N/A	N/A	N/A
Coverage ratio, Rc	0.940	0.940	0.940	0.940	0.940
Friction angle along geogrid-soil interface, ρ	26.56	26.56	26.56	26.56	26.56
Pullout resistance factor, F*	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ
Scale-effect correction factor, α	1.0	1.0	1.0	1.0	1.0

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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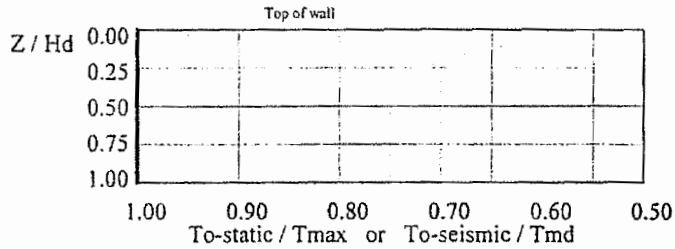
INPUT DATA: Facia and Connection (according to revised Demo 82)
(Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.48/1.48 ft. Horizontal distance to Center of Gravity of block is 0.74 ft.
Average unit weight of block is $\gamma_f = 114.58$ lb/ft^3

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ (1)	CRult (2)	σ	CRult	σ	CRult	σ	CRult	σ	CRult
0.0	1.00	0.0	1.00	0.0	1.00	0.0	0.38	0.0	0.38
						1200.9	0.44	1200.9	0.44
						2999.0	0.53	3600.5	0.56
						6000.1	0.68	7198.9	0.74

Geogrid Type #1(3)		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr
0.0	0.15	0.0	0.15	0.0	0.15	0.0	0.38	0.0	0.38
480.3	0.20	480.3	0.20	599.4	0.21	1200.9	0.44	1200.9	0.44
1200.9	0.27	1200.9	0.27	1800.3	0.33	2999.0	0.53	3600.5	0.56
2399.6	0.39	2399.6	0.39	3600.5	0.51	6000.1	0.68	7198.9	0.74

(1) σ = Confining stress in between stacked blocks [lb/ft^2]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

In seismic analysis, long term strength is reduced to 100% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	UX1100MSE..	UX1400MSE..	UX1500MSE..	UX1600MSE..	UX1700MSE..
Connection strength reduction factor, RFd	1.10	1.10	1.10	1.10	1.10
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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INPUT DATA: Geometry and Surcharge loads (of SUPERIMPOSED wall)

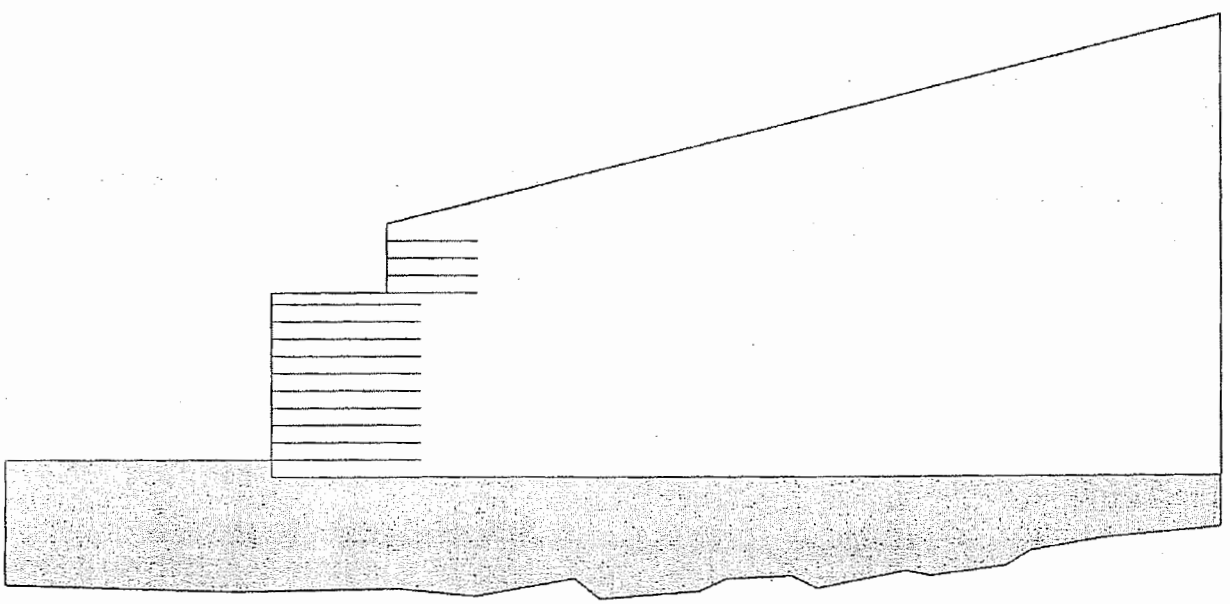
Design height, Hd	22.00	[ft]	{ Embedded depth is E = 1.50 ft, and height above top of finished bottom grade is H = 20.50 ft, where H1 = 6.00 and H2 = 14.50 }
Batter, ω	0.0	[deg]	
Backslope, β	14.0	[deg]	
Backslope rise	20.0	[ft]	Broken back equivalent angle, I = 14.04° (see Fig. 25 in DEMO 82)

Offset of upper segment from lower one, Offset = 10.0 ft, Blackslope2 = 0.0 deg. and Backslope rise, S2 = 0.0 ft.

UNIFORM SURCHARGE
Uniformly distributed dead load is 0.0 [lb/ft ²]

OTHER EXTERNAL LOAD(S)
[S1] Strip Load, Qv-d = 0.0 and Qv-l = 250.0 [lb/ft ²].
Footing width, b=150.0 [ft]. Distance of center of footing from wall face, d = 155.0 [ft] @ depth of 0.0 [ft] below soil surface.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10[ft]

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ANALYSIS: CALCULATED FACTORS (Static conditions)

N/A*

Bearing capacity, Fs = ~~57.80~~, Meyerhof stress = 2832 lb/ft².

Foundation Interface: Direct sliding, Fs = 2.720, Eccentricity, e/L = 0.0746, Fs-overturning = 4.17

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.00	13.00	3	3.35	4.19	4.186	52.770	2.209	0.0746	UX1500MSE-SS
2	1.50	13.00	3	1.67	2.20	2.205	24.255	2.308	0.0586	UX1500MSE-SS
3	3.00	13.00	3	1.70	2.37	2.374	22.580	2.415	0.0429	UX1500MSE-SS
4	4.50	13.00	3	1.74	2.57	2.571	20.891	2.529	0.0271	UX1500MSE-SS
5	6.00	13.00	3	1.78	2.80	2.804	19.203	2.648	0.0111	UX1500MSE-SS
6	7.50	13.00	3	1.83	3.08	3.084	17.517	2.771	-0.0058	UX1500MSE-SS
7	9.00	13.00	3	1.89	3.42	3.425	15.833	2.890	-0.0243	UX1500MSE-SS
8	10.50	13.00	3	1.97	3.85	3.851	14.153	2.992	-0.0461	UX1500MSE-SS
9	12.00	13.00	3	2.07	4.40	4.398	12.477	3.047	-0.0746	UX1500MSE-SS
10	13.50	13.00	3	2.20	5.13	5.127	10.808	2.989	-0.1182	UX1500MSE-SS
11	15.00	13.00	3	1.90	4.90	4.903	7.301	2.664	-0.2053	UX1500MSE-SS
12	16.00	8.00	2	3.99	8.20	8.199	25.911	4.278	0.0016	UX1400MSE-SS
13	17.50	8.00	2	2.17	4.82	4.817	10.230	5.067	-0.0149	UX1400MSE-SS
14	19.00	8.00	2	2.58	6.28	6.284	7.864	6.198	-0.0340	UX1400MSE-SS
15	20.50	8.00	2	2.51	6.76	6.765	3.676	7.871	-0.0643	UX1400MSE-SS

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

N/A* N/A*

Bearing capacity, Fs = ~~15.85~~, Meyerhof stress = 9387 lb/ft².

Foundation Interface: Direct sliding, Fs = ~~1.03~~, Eccentricity, e/L = ~~0.3640~~, Fs-overturning = ~~1.31~~ N/A*

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.00	13.00	3	2.85	3.44	3.440	27.774	0.841	0.3640	UX1500MSE-SS
2	1.50	13.00	3	1.55	1.99	1.992	15.445	0.905	0.2985	UX1500MSE-SS
3	3.00	13.00	3	1.58	2.14	2.144	14.368	1.264	0.1423	UX1500MSE-SS
4	4.50	13.00	3	1.62	2.32	2.321	13.284	1.377	0.1050	UX1500MSE-SS
5	6.00	13.00	3	1.67	2.53	2.531	12.200	1.511	0.0699	UX1500MSE-SS
6	7.50	13.00	3	1.72	2.78	2.782	11.117	1.671	0.0367	UX1500MSE-SS
7	9.00	13.00	3	1.78	3.09	3.088	10.036	1.864	0.0044	UX1500MSE-SS
8	10.50	13.00	3	1.86	3.47	3.469	8.956	2.093	-0.0285	UX1500MSE-SS
9	12.00	13.00	3	1.96	3.96	3.958	7.879	2.352	-0.0654	UX1500MSE-SS
10	13.50	13.00	3	2.10	4.61	4.608	6.807	2.585	-0.1147	UX1500MSE-SS
11	15.00	13.00	3	1.84	4.49	4.492	4.789	2.573	-0.2048	UX1500MSE-SS
12	16.00	8.00	2	3.30	5.75	5.752	10.685	1.717	0.0815	UX1400MSE-SS
13	17.50	8.00	2	1.97	3.94	3.936	5.475	2.224	0.0299	UX1400MSE-SS
14	19.00	8.00	2	2.33	4.99	4.995	4.005	3.153	-0.0143	UX1400MSE-SS
15	20.50	8.00	2	2.30	5.45	5.449	1.918	5.263	-0.0595	UX1400MSE-SS

N/A*

* See external stability analysis

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SIERRASCAPE®
RETAINING WALL SYSTEMS

AASHTO DESIGN METHOD
LASO TA-73 Airport Landfills

PROJECT IDENTIFICATION

Title:	LASO TA-73 Airport Landfills
Project Number:	D06602
Client:	Slaton Bros SW
Designer:	CLC
Station Number:	1+39.8-1+56.5

Description:

Wall 3_DH=6'_EXTERNAL

Company's information:

Name: Tensar Earth Technologies, Inc.
Street: 5883 Glenridge Drive
Suite 200
Atlanta, GA 30328
Telephone #: (404) 250-1290
Fax #: (404) 250-9185
E-Mail: ccampbell@tensarcorp.com

Original file path and name: k:_d\D06602\Final\Design\Design without Wall 1\Wall3_6..... .....ll 1\Wall3_6'_EX.BEN

Original date and time of creating this file: May 22, 2006

PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ		130.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	32.0 °

RETAINED SOIL

Unit weight, γ		100.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	35.5 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$		130.0 lb/ft ^{3}
Equivalent internal angle of friction,	$\phi_{equiv.}$	32.0 °
Equivalent cohesion, $c_{equiv.}$		4000.0 lb/ft ^{2}

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3073 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ = 61.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.2866 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 35.49 N γ = 30.21

SEISMICITY

Maximum ground acceleration coefficient, α_o = 0.131
Kae (α_o > 0) = 0.4015 Kae (α_o = 0) = 0.2486 Δ Kae = 0.1529 (see eq. 37 in DEMO 82)
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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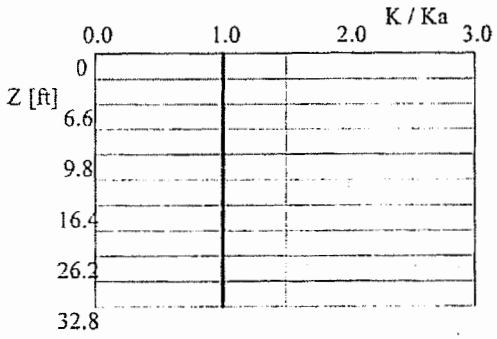
INPUT DATA: Geogrids
(Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	3974.1	4796.3	7811.2	9866.7	11990.8
Durability reduction factor, RFd	1.00	1.00	1.00	1.00	1.00
Installation-damage reduction factor, RFid	1.10	1.10	1.10	1.10	1.10
Creep reduction factor, RFc	2.34	2.21	2.40	2.29	2.22
Fs-overall for strength	N/A	N/A	N/A	N/A	N/A
Coverage ratio, Rc	0.940	0.940	0.940	0.940	0.940
Friction angle along geogrid-soil interface, ρ	26.56	26.56	26.56	26.56	26.56
Pullout resistance factor, F*	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ
Scale-effect correction factor, α	1.0	1.0	1.0	1.0	1.0

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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License number MSEW-301064

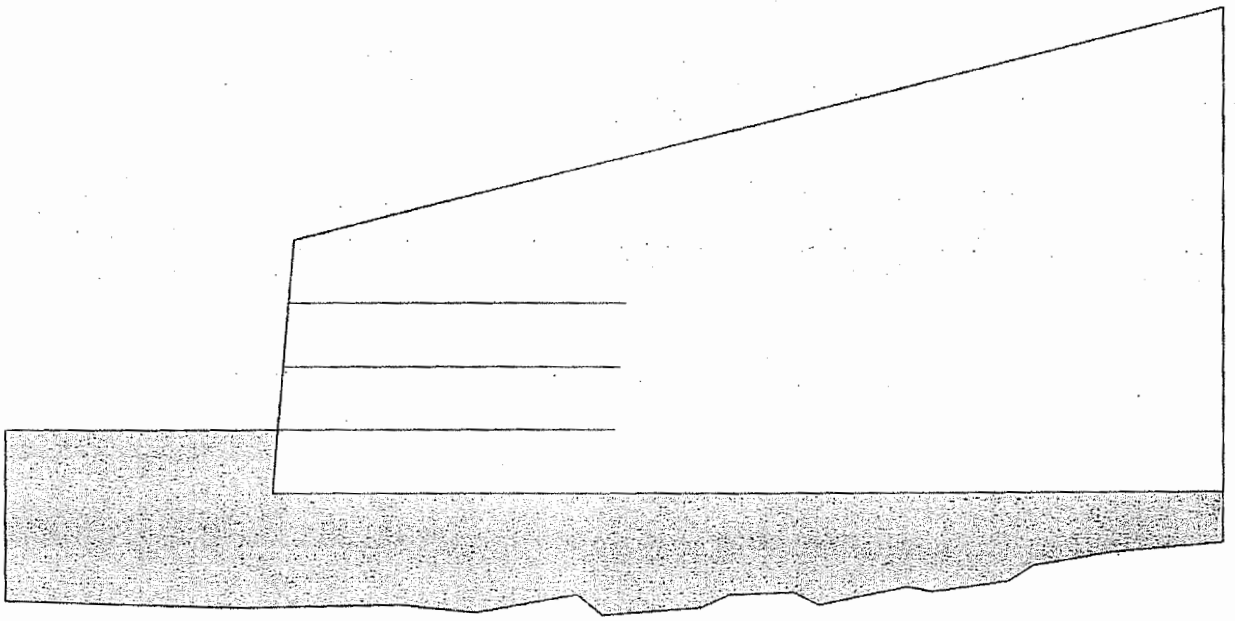
INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd	6.00	[ft]	{ Embedded depth is E = 1.50 ft, and height above top of finished bottom grade is H = 4.50 ft }
Batter, ω	4.8	[deg]	
Backslope, β	14.0	[deg]	
Backslope rise	20.0	[ft]	Broken back equivalent angle, l = 14.04° (see Fig. 25 in DEMO 82)

UNIFORM SURCHARGE
Uniformly distributed dead load is 0.0 [lb/ft ²]

OTHER EXTERNAL LOAD(S)
[S1] Strip Load, Qv-d = 0.0 and Qv-l = 250.0 [lb/ft ²].
Footing width, b=150.0 [ft]. Distance of center of footing from wall face, d = 155.0 [ft] @ depth of 0.0 [ft] below soil surface.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 [ft]

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ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = ~~170.98~~ N/A, Meyerhof stress = 920 lb/ft².

Foundation Interface: Direct sliding, Fs = 5.199, Eccentricity, e/L = -0.0125, Fs-overturning = 13.99

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.00	8.00	2	4.90	10.07	10.066	35.495	4.222	-0.0125	UX1400MSE-SS
2	1.50	8.00	2	2.77	6.16	6.160	16.258	5.030	-0.0255	UX1400MSE-SS
3	3.00	8.00	2	3.61	8.78	8.781	15.677	6.184	-0.0410	UX1400MSE-SS
4	4.50	8.00	2	4.64	12.51	12.505	13.244	7.876	-0.0678	UX1400MSE-SS

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = ~~165.23~~ N/A, Meyerhof stress = 950 lb/ft².

Foundation Interface: Direct sliding, Fs = 3.065, Eccentricity, e/L = 0.0234, Fs-overturning = 7.39

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.00	8.00	2	4.56	8.73	8.729	21.213	2.489	0.0234	UX1400MSE-SS
2	1.50	8.00	2	2.67	5.67	5.675	10.940	3.157	-0.0057	UX1400MSE-SS
3	3.00	8.00	2	3.45	7.91	7.910	10.088	4.279	-0.0325	UX1400MSE-SS
4	4.50	8.00	2	4.41	10.97	10.970	8.093	6.423	-0.0658	UX1400MSE-SS

N/A*

* See internal stability analysis

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AASHTO DESIGN METHOD
LASO TA-73 Airport Landfills

PROJECT IDENTIFICATION

Title: LASO TA-73 Airport Landfills
Project Number: D06602
Client: Slaton Bros SW
Designer: CLC
Station Number: 1+39.8-1+56.5

Description:

Wall 3_DH=6'_INTERNAL

Company's information:

Name: Tensar Earth Technologies, Inc.
Street: 5883 Glenridge Drive
Suite 200
Atlanta, GA 30328
Telephone #: (404) 250-1290
Fax #: (404) 250-9185
E-Mail: ccampbell@tensarcorp.com

Original file path and name: k:_d\D06602\Final\Design\Design without Wall 1\Wall3_6.....
.....ll 1\Wall3_6'_IN.BEN
Original date and time of creating this file: May 22, 2006

PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ		130.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	32.0 °

RETAINED SOIL

Unit weight, γ		100.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	35.5 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$		130.0 lb/ft ^{3}
Equivalent internal angle of friction,	$\phi_{equiv.}$	32.0 °
Equivalent cohesion, $c_{equiv.}$		4000.0 lb/ft ^{2}

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3073 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ= 61.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.2866 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 35.49 N γ= 30.21

SEISMICITY

Maximum ground acceleration coefficient, α_o = 0.262
Kae (α_o> 0) = 0.6339 Kae (α_o= 0) = 0.2486 Δ Kae = 0.3853 (see eq. 37 in DEMO 82)
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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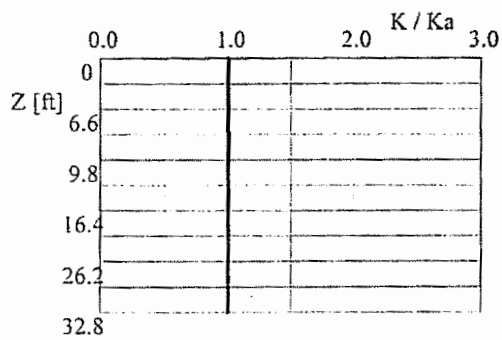
INPUT DATA: Geogrids
(Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	3974.1	4796.3	7811.2	9866.7	11990.8
Durability reduction factor, RFd	1.00	1.00	1.00	1.00	1.00
Installation-damage reduction factor, RFid	1.10	1.10	1.10	1.10	1.10
Creep reduction factor, RFc	2.34	2.21	2.40	2.29	2.22
Fs-overall for strength	N/A	N/A	N/A	N/A	N/A
Coverage ratio, Rc	0.940	0.940	0.940	0.940	0.940
Friction angle along geogrid-soil interface, ρ	26.56	26.56	26.56	26.56	26.56
Pullout resistance factor, F*	$0.80 \cdot \tan\phi$	$0.80 \cdot \tan\phi$	$0.80 \cdot \tan\phi$	$0.80 \cdot \tan\phi$	$0.80 \cdot \tan\phi$
Scale-effect correction factor, α	1.0	1.0	1.0	1.0	1.0

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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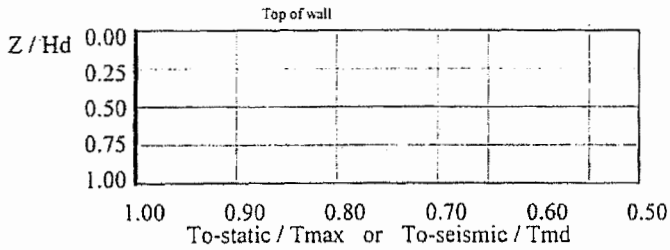
INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.48/1.48 ft. Horizontal distance to Center of Gravity of block is 0.74 ft.
Average unit weight of block is $\gamma_r = 114.58$ lb/ft³

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ (1)	CRult (2)	σ	CRult	σ	CRult	σ	CRult	σ	CRult
0.0	1.00	0.0	1.00	0.0	1.00	0.0	0.38	0.0	0.38
						1200.9	0.44	1200.9	0.44
						2999.0	0.53	3600.5	0.56
						6000.1	0.68	7198.9	0.74

Geogrid Type #1 3)		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr
0.0	0.15	0.0	0.15	0.0	0.15	0.0	0.38	0.0	0.38
480.3	0.20	480.3	0.20	599.4	0.21	1200.9	0.44	1200.9	0.44
1200.9	0.27	1200.9	0.27	1800.3	0.33	2999.0	0.53	3600.5	0.56
2399.6	0.39	2399.6	0.39	3600.5	0.51	6000.1	0.68	7198.9	0.74

(1) σ = Confining stress in between stacked blocks [lb/ft²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

In seismic analysis, long term strength is reduced to 100% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	UX1100MSE..	UX1400MSE..	UX1500MSE..	UX1600MSE..	UX1700MSE..
Connection strength reduction factor, RFd	1.10	1.10	1.10	1.10	1.10
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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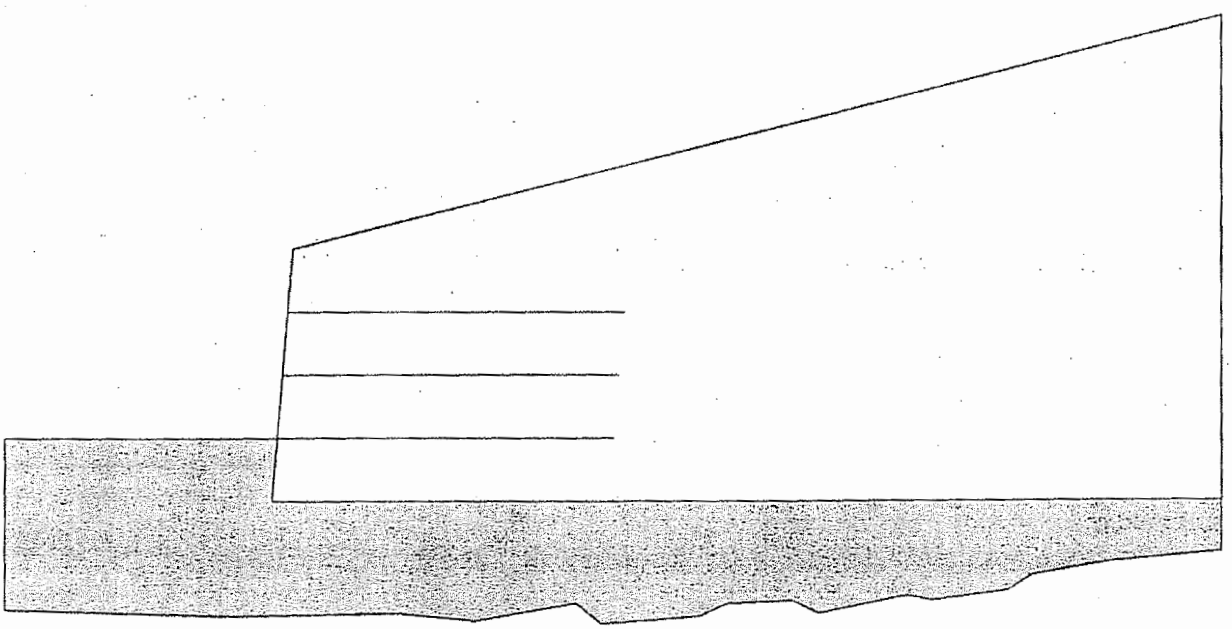
INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd	6.00	[ft]	{ Embedded depth is E = 1.50 ft, and height above top of finished bottom grade is H = 4.50 ft }
Batter, ω	4.8	[deg]	
Backslope, β	14.0	[deg]	
Backslope rise	20.0	[ft]	Broken back equivalent angle, I = 14.04° (see Fig. 25 in DEMO 82)

UNIFORM SURCHARGE
Uniformly distributed dead load is 0.0 [lb/ft ²]

OTHER EXTERNAL LOAD(S)
[S1] Strip Load, Qv-d = 0.0 and Qv-l = 250.0 [lb/ft ²].
Footing width, b=150.0 [ft]. Distance of center of footing from wall face, d = 155.0 [ft] @ depth of 0.0 [ft] below soil surface.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 [ft]

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ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = ~~170.98~~ N/A, Meyerhof stress = 920 lb/ft².

Foundation Interface: Direct sliding, Fs = 5.199, Eccentricity, e/L = -0.0125, Fs-overturning = 13.99

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.00	8.00	2	4.90	10.07	10.066	35.495	4.222	-0.0125	UX1400MSE-SS
2	1.50	8.00	2	2.77	6.16	6.160	16.258	5.030	-0.0255	UX1400MSE-SS
3	3.00	8.00	2	3.61	8.78	8.781	15.677	6.184	-0.0410	UX1400MSE-SS
4	4.50	8.00	2	4.64	12.51	12.505	13.244	7.876	-0.0678	UX1400MSE-SS

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = 149.07, Meyerhof stress = 1044 lb/ft².

Foundation Interface: Direct sliding, Fs = ~~2.188~~ N/A, Eccentricity, e/L = ~~0.0602~~ N/A, Fs-overturning = ~~4.99~~ N/A

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.00	8.00	2	4.32	7.89	7.889	17.637	~~1.776~~	~~0.0602~~	UX1400MSE-SS
2	1.50	8.00	2	2.59	5.34	5.338	9.704	~~2.311~~	~~0.0150~~	UX1400MSE-SS
3	3.00	8.00	2	3.33	7.33	7.328	8.721	3.280	-0.0233	UX1400MSE-SS
4	4.50	8.00	2	4.24	9.99	9.988	6.805	5.429	-0.0635	UX1400MSE-SS

* see external stability analysis N/A*

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SIERRASCAPE®
RETAINING WALL SYSTEMS

AASHTO DESIGN METHOD
LASO TA-73 Airport Landfills

PROJECT IDENTIFICATION

Title: LASO TA-73 Airport Landfills
Project Number: D06602
Client: Slaton Bros SW
Designer: CLC
Station Number: Wall 2_1+00.0-1+35.7/ Wall 4_1+00.0-1+50.0

Description:

Tiered wall...Wall 2_DH=16.0' and Wall 4 _DH=7', 10' offset_EXTERNAL

Company's information:

Name: Tensar Earth Technologies, Inc.
Street: 5883 Glenridge Drive
Suite 200
Atlanta, GA 30328
Telephone #: (404) 250-1290
Fax #: (404) 250-9185
E-Mail: ccampbell@tensarcorp.com

Original file path and name: k:_d\D06602\Final\Design\Design without Wall 1\Wall2an.....
.....andWall 4_16'_EX.BEN
Original date and time of creating this file: May 22, 2006

PROGRAM MODE: ANALYSIS
of SUPERIMPOSED WALL
using GEOGRID as reinforcing material.

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License number MSEW-301064

SOIL DATA

REINFORCED SOIL

Unit weight, γ		130.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	32.0 °

RETAINED SOIL

Unit weight, γ		100.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	35.5 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$		130.0 lb/ft ^{3}
Equivalent internal angle of friction,	$\phi_{equiv.}$	32.0 °
Equivalent cohesion, $c_{equiv.}$		4000.0 lb/ft ^{2}

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3073 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ = 61.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.2866 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 35.49 N γ= 30.21

SEISMICITY

Maximum ground acceleration coefficient, α_o = 0.131
Kae (α_o> 0) = 0.4492 Kae (α_o= 0) = 0.2866 Δ Kae = 0.1625 (see eq. 37 in DEMO 82)
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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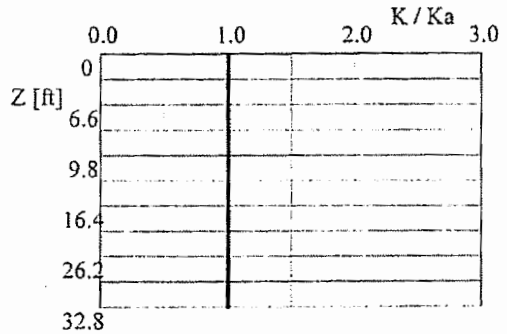
INPUT DATA: Geogrids
(Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	3974.1	4796.3	7811.2	9866.7	11990.8
Durability reduction factor, RFd	1.00	1.00	1.00	1.00	1.00
Installation-damage reduction factor, RFid	1.10	1.10	1.10	1.10	1.10
Creep reduction factor, RFc	2.34	2.21	2.40	2.29	2.22
Fs-overall for strength	N/A	N/A	N/A	N/A	N/A
Coverage ratio, Rc	0.940	0.940	0.940	0.940	0.940
Friction angle along geogrid-soil interface, ρ	26.56	26.56	26.56	26.56	26.56
Pullout resistance factor, F*	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ
Scale-effect correction factor, α	1.0	1.0	1.0	1.0	1.0

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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INPUT DATA: Geometry and Surcharge loads (of SUPERIMPOSED wall)

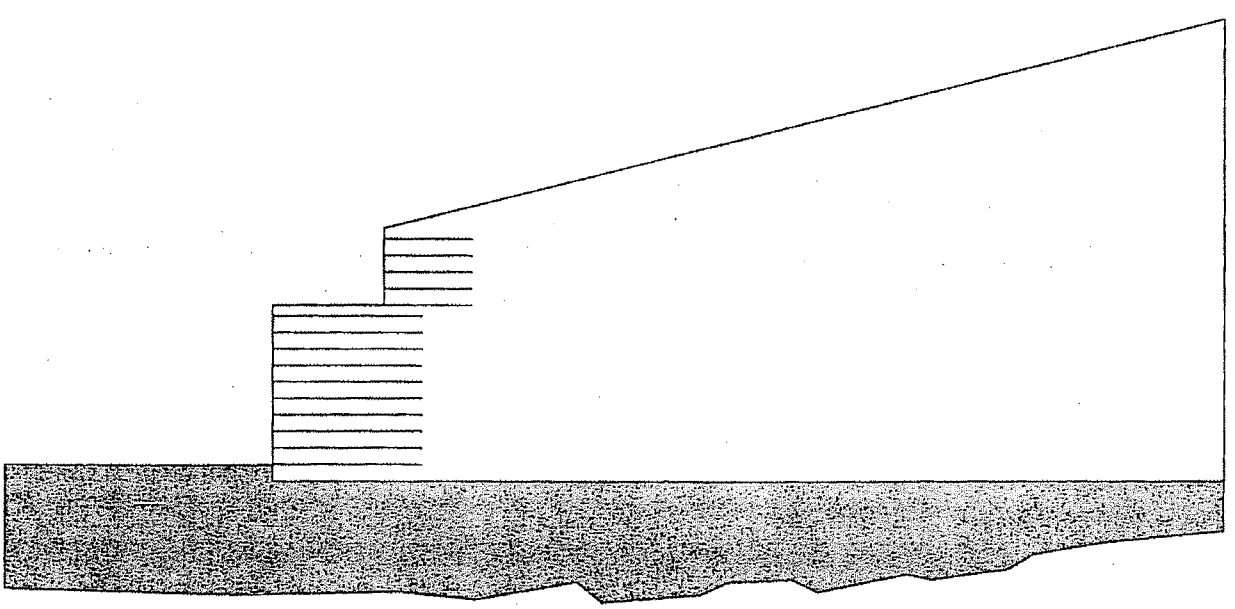
Design height, Hd	23.00	[ft]	{ Embedded depth is E = 1.50 ft, and height above top of finished bottom grade is H = 21.50 ft, where H1 = 7.00 and H2 = 14.50 }
Batter, ω	0.0	[deg]	
Backslope, β	14.0	[deg]	
Backslope rise	20.0	[ft]	Broken back equivalent angle, I = 14.04° (see Fig. 25 in DEMO 82)

Offset of upper segment from lower one, Offset = 10.0 ft, Blackslope2 = 0.0 deg. and Backslope rise, S2 = 0.0 ft.

UNIFORM SURCHARGE
Uniformly distributed dead load is 0.0 [lb/ft ²]

OTHER EXTERNAL LOAD(S)
[S1] Strip Load, Qv-d = 0.0 and Qv-l = 250.0 [lb/ft ²].
Footing width, b=150.0 [ft]. Distance of center of footing from wall face, d = 155.0 [ft] @ depth of 0.0 [ft] below soil surface.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10[ft]

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ANALYSIS: CALCULATED FACTORS (Static conditions)

N/A

Bearing capacity, Fs = ~~56.84~~, Meyerhof stress = 2897 lb/ft².

Foundation Interface: Direct sliding, Fs = 2.637, Eccentricity, e/L = 0.0723, Fs-overturning = 4.06

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.00	13.50	3	3.22	4.02	4.023	55.132	2.141	0.0723	UX1500MSE-SS
2	1.50	13.50	3	1.60	2.11	2.114	25.433	2.228	0.0560	UX1500MSE-SS
3	3.00	13.50	3	1.63	2.27	2.270	23.741	2.321	0.0398	UX1500MSE-SS
4	4.50	13.50	3	1.66	2.45	2.449	22.066	2.418	0.0234	UX1500MSE-SS
5	6.00	13.50	3	1.69	2.66	2.660	20.378	2.518	0.0065	UX1500MSE-SS
6	7.50	13.50	3	1.73	2.91	2.910	18.692	2.618	-0.0115	UX1500MSE-SS
7	9.00	13.50	3	1.77	3.21	3.212	17.024	2.711	-0.0314	UX1500MSE-SS
8	10.50	13.50	3	1.83	3.58	3.584	15.345	2.786	-0.0550	UX1500MSE-SS
9	12.00	13.50	3	1.91	4.05	4.053	13.672	2.819	-0.0856	UX1500MSE-SS
10	13.50	13.50	3	2.00	4.66	4.664	12.022	2.762	-0.1308	UX1500MSE-SS
11	15.00	13.50	3	1.69	4.37	4.368	8.249	2.508	-0.2141	UX1500MSE-SS
12	16.00	8.00	2	3.66	7.17	7.167	26.437	3.875	0.0126	UX1400MSE-SS
13	17.50	8.00	2	1.95	4.12	4.120	10.697	4.512	-0.0038	UX1400MSE-SS
14	19.00	8.00	2	2.25	5.15	5.148	8.589	5.397	-0.0208	UX1400MSE-SS
15	20.50	8.00	2	2.73	6.86	6.859	6.211	6.685	-0.0420	UX1400MSE-SS
16	22.00	8.00	2	3.29	9.19	9.187	2.827	8.559	-0.0821	UX1400MSE-SS

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

N/A

Bearing capacity, Fs = ~~35.17~~, Meyerhof stress = 4462 lb/ft².

Foundation Interface: Direct sliding, Fs = 1.457, Eccentricity, e/L = 0.2169, Fs-overturning = 1.98

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.00	13.50	3	2.94	3.60	3.603	34.475	1.183	0.2169	UX1500MSE-SS
2	1.50	13.50	3	1.54	2.00	2.000	17.882	1.261	0.1755	UX1500MSE-SS
3	3.00	13.50	3	1.56	2.15	2.146	16.687	1.351	0.1358	UX1500MSE-SS
4	4.50	13.50	3	1.59	2.32	2.315	15.504	1.756	0.0583	UX1500MSE-SS
5	6.00	13.50	3	1.63	2.51	2.514	14.311	1.885	0.0327	UX1500MSE-SS
6	7.50	13.50	3	1.67	2.75	2.750	13.119	2.030	0.0072	UX1500MSE-SS
7	9.00	13.50	3	1.72	3.03	3.034	11.941	2.190	-0.0190	UX1500MSE-SS
8	10.50	13.50	3	1.78	3.38	3.384	10.754	2.357	-0.0476	UX1500MSE-SS
9	12.00	13.50	3	1.85	3.83	3.825	9.571	2.512	-0.0818	UX1500MSE-SS
10	13.50	13.50	3	1.95	4.40	4.399	8.405	2.599	-0.1294	UX1500MSE-SS
11	15.00	13.50	3	1.66	4.17	4.166	5.910	2.474	-0.2139	UX1500MSE-SS
12	16.00	8.00	2	3.32	5.97	5.972	14.664	2.142	0.0665	UX1400MSE-SS
13	17.50	8.00	2	1.86	3.73	3.735	6.970	2.621	0.0292	UX1400MSE-SS
14	19.00	8.00	2	2.14	4.62	4.622	5.490	3.378	-0.0036	UX1400MSE-SS
15	20.50	8.00	2	2.59	6.06	6.060	3.848	4.720	-0.0355	UX1400MSE-SS
16	22.00	8.00	2	3.12	7.99	7.989	1.699	7.441	-0.0812	UX1400MSE-SS

N/A *

* See Internal Stability Analysis

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SIERRASCAPE®
RETAINING WALL SYSTEMS

AASHTO DESIGN METHOD
LASO TA-73 Airport Landfills

PROJECT IDENTIFICATION

Title:	LASO TA-73 Airport Landfills
Project Number:	D06602
Client:	Slaton Bros SW
Designer:	CLC
Station Number:	Wall 2_1+00.0-1+35.7/ Wall 4_1+00.0-1+50.0

Description:

Tiered wall...Wall 2_DH=16.0' and Wall 4 _DH=7', 10' offset_INTERNAL

Company's information:

Name: Tensar Earth Technologies, Inc.
Street: 5883 Glenridge Drive
Suite 200
Atlanta, GA 30328
Telephone #: (404) 250-1290
Fax #: (404) 250-9185
E-Mail: ccampbell@tensarcorp.com

Original file path and name: k:_d\D06602\Final\Design\Design without Wall 1\Wall2an.....
.....2andWall4_16'_IN.BEN

Original date and time of creating this file: May 22, 2006

PROGRAM MODE: ANALYSIS
of SUPERIMPOSED WALL
using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ 130.0 lb/ft³
Design value of internal angle of friction, ϕ 32.0 °

RETAINED SOIL

Unit weight, γ 100.0 lb/ft³
Design value of internal angle of friction, ϕ 35.5 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$ 130.0 lb/ft³
Equivalent internal angle of friction, $\phi_{equiv.}$ 32.0 °
Equivalent cohesion, $c_{equiv.}$ 4000.0 lb/ft²

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.3073 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Inclination of internal slip plane, ψ = 61.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.2866 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 35.49 N γ = 30.21

SEISMICITY

Maximum ground acceleration coefficient, α_o = 0.262
Kae (α_o> 0) = 0.6986 Kae (α_o= 0) = 0.2866 Δ Kae = 0.4120 (see eq. 37 in DEMO 82)
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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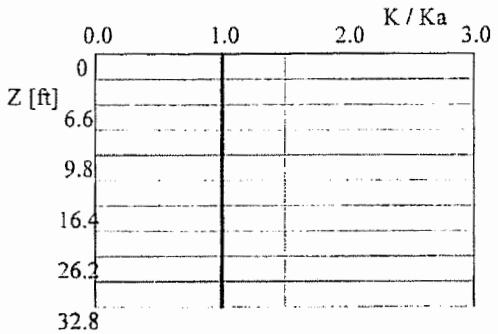
INPUT DATA: Geogrids
(Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	3974.1	4796.3	7811.2	9866.7	11990.8
Durability reduction factor, RFd	1.00	1.00	1.00	1.00	1.00
Installation-damage reduction factor, RFid	1.10	1.10	1.10	1.10	1.10
Creep reduction factor, RFc	2.34	2.21	2.40	2.29	2.22
Fs-overall for strength	N/A	N/A	N/A	N/A	N/A
Coverage ratio, Rc	0.940	0.940	0.940	0.940	0.940
Friction angle along geogrid-soil interface, ρ	26.56	26.56	26.56	26.56	26.56
Pullout resistance factor, F*	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ	0.80·tanϕ
Scale-effect correction factor, α	1.0	1.0	1.0	1.0	1.0

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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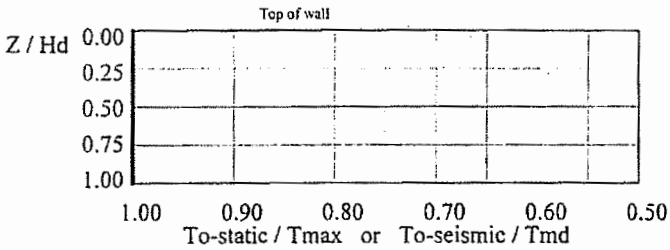
INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.48/1.48 ft. Horizontal distance to Center of Gravity of block is 0.74 ft.
Average unit weight of block is $\gamma_f = 114.58$ lb/ft³

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ (1)	CRult (2)	σ	CRult	σ	CRult	σ	CRult	σ	CRult
0.0	1.00	0.0	1.00	0.0	1.00	0.0	0.38	0.0	0.38
						1200.9	0.44	1200.9	0.44
						2999.0	0.53	3600.5	0.56
						6000.1	0.68	7198.9	0.74

Geogrid Type #1(3)		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr	σ	CRcr
0.0	0.15	0.0	0.15	0.0	0.15	0.0	0.38	0.0	0.38
480.3	0.20	480.3	0.20	599.4	0.21	1200.9	0.44	1200.9	0.44
1200.9	0.27	1200.9	0.27	1800.3	0.33	2999.0	0.53	3600.5	0.56
2399.6	0.39	2399.6	0.39	3600.5	0.51	6000.1	0.68	7198.9	0.74

(1) σ = Confining stress in between stacked blocks [lb/ft²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

In seismic analysis, long term strength is reduced to 100% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	UX1100MSE..	UX1400MSE..	UX1500MSE..	UX1600MSE..	UX1700MSE..
Connection strength reduction factor, RFd	1.10	1.10	1.10	1.10	1.10
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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INPUT DATA: Geometry and Surcharge loads (of SUPERIMPOSED wall)

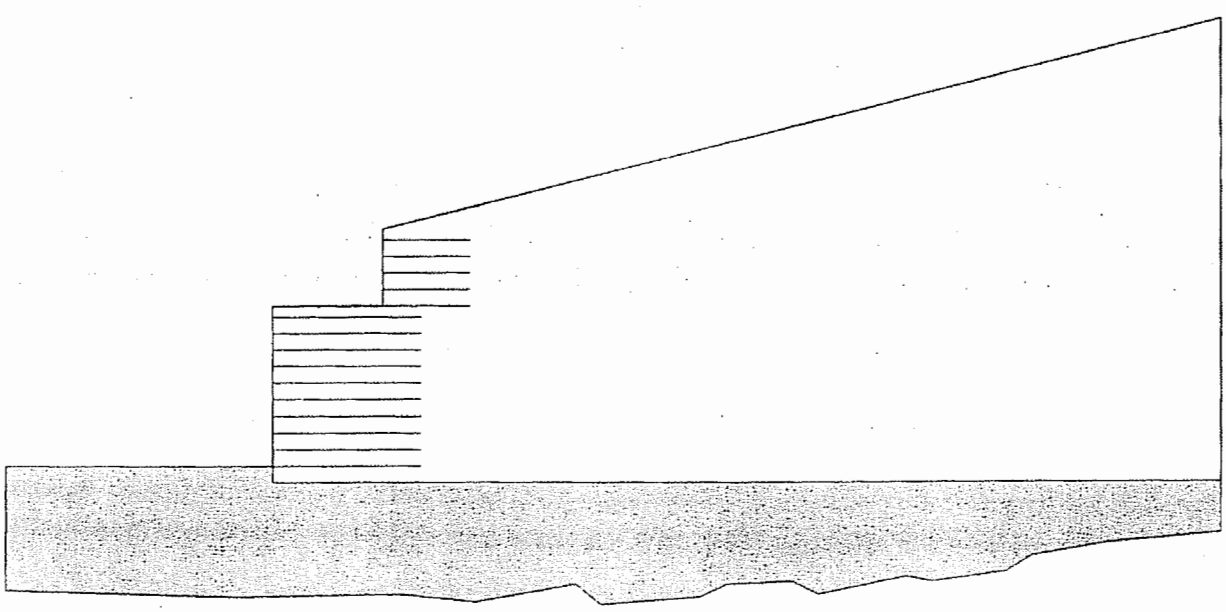
Design height, Hd	23.00	[ft]	{ Embedded depth is E = 1.50 ft, and height above top of finished bottom grade is H = 21.50 ft, where H1 = 7.00 and H2 = 14.50 }
Batter, ω	0.0	[deg]	
Backslope, β	14.0	[deg]	
Backslope rise	20.0	[ft]	Broken back equivalent angle, I = 14.04° (see Fig. 25 in DEMO 82)

Offset of upper segment from lower one, Offset = 10.0 ft, Blackslope2 = 0.0 deg. and Backslope rise, S2 = 0.0 ft.

UNIFORM SURCHARGE
Uniformly distributed dead load is 0.0 [lb/ft ²]

OTHER EXTERNAL LOAD(S)
[S1] Strip Load, Qv-d = 0.0 and Qv-l = 250.0 [lb/ft ²].
Footing width, b=150.0 [ft]. Distance of center of footing from wall face, d = 155.0 [ft] @ depth of 0.0 [ft] below soil surface.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10[ft]

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ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, Fs = ~~56.84~~ N/A*, Meyerhof stress = 2897 lb/ft².

Foundation Interface: Direct sliding, Fs = 2.637, Eccentricity, e/L = 0.0723, Fs-overturning = 4.06

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.00	13.50	3	3.22	4.02	4.023	55.132	2.141	0.0723	UX1500MSE-SS
2	1.50	13.50	3	1.60	2.11	2.114	25.433	2.228	0.0560	UX1500MSE-SS
3	3.00	13.50	3	1.63	2.27	2.270	23.741	2.321	0.0398	UX1500MSE-SS
4	4.50	13.50	3	1.66	2.45	2.449	22.066	2.418	0.0234	UX1500MSE-SS
5	6.00	13.50	3	1.69	2.66	2.660	20.378	2.518	0.0065	UX1500MSE-SS
6	7.50	13.50	3	1.73	2.91	2.910	18.692	2.618	-0.0115	UX1500MSE-SS
7	9.00	13.50	3	1.77	3.21	3.212	17.024	2.711	-0.0314	UX1500MSE-SS
8	10.50	13.50	3	1.83	3.58	3.584	15.345	2.786	-0.0550	UX1500MSE-SS
9	12.00	13.50	3	1.91	4.05	4.053	13.672	2.819	-0.0856	UX1500MSE-SS
10	13.50	13.50	3	2.00	4.66	4.664	12.022	2.762	-0.1308	UX1500MSE-SS
11	15.00	13.50	3	1.69	4.37	4.368	8.249	2.508	-0.2141	UX1500MSE-SS
12	16.00	8.00	2	3.66	7.17	7.167	26.437	3.875	0.0126	UX1400MSE-SS
13	17.50	8.00	2	1.95	4.12	4.120	10.697	4.512	-0.0038	UX1400MSE-SS
14	19.00	8.00	2	2.25	5.15	5.148	8.589	5.397	-0.0208	UX1400MSE-SS
15	20.50	8.00	2	2.73	6.86	6.859	6.211	6.685	-0.0420	UX1400MSE-SS
16	22.00	8.00	2	3.29	9.19	9.187	2.827	8.559	-0.0821	UX1400MSE-SS

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, Fs = ~~14.83~~ N/A*, Meyerhof stress = 10032 lb/ft².

Foundation Interface: Direct sliding, Fs = ~~1.012~~ N/A*, Eccentricity, e/L = ~~0.3690~~ N/A*, Fs-overturning = ~~1.29~~ N/A*

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION Fs-overall [connection strength]	Fs-overall [geogrid strength]	Geogrid strength Fs	Pullout resistance Fs	Direct sliding Fs	Eccentricity e/L	Product name
1	0.00	13.50	3	2.76	3.33	3.326	29.341	0.822	0.3690	UX1500MSE-SS
2	1.50	13.50	3	1.49	1.92	1.916	16.300	0.881	0.3040	UX1500MSE-SS
3	3.00	13.50	3	1.52	2.06	2.056	15.208	0.951	0.2420	UX1500MSE-SS
4	4.50	13.50	3	1.55	2.22	2.218	14.125	1.387	0.0928	UX1500MSE-SS
5	6.00	13.50	3	1.58	2.41	2.408	13.035	1.515	0.0587	UX1500MSE-SS
6	7.50	13.50	3	1.63	2.63	2.633	11.945	1.666	0.0259	UX1500MSE-SS
7	9.00	13.50	3	1.68	2.91	2.905	10.867	1.844	-0.0064	UX1500MSE-SS
8	10.50	13.50	3	1.74	3.24	3.239	9.782	2.049	-0.0398	UX1500MSE-SS
9	12.00	13.50	3	1.81	3.66	3.661	8.700	2.270	-0.0778	UX1500MSE-SS
10	13.50	13.50	3	1.91	4.21	4.208	7.633	2.457	-0.1279	UX1500MSE-SS
11	15.00	13.50	3	1.64	4.02	4.017	5.454	2.442	-0.2137	UX1500MSE-SS
12	16.00	8.00	2	3.09	5.27	5.268	11.772	1.492	0.1212	UX1400MSE-SS
13	17.50	8.00	2	1.80	3.47	3.475	6.068	1.858	0.0633	UX1400MSE-SS
14	19.00	8.00	2	2.06	4.27	4.272	4.728	2.467	0.0146	UX1400MSE-SS
15	20.50	8.00	2	2.49	5.54	5.543	3.259	3.654	-0.0284	UX1400MSE-SS
16	22.00	8.00	2	3.00	7.23	7.234	1.417	6.583	-0.0800	UX1400MSE-SS

N/A*

* See external stability analysis

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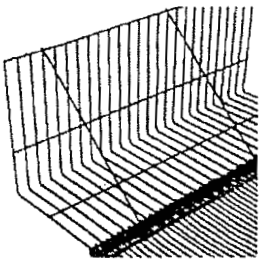
SIERRASCAPE®

RETAINING WALL SYSTEM

INSTALLATION GUIDE



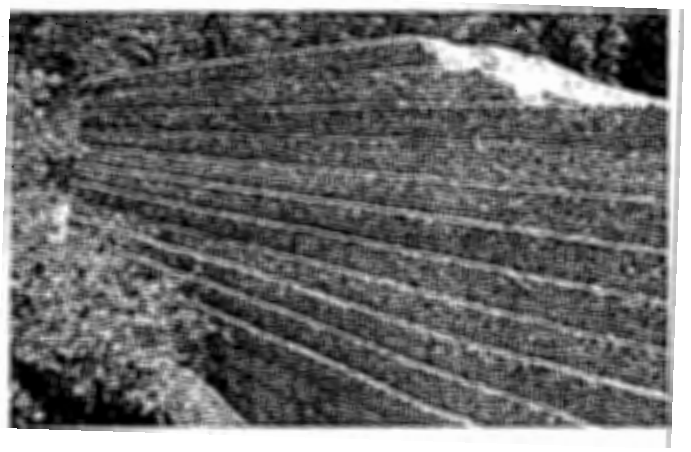
This manual for the SierraScape® Retaining Wall System from Tensar Earth Technologies (TET) is provided as a guideline for construction and quality control of the installation. This manual shall be provided to the Owner's Engineer, the construction quality assurance inspector, and the Contractor.

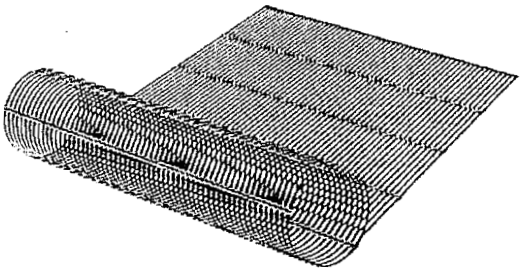
1. Responsibilities for Construction Compliance

The Contractor must provide for construction of the wall in accordance with the contract documents, plans, and specifications. The Contractor is also responsible for the verification of line, grade, and other physical features.

The TET technical representative may assist the Contractor and the inspection staff with the procedures within this manual and the contract plans, documents, and specifications. The representative may be on site at the start of construction and thereafter only as requested or necessary.

The TET technical representative is not authorized to countermand any details or instructions herein or on the approved construction drawings without the express written agreement of the Engineer.





Tensar Uniaxial (UX) Geogrid.

2. Materials and Handling

MATERIALS SUPPLIED

Tensar® Uniaxial (UX) and Biaxial (BX) Reinforcement Geogrids

Non-woven needle punched geotextile or Turf Reinforcement Mat (TRM) from TET (depending on facing option)

SierraScape Facing Elements

Support Struts

SierraScape Connection Rods

HANDLING WALL MATERIALS

Tensar Geogrids are shipped in roll form. The Contractor is responsible for off-loading the rolls. Standard roll sizes of the UX Geogrids are 4.36 feet wide x 200 or 250 feet long and weigh between 75 and 180 pounds. The rolls should be color coded by the Contractor on their edges, according to type, prior to the removal of the labels. The standard roll size for BX1100 Geogrid is 10 and 13 feet wide x 246 feet long, while the standard roll size for BX1200 is 10 and 13 feet wide x 165 feet long.

Preparing the subgrade.

The SierraScape facing units are typically packaged 50 to a bundle. The support struts and SierraScape connection rods are boxed loose. All materials are to be off-loaded by the Contractor.

It is the Contractor's responsibility to verify the quantities shipped and the condition of the materials.

Geotextile and TRM are shipped in roll form and are to be off-loaded by the Contractor. The standard roll sizes are 15 feet wide by 300 feet long and 6.7 feet wide by 150 feet long, respectively.

If certifications are required by the contract documents, they will be supplied along with the material that is shipped. It is the Contractor's responsibility to ensure that the Engineer is provided this information.

The Contractor is allowed one hour to off-load the facing units, geogrid, and accessories.

CONTRACTOR SUPPLIED MATERIALS

Reinforced, select, or plantable fill

Cable ties or tie wire

Utility saw

Alignment system materials (laser, stringline, etc.)

Side cut shears

4-foot level

All labor, equipment, and supervision necessary to perform the total wall construction.

3. Preparatory Work for Wall Construction

Verify the condition, approval, and receipt of the SierraScape facing units, connection rods, support struts, Tensar Geogrid, and fill materials. Materials should arrive in good condition. TET will not replace materials that have been accepted by the Contractor.

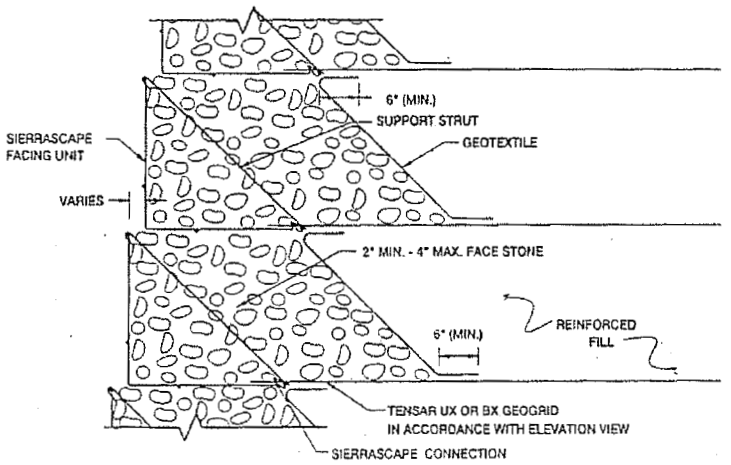
Prepare subgrade by excavating to the plan elevation and horizontally to the design geogrid lengths. It is the Contractor's responsibility to verify that insitu conditions are as shown on the design plans prior to beginning construction. If site conditions vary from the plans, the wall may require redesign. In this case, the Engineer must be notified by the Contractor prior to proceeding with the SierraScape Wall construction.

The subgrade shall be approved before proceeding with the wall construction. Any soils found unsuitable by the Engineer shall be treated in a manner approved by the Engineer.

Grade and proof roll subgrade.

Checking setback and wall alignment.

Placing the geogrid over the connection loops of the facing element.



SierraScape Facing Detail (stone-filled face).

4. Wall Construction

Install offset stringline, story pole, or other control for the purpose of checking wall alignment.

Pre-cut the geogrid and geotextile to the lengths stated on the Plans.

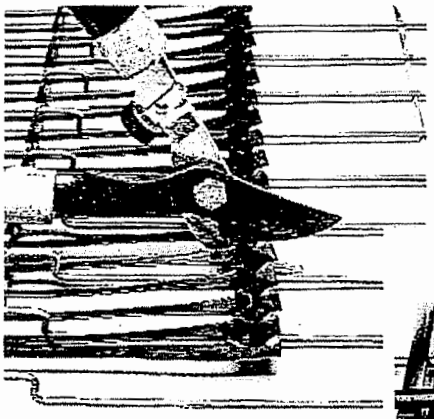
Install the facing elements on level grade. Butt facing elements end-to-end with the extended horizontal wires on one unit overlapping the adjacent unit. *Note: the elements may move forward during backfill placement and compaction. Set the first few courses 1 to 2 inches behind the face control line. Adjust setback of upper courses based on observed movements.*

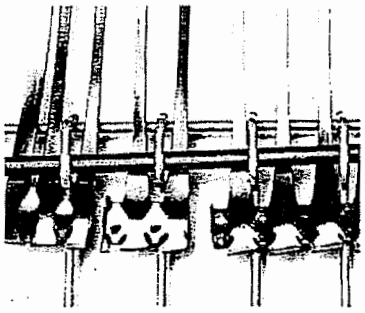
Attach the end vertical wires of adjacent elements with cable ties or tie wires to maintain alignment and contain fill.

Two strips of Tensar UX Geogrid shall be attached to each facing element. The geogrid shall not overlap adjacent facing elements. The two outer ribs of the left geogrid shall be placed between the outer two wires on the left side of the facing element. The outer ribs of the other geogrid shall be positioned between outer wires on the right side of the facing element. Two geogrid ribs shall be positioned between each pair of wires. As shown in the photo (to the right), the transverse bar of the UX Geogrid will have to be cut in places to position pairs of ribs between pairs of wires. Cuts shall be made only at apertures between wire pairs. *Note: The transverse bar may need to be cut in a few more places to allow contact between the geogrid and the connection loops.*

Thread the connection rod through the connection loop over the ribs of the Tensar UX Geogrid.

Inserting the SierraScape connection rod.





When geogrid apertures do not perfectly align with the SierraScape "loops", cut the geogrid at the transverse bar that does not bear on a connection loop.

Installing support struts at both ends of the SierraScape facing unit.

Wall Construction Continued...

Place face backing as specified where face fill is finer than 2- to 4-inch stone. Where 1- to 2-inch stone face fill is specified, use BX1100 or BX1120 Geogrid to retain the stone. Where finer grained fill is specified, use a TRM or geotextile. The face backing will be 2 feet wide to cover the face and extend 6 inches under the fill. It may be connected to the top with clips, ties, or the diagonal struts discussed below.

Connect the top and back horizontal wires of the facing elements with diagonal stiffening struts spaced at approximately 16-inch spacing. One strut should be positioned between the two end wires to support the joint between facing units.

In preparation for fill placement, pull the UX Geogrid toward the reinforced backfill zone so that it is tight against the connection. Maintain alignment of the facing elements by standing on them. Place the first 9-inch lift of backfill on top of the geogrid, while maintaining an open zone at the facing element for the stone facing. The fill should be placed near the face of the wall first and then proceed toward the tails of the geogrid. This will promote further tensioning of the geogrid.

After the backfill is placed on the geogrid, roll the pre-cut geotextile along the front edge of the backfill (if required). A tab of at least 6 inches of geotextile is required to extend under the stone facing.

Facing fill material should be installed in 9-inch loose lifts unless the plans require smaller lifts. To provide a level surface for the next facing element, it is optional to use a thin layer of well-graded aggregate at the top of the basket.

A vibratory plate tamper is recommended for compacting facing and reinforced fill materials within 3 feet of the wall face or as the plans require. *Note: Good compaction at the wall face will minimize "pillowing" of the lower facing units as the wall construction proceeds.*

Conventional rolled compaction equipment may be used to compact reinforced fill beyond the 3-foot face zone to 95% of AASHTO-T99 maximum dry density or as otherwise specified. The thickness of compacted lift shall be no more than 9 inches.

Alignment adjustments will be required as the type of fill, the moisture content, equipment, and wall height will effect the amount of movement of an individual facing element. *Note: The facing elements may not move uniformly. Subsequent rows of facing elements can be set with a relative setback based upon observed movements. The Contractor should check facing alignment as every course of elements is placed. To correct alignment, a 2-inch maximum overhang is permitted.*

At the end of each day, the Contractor must ensure that the reinforced backfill is graded to drain away from the face of the wall. Berms and/or ditches must also be in place and functioning to prevent the entrance of runoff into the wall construction site.

Placing backfill over the geotextile separator.

Compacting the reinforced backfill.

5. Definitions

Contract Document:
The Agreement between the Owner and the Contractor including conditions of the contract drawings, specifications, and the provisions of the Agreement between the Contractor and the Supplier of the SierraScape System. These documents shall also include addenda and other modifications issued prior to the execution of the Contract.

Geotextile:
A non-woven, needle punched fabric used for separation and filtration.

Inspector:
The Authorized Representative assigned to see that the workmanship and materials are in accordance with the terms of the Contract.

Plans:
The part of the Contract documents consisting of the approved plans, profiles, typical cross sections, working drawings and supplemental drawings, or exact reproduction thereof, which shows the location, character, details, and dimensions of the Work to be performed.

Reinforced Fill:
The fill material that interacts with the geogrid reinforcement to create a mechanically stabilized earth mass. Its limits extend from the back of the facing elements to the tails of the soil reinforcement or as stated on the Plans.

Setback (Batter):
The rearward offset from the vertical plane between two vertically adjacent courses.

SierraScape Connection Rods:
Mechanical connection devices made of high-density polyethylene with fiberglass inclusions to positively connect the geogrid to the SierraScape facing elements.

SierraScape Facing Elements:
Wire-formed baskets that provide facial stability during placement and compaction of the fill material; the internally braced elements simplify facing alignment.

Support Struts:
Wire-formed braces designed to stiffen the SierraScape facing elements and maintain facing alignment.

Specification:
A description of the quality and quantity of the materials and workmanship that will be required of the Contractor in the execution of the Work under the Contract between the Owner and the Contractor.

Tensar Geogrids:
Polymeric grids formed by a regular network of integrally connected tensile elements with apertures of sufficient size to allow interlocking with surrounding soil, rock, or earth and functioning primarily as reinforcement.

Tensar Earth Technologies is your single-source for the SierraScape System. To find out how we can help you simplify your next wall construction project, call 800-TENSAR-1, e-mail info@tensarcorp.com, or visit www.tensarcorp.com.

Tensar®

Tensar Earth Technologies, Inc.
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Tensar Earth Technologies, Inc.
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www.tensarcorp.com

Product Specification
Tensar Structural Geogrid

- UX1000HS Structural Geogrid
- UX1100HS Structural Geogrid
- UX1400HS Structural Geogrid
- UX1500HS Structural Geogrid
- UX1600HS Structural Geogrid
- UX1700HS Structural Geogrid
- UX1800HS Structural Geogrid

Tensar Earth Technologies, Inc. warrants that at the time of delivery the geogrid furnished hereunder shall be of the quality and specification stated herein. If the geogrid does not meet the specifications on this page and Tensar is notified prior to installation, Tensar will replace the geogrid at no cost to the customer.

This product specification supersedes all prior specifications for the product described above and is not applicable to any products shipped prior to August 1, 2005

Tensar Earth Technologies, Inc.
5883 Glenridge Drive, Suite 200
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Product Specification - Structural Geogrid UX1400HS

Tensar Earth Technologies, Inc. reserves the right to change its product specifications at any time. It is the responsibility of the specifier and purchaser to ensure that product specifications used for design and procurement purposes are current and consistent with the products used in each instance. Please contact Tensar Earth Technologies, Inc. at 800-836-7271 for assistance

Product Type:	**Integrally Formed Structural Geogrid**
Polymer:	**High Density Polyethylene**
Load Transfer Mechanism:	**Positive Mechanical Interlock**
Recommended Applications:	**Sierra System (Reinforced Slopes), Prism System (Embankments), Temporary Walls**

Product Properties

Index Properties	**Units**	**MD Values[1]**
▪ Tensile Strength @ 5% Strain[2]	kN/m (lb/ft)	31 (2,130)
▪ Ultimate Tensile Strength[2]	kN/m (lb/ft)	70 (4,800)
▪ Junction Strength[3]	kN/m (lb/ft)	66 (4,520)
▪ Flexural Stiffness[4]	mg-cm	730,000
Durability		
▪ Resistance to Long Term Degradation[5]	%	100
▪ Resistance to UV Degradation[6]	%	95
Load Capacity		
▪ Maximum Allowable (Design) Strength[7]	kN/m (lb/ft)	30.2 (2,070)
Recommended Allowable Strength Reduction Factors[7]		
▪ Minimum Reduction Factor for Installation Damage (RF_{ID})[8]		1.05
▪ Minimum Reduction Factor for Creep (RF_{CR})		2.21
▪ Minimum Reduction Factor for Durability (RF_D)		1.00

Dimensions and Delivery

The structural geogrid shall be delivered to the jobsite in roll form with each roll individually identified and nominally measuring 1.33 meters (4.36 feet) in width and 76.2 meters (250.0 feet) in length. A typical truckload quantity is 432 rolls.

Notes:

1. Unless indicated otherwise, values shown are minimum average roll values determined in accordance with ASTM D4759. Brief descriptions of test procedures are given in the following notes. Complete descriptions of test procedures are available on request from Tensar Earth Technologies, Inc.
2. True resistance to elongation when initially subjected to a load measured via ASTM D6637 without deforming test materials under load before measuring such resistance or employing "secant" or "offset" tangent methods of measurement so as to overstate tensile properties.
3. Load transfer capability determined in accordance with GRI-GG2-87.
4. Resistance to bending force determined in accordance with ASTM D5732-95, using specimen dimensions of 864 millimeters in length by one aperture in width.
5. Resistance to loss of load capacity or structural integrity when subjected to chemically aggressive environments in accordance with EPA 9090 immersion testing.
6. Resistance to loss of load capacity or structural integrity when subjected to 500 hours of ultraviolet light and aggressive weathering in accordance with ASTM D4355.
7. Reduction factors are used to calculate the geogrid strength available for resisting force in long-term load bearing applications. Allowable Strength (T_{allow}) is determined by reducing the ultimate tensile strength (T_{ult}) by reduction factors for installation damage (RF_{ID}), creep (RF_{CR}) and chemical/biological durability ($RF_D = RF_{CD} \cdot RF_{BD}$) per GRI-GG4 [$T_{allow} = T_{ult}/(RF_{ID} \cdot RF_{CR} \cdot RF_D)$]. Recommended minimum reduction factors are based on product-specific testing. Project specifications, standard public agency specifications and/or design code requirements may require higher reduction factors. **It is the responsibility of the designer to ensure that appropriate reduction factors are applied.** Contact Tensar Earth Technologies, Inc. for further recommendations.
8. Minimum value is based on Installation Damage Testing in Sand, Silt, and Clay soils. Coarser soils require increased RF_{ID} values.

Tensar Earth Technologies, Inc. warrants that at the time of delivery the geogrid furnished hereunder shall be of the quality and specification stated herein. If the geogrid does not meet the specifications on this page and Tensar is notified prior to installation, Tensar will replace the geogrid at no cost to the customer.

This product specification supersedes all prior specifications for the product described above and is not applicable to any products shipped prior to August 1, 2005

Tensar Earth Technologies, Inc.
5883 Glenridge Drive, Suite 200
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Phone: (800) 836-7271
www.tensarcorp.com

Product Specification - Structural Geogrid UX1500HS

Tensar Earth Technologies, Inc. reserves the right to change its product specifications at any time. It is the responsibility of the specifier and purchaser to ensure that product specifications used for design and procurement purposes are current and consistent with the products used in each instance. Please contact Tensar Earth Technologies, Inc. at 800-836-7271 for assistance

Product Type: Integrally Formed Structural Geogrid
Polymer: High Density Polyethylene
Load Transfer Mechanism: Positive Mechanical Interlock
Recommended Applications: Sierra System (Reinforced Slopes), Prism System (Embankments), Temporary Walls

Product Properties

Index Properties	Units	MD Values[1]
▪ Tensile Strength @ 5% Strain[2]	kN/m (lb/ft)	52 (3,560)
▪ Ultimate Tensile Strength[2]	kN/m (lb/ft)	114 (7,810)
▪ Junction Strength[3]	kN/m (lb/ft)	105 (7,200)
▪ Flexural Stiffness[4]	mg-cm	5,100,000
Durability		
▪ Resistance to Long Term Degradation[5]	%	100
▪ Resistance to UV Degradation[6]	%	95
Load Capacity		
▪ Maximum Allowable (Design) Strength[7]	kN/m (lb/ft)	45.2 (3,100)
Recommended Allowable Strength Reduction Factors[7]		
▪ Minimum Reduction Factor for Installation Damage (RF_{ID})[8]		1.05
▪ Minimum Reduction Factor for Creep (RF_{CR})		2.40
▪ Minimum Reduction Factor for Durability (RF_D)		1.00

Dimensions and Delivery

The structural geogrid shall be delivered to the jobsite in roll form with each roll individually identified and nominally measuring 1.33 meters (4.36 feet) in width and 61.0 meters (200.0 feet) in length. A typical truckload quantity is 324 rolls.

Notes:

1. Unless indicated otherwise, values shown are minimum average roll values determined in accordance with ASTM D4759. Brief descriptions of test procedures are given in the following notes. Complete descriptions of test procedures are available on request from Tensar Earth Technologies, Inc.
2. True resistance to elongation when initially subjected to a load measured via ASTM D6637 without deforming test materials under load before measuring such resistance or employing "secant" or "offset" tangent methods of measurement so as to overstate tensile properties.
3. Load transfer capability determined in accordance with GRI-GG2-87.
4. Resistance to bending force determined in accordance with ASTM D5732-95, using specimen dimensions of 864 millimeters in length by one aperture in width.
5. Resistance to loss of load capacity or structural integrity when subjected to chemically aggressive environments in accordance with EPA 9090 immersion testing.
6. Resistance to loss of load capacity or structural integrity when subjected to 500 hours of ultraviolet light and aggressive weathering in accordance with ASTM D4355.
7. Reduction factors are used to calculate the geogrid strength available for resisting force in long-term load bearing applications. Allowable Strength (T_{allow}) is determined by reducing the ultimate tensile strength (T_{ult}) by reduction factors for installation damage (RF_{ID}), creep (RF_{CR}) and chemical/biological durability ($RF_D = RF_{CD} \cdot RF_{BD}$) per GRI-GG4 [$T_{allow} = T_{ult}/(RF_{ID} \cdot RF_{CR} \cdot RF_D)$]. Recommended minimum reduction factors are based on product-specific testing. Project specifications, standard public agency specifications and/or design code requirements may require higher reduction factors. **It is the responsibility of the designer to ensure that appropriate reduction factors are applied.** Contact Tensar Earth Technologies, Inc. for further recommendations.
8. Minimum value is based on Installation Damage Testing in Sand, Silt, and Clay soils. Coarser soils require increased RF_{ID} values.

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Tensar

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Product Specification - Structural Geogrid UX1600HS

Tensar Earth Technologies, Inc. reserves the right to change its product specifications at any time. It is the responsibility of the specifier and purchaser to ensure that product specifications used for design and procurement purposes are current and consistent with the products used in each instance. Please contact Tensar Earth Technologies, Inc. at 800-836-7271 for assistance

Product Type: Integrally Formed Structural Geogrid
Polymer: High Density Polyethylene
Load Transfer Mechanism: Positive Mechanical Interlock
Recommended Applications: Sierra System (Reinforced Slopes), Prism System (Embankments), Temporary Walls

Product Properties

Index Properties	Units	MD Values[1]
▪ Tensile Strength @ 5% Strain[2]	kN/m (lb/ft)	58 (3,980)
▪ Ultimate Tensile Strength[2]	kN/m (lb/ft)	144 (9,870)
▪ Junction Strength[3]	kN/m (lb/ft)	135 (9,250)
▪ Flexural Stiffness[4]	mg-cm	6,000,000
Durability		
▪ Resistance to Long Term Degradation[5]	%	100
▪ Resistance to UV Degradation[6]	%	95
Load Capacity		
▪ Maximum Allowable (Design) Strength[7]	kN/m (lb/ft)	59.9 (4,110)
Recommended Allowable Strength Reduction Factors[7]		
▪ Minimum Reduction Factor for Installation Damage (RF_{ID})[8]		1.05
▪ Minimum Reduction Factor for Creep (RF_{CR})		2.29
▪ Minimum Reduction Factor for Durability (RF_D)		1.00

Dimensions and Delivery

The structural geogrid shall be delivered to the jobsite in roll form with each roll individually identified and nominally measuring 1.33 meters (4.36 feet) in width and 61.0 meters (200.0 feet) in length. A typical truckload quantity is 216 rolls.

Notes:

1. Unless indicated otherwise, values shown are minimum average roll values determined in accordance with ASTM D4759. Brief descriptions of test procedures are given in the following notes. Complete descriptions of test procedures are available on request from Tensar Earth Technologies, Inc.
2. True resistance to elongation when initially subjected to a load measured via ASTM D6637 without deforming test materials under load before measuring such resistance or employing "secant" or "offset" tangent methods of measurement so as to overstate tensile properties.
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Tensar

CONSTRUCTION DRAWINGS
Prepared For

SIERRASCAPE®
RETAINING WALL SYSTEMS

LASO TA-73 AIRPORT LANDFILLS

W.O. NO. 13104.002.001.7000

LOS ALAMOS COUNTY, NEW MEXICO

INDEX

SHEET	DESCRIPTION
1.	Title Sheet
2.	Construction Requirements
3.	Plan View
4.	Elevation View – Wall 2
5.	Elevation View – Wall 2 (Cont.)
6.	Elevation View – Wall 3
7.	Elevation View – Wall 4
8.	Typical Cross-Section
9.	Typical Cross-Section
10.	Typical Details
11.	Typical Details

THIS DESIGN IS BASED UPON SPECIFIC PROPERTIES OF TENSAR PRODUCTS (GEOGRIDS, DRAINAGE COMPOSITES AND EROSION MEDIA), WHICH ARE PROPRIETARY TO THE TENSAR CORPORATION 1210 CITIZENS PARKWAY, MORROW, GA, 30260. ANY SUBSTITUTION OF THE SPECIFIED PRODUCTS WILL INVALIDATE THIS DESIGN. THIS DRAWING IS BEING FURNISHED FOR USE ON THIS SPECIFIC PROJECT ONLY. ANY PARTY ACCEPTING THIS DOCUMENT DOES SO IN CONFIDENCE AND AGREES THAT IT SHALL NOT BE DUPLICATED WHOLE OR IN PART, NOR DISCLOSED TO OTHERS, WITHOUT THE CONSENT OF TENSAR EARTH TECHNOLOGIES, INC.

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SIERRASCAPE
RETAINING WALL SYSTEMS

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Atlanta, Georgia 30328
(404) 250-1290

REVISIONS \ ISSUE

0	5/24/06	ISSUED FOR REVIEW	

Project Number	D06602
File Name	D0660201.DWG
Date Drawn	5/24/06
Scale	AS SHOWN
Designed by	CLC
Drawn by	KJK
Checked by	

LASO TA-73 AIRPORT LANDFILLS
W.O. NO. 13104.002.001.7000
LOS ALAMOS COUNTY, NEW MEXICO

TITLE SHEET

Sheet Number
1 OF 11

CONSTRUCTION REQUIREMENTS FOR PLACEMENT OF TENSAR GEOGRIDS AND BACKFILL SOILS FOR TENSAR SIERRASCAPE REINFORCED RETAINING WALLS

1.0 MATERIAL

1.1 BACKFILL SOILS

1.1.1 REINFORCED BACKFILL MATERIAL SPECIFIED BELOW SHALL BE ON-SITE SOILS OR SELECT FREE DRAINING BACKFILL. REINFORCED BACKFILL MATERIALS SHALL BE APPROVED BY OWNER OR OWNER'S REPRESENTATIVE AND SHALL MEET THE STRENGTH REQUIREMENTS AS DEFINED IN SECTION 7.0. THE REINFORCED BACKFILL MATERIAL SHALL MEET THE FOLLOWING GRADATION:

SIEVE SIZE	PERCENT PASSING
2"	100
No. 4	100-20
No. 40	0 - 50
No. 200	0 - 15

THE PORTION OF THE REINFORCED BACKFILL MATERIAL PASSING THE No. 40 SIEVE SHALL HAVE A LIQUID LIMIT LESS THAN 40 AND A PLASTICITY INDEX LESS THAN 8. REINFORCED BACKFILL MATERIAL SHALL BE CLASSIFIED PER THE UNIFIED SOIL CLASSIFICATION SYSTEM AS LOW PLASTICITY OR NON-PLASTIC SOILS.

1.1.2 REINFORCED BACKFILL AND RETAINED SOIL/FILL MATERIALS SHALL BE FREE OF EXCESS MOISTURE, ROOTS, MUCK, SOD, SNOW, FROZEN LUMPS, ORGANIC MATTER OR OTHER DELETERIOUS MATERIALS. ALL ROCK PARTICLES AND HARD EARTH CLODS SHALL BE LESS THAN THREE INCHES IN THE LONGEST DIMENSION. REINFORCED BACKFILL MATERIALS WHICH DO NOT MEET THIS CRITERIA SHALL BE CONSIDERED UNSUITABLE AND SHALL BE REMOVED.

1.2 GEOGRID REINFORCEMENT SHALL BE TENSAR UNIAXIAL GEOGRIDS MANUFACTURED BY THE TENSAR CORPORATION, MORROW, GEORGIA

1.3 GEOTEXTILE FABRIC SHALL BE AASHTO M288 CLASS 3 GEOTEXTILE

1.4 THE WALL FACING SHALL BE GALVANIZED 1.80"X12.67" (0.192"ø x 0.243"ø) WELDED WIRE FORMS. WIRE FORM GEOMETRY SHALL BE AS DETAILED IN THE CONSTRUCTION DRAWINGS.

2.0 TECHNICAL REQUIREMENTS

2.1 THE OWNER OR OWNER'S REPRESENTATIVE SHALL VERIFY THAT REINFORCED BACKFILL MATERIAL MEETS THE GRADATION AND OTHER REQUIREMENTS OF SECTION 1.1 PRIOR TO PROCEEDING WITH CONSTRUCTION.

2.2 PRIOR TO CONSTRUCTION OF THE TENSAR REINFORCED WALL, THE CONTRACTOR SHALL CLEAR AND GRUB THE REINFORCED BACKFILL ZONE AREA, REMOVING TOPSOIL, BRUSH, SOD OR OTHER ORGANIC OR DELETERIOUS MATERIAL. ANY UNSUITABLE SOILS SHALL BE OVER-EXCAVATED, REPLACED AND COMPACTED WITH BACKFILL MATERIAL TO PROJECT SPECIFICATIONS OR AS OTHERWISE DIRECTED BY THE OWNER OR OWNER'S REPRESENTATIVE.

2.3 FOUNDATION SHALL BE PREPARED AS PER PROJECT SPECIFICATIONS. THE OWNER OR OWNER'S REPRESENTATIVE SHALL CONFIRM THAT THE SITE HAS BEEN PROPERLY PREPARED AND THE DESIGN PARAMETERS IN SECTION 7.0 ARE APPROPRIATE PRIOR TO FILL PLACEMENT.

2.4 FILL SHALL BE PLACED IN HORIZONTAL LAYERS NOT EXCEEDING 10 INCHES IN UNCOMPACTED THICKNESS FOR HEAVY COMPACTION EQUIPMENT. FOR ZONES WHERE COMPACTION IS ACCOMPLISHED WITH HAND-OPERATED EQUIPMENT, FILL SHALL BE PLACED IN HORIZONTAL LAYERS NOT EXCEEDING 6 INCHES IN UNCOMPACTED THICKNESS. ONLY HAND-OPERATED EQUIPMENT SHALL BE ALLOWED WITHIN THREE FEET OF THE BACK FACE OF WALL

2.5 FILL MATERIALS SHALL BE PLACED FROM THE BACK OF THE WELDED WIRE FORMS TOWARDS THE ENDS OF THE GEOGRID TO ENSURE FURTHER TENSIONING.

2.6 FILL SHALL BE COMPACTED AS SPECIFIED BY PROJECT SPECIFICATIONS OR TO A MINIMUM OF 95% OF THE MAXIMUM DRY DENSITY AS DETERMINED IN ACCORDANCE WITH AASHTO T-99 (STANDARD PROCTOR), AT A MOISTURE CONTENT NO GREATER THAN 2 PERCENTAGE POINTS WET AND NO LESS THAN 1 PERCENTAGE POINT DRY OF OPTIMUM.

2.7 TESTING METHODS AND FREQUENCY, AND VERIFICATION OF MATERIAL SPECIFICATIONS SHALL BE THE RESPONSIBILITY OF THE OWNER OR OWNER'S REPRESENTATIVE.

2.8 WELDED WIRE FACING SHALL BE ERECTED AND MAINTAINED DURING CONSTRUCTION TO THE BATTER AS SHOWN ON THE DRAWINGS. INDIVIDUAL WIRE FORM DEFORMATIONS SHALL BE LIMITED TO 2.5 INCHES AT THE TOP AND A BULGE OF 2 INCHES, MEASURED FROM THE BASE OF THE WIRE FORM. THE CONTRACTOR SHALL PROVIDE ALIGNMENT CONTROL FOR EACH COURSE OF WELDED WIRE FORMS AND MAKE ALIGNMENT CORRECTIONS AS NECESSARY.

2.9 IF EXCESSIVE DEFORMATION OCCURS AS DEFINED BY SECTION 2.8 COMPACTION PROCEDURES SHOULD BE MODIFIED TO PROVIDE MAXIMUM ALLOWABLE COMPACTION AT THE WALL FACE. ALSO, ADDITIONAL STRUTS MAY BE REQUIRED TO STIFFEN THE WIRE FACE

2.10 WELDED WIRE FORMS SHALL BE INSTALLED USING THE CORRECT ANGLE SHOWN ON THE DRAWINGS. THE ENDS OF THE WIRE FORMS SHALL BE OVERLAPPED 2.4 INCHES AND THE WIRE FORM JOINTS SHALL BE STAGGERED VERTICALLY. ANY PROTRUDING WIRES SHALL BE BENT OR CUT OFF

2.11 A COMPLETE SET OF APPROVED CONSTRUCTION DRAWINGS AND CONTRACT SPECIFICATIONS SHALL BE ON-SITE AT ALL TIMES DURING CONSTRUCTION OF THE TENSAR REINFORCED RETAINING WALL.

3.0 TENSAR GEOGRID PLACEMENT

3.1 TENSAR GEOGRID SHALL BE PLACED AT THE LOCATIONS AND ELEVATIONS SHOWN ON THE DRAWINGS

3.2 TENSAR GEOGRID LENGTHS SHALL BE AS SHOWN ON THE CONSTRUCTION DRAWINGS. TENSAR GEOGRID LENGTHS ARE MEASURED FROM THE CONNECTION LOOP, EXTENDING TO THE TAIL OF THE GEOGRIDS. REINFORCED FILL ZONE LENGTH (BASE WIDTH) IS MEASURED FROM THE FRONT FACE OF THE WALL, EXTENDING TO THE TAIL OF THE GEOGRIDS.

3.2.1 TENSAR GEOGRID REINFORCEMENT SHALL BE CONTINUOUS THROUGHOUT THEIR EMBEDMENT LENGTH(S)

3.3 TRACKED CONSTRUCTION EQUIPMENT SHALL NOT BE OPERATED DIRECTLY ON THE GEOGRID. A MINIMUM BACKFILL THICKNESS OF 6 INCHES IS REQUIRED FOR OPERATION OF TRACKED VEHICLES OVER THE GEOGRID. TURNING OF TRACKED VEHICLES SHOULD KEPT TO A MINIMUM TO PREVENT TRACKS FROM DISPLACING THE FILL AND/OR THE GEOGRID.

3.4 RUBBER-TIRED VEHICLES MAY PASS OVER THE GEOGRID REINFORCEMENT AT SLOW SPEEDS, LESS THAN 10 MPH. SUDDEN BRAKING AND SHARP TURNING SHALL BE AVOIDED

3.5 TENSAR UNIAXIAL GEOGRIDS SHALL BE CUT NEXT TO THE CROSS-MACHINE DIRECTION BAR. THE GEOGRID SHALL BE PLACED SUCH THAT THE CONNECTION LOOPS PASS THROUGH THE LONG AXIS OF THE APERTURES (MACHINE DIRECTION) WITH THE CONNECTION ROD THREADED THROUGH THE CONNECTION LOOPS AND OVER THE LONG AXIS OF THE APERTURES. TENSAR UNIAXIAL GEOGRID SHALL BE ROLLED OUT WITH THE MACHINE DIRECTION PERPENDICULAR TO THE WALL FACE.

3.6 A MINIMUM OF 3 INCHES OF FILL MATERIAL SHALL BE REQUIRED BETWEEN LAYERS OF UNIAXIAL GEOGRIDS, UNLESS OTHERWISE SHOWN.

4.0 CHANGES TO GEOGRID LAYOUT OR PLACEMENT

4.1 NO CHANGES TO THE TENSAR GEOGRID LAYOUT, INCLUDING, BUT NOT LIMITED TO, LENGTH, GEOGRID TYPE, OR ELEVATION SHALL BE MADE WITHOUT THE EXPRESS, WRITTEN CONSENT OF TENSAR EARTH TECHNOLOGIES, INC

5.0 DRAINAGE

5.1 AT THE END OF EACH WORKDAY, BACKFILL SURFACE SHALL BE GRADED AWAY FROM THE WALL FACE A MINIMUM OF 2 PERCENT SLOPE AND A TEMPORARY SOIL BERM SHALL BE CONSTRUCTED NEAR THE WALL CREST TO PREVENT SURFACE WATER RUNOFF FROM OVERTOPPING THE WALL

5.2 AT THE END OF EACH WORKDAY, BACKFILL SURFACE SHALL BE COMPACTED WITH A SMOOTH WHEEL ROLLER TO MINIMIZE PONDING OF WATER AND SATURATION OF THE BACKFILL

5.3 THE ENGINEERING, DESIGN, ANALYSIS, DETAILING, AND MITIGATION OF BOTH SURFACE DRAINAGE AND SEEPAGE OF GROUNDWATER SHALL BE THE RESPONSIBILITY OF THE OWNER OR OWNER'S REPRESENTATIVE.

5.4 PERMANENT SURFACE WATER DIVERSION SHALL BE REQUIRED AND PROVIDED BY THE OWNER OR OWNER'S REPRESENTATIVE.

5.5 THE TENSAR REINFORCED WALL HAS BEEN DESIGNED ON THE ASSUMPTION THAT THE REINFORCED BACKFILL MATERIAL SHALL BE FREE OF SUBSURFACE DRAINAGE OF WATER (SEEPAGE). PERMANENT SUBSURFACE WATER (SEEPAGE) COLLECTION AND DIVERSION SHALL BE THE RESPONSIBILITY OF THE OWNER OR OWNER'S REPRESENTATIVE.

5.6 CARE SHALL BE TAKEN NOT TO CONTAMINATE THE GEOTEXTILE FABRIC WITH FINE-GRAINED SOILS OR OTHER DELETERIOUS MATERIALS

5.0 METHOD OF PAYMENT

SEE CONTRACT DOCUMENTS

7.0 DESIGN PARAMETERS

7.1 DESIGN OF THE REINFORCED SOIL STRUCTURE IS BASED ON THE FOLLOWING PARAMETERS:

	EFFECTIVE FRICTION ANGLE	EFFECTIVE COHESION	MOIST UNIT WEIGHT
REINFORCED BACKFILL	32°	0 psf	130 pcf
RETAINED SOIL	35.5°	0 psf	100 pcf
FOUNDATION SOIL	32°	4000 psf	130 pcf

7.2 FACTORS OF SAFETY:

7.2.1 INTERNAL STABILITY

	STATIC	SEISMIC
MINIMUM FACTOR OF SAFETY FOR GEOGRID STRENGTH	= 1.5	= 1.1
MINIMUM FACTOR OF SAFETY FOR GEOGRID PULLOUT	= 1.5	= 1.1
MINIMUM FACTOR OF SAFETY FOR CONNECTION	= 1.5	= 1.1
SOIL-GEOGRID INTERACTION COEFFICIENT	= 0.8	
PERCENT COVERAGE OF GEOGRID	= 94 %	
DESIGN LIFE	= 75 YEARS	

7.2.2 EXTERNAL STABILITY

MINIMUM FACTOR OF SAFETY FOR SLIDING AT BASE	= 1.5	= 1.1
MAXIMUM FACTOR OF SAFETY FOR ECCENTRICITY, B/L	= 1/6	= 1/3

7.2.3 GLOBAL STABILITY:
GLOBAL STABILITY AND FOUNDATION BEARING CAPACITY ARE THE RESPONSIBILITY OF THE OWNER OR OWNER'S REPRESENTATIVE. TENSAR EARTH TECHNOLOGIES, INC. ACCEPTS NO LIABILITY OR RESPONSIBILITY FOR GLOBAL STABILITY OR FOUNDATION BEARING CAPACITY.

7.3 LOADINGS:

7.3.1 TRAFFIC SURCHARGE	= 250 psf
7.3.2 SEISMIC ACCELERATION COEFFICIENT	= 0.262 g

7.4 HYDROSTATIC DESIGN:
GROUNDWATER/PHREATIC ARE SURFACES NOT CONSIDERED IN THE WALL DESIGN. WATER SURFACE IS ASSUMED TO BE SUFFICIENTLY BELOW BOTTOM OF WALL AS NOT TO INFLUENCE INTERNAL AND EXTERNAL STABILITY.

7.5 MAXIMUM APPLIED BEARING PRESSURE (STATIC) = 3915 psf

8.0 SPECIAL PROVISIONS

8.1 THE DESIGN PRESENTED HEREIN IS BASED ON SOIL PARAMETERS, FOUNDATION CONDITIONS, GROUNDWATER CONDITIONS, AND LOADINGS STATED IN SECTION 7.0.

8.2 WALL ELEVATION VIEWS AND LOCATIONS, AND GEOMETRY OF EXISTING STRUCTURES MUST BE VERIFIED BY THE OWNER OR OWNER'S REPRESENTATIVE PRIOR TO CONSTRUCTION.

8.3 TENSAR EARTH TECHNOLOGIES, INC. ASSUMES NO LIABILITY FOR INTERPRETATION OR VERIFICATION OF SUBSURFACE CONDITIONS, FOR SUITABILITY OF SOIL DESIGN PARAMETERS OR FOR INTERPRETATION OF SUBSURFACE GROUNDWATER CONDITIONS.

8.4 THE OWNER OR OWNER'S REPRESENTATIVE IS RESPONSIBLE FOR REVIEWING AND VERIFYING THAT THE ACTUAL SITE CONDITIONS AND PARAMETERS ARE AS DESCRIBED HEREIN PRIOR TO AND DURING CONSTRUCTION. THE OWNER OR OWNER'S REPRESENTATIVE SHALL BE ON-SITE TO ASSURE CONSTRUCTION IS IN ACCORDANCE WITH THESE NOTES AND DRAWINGS AND THE CONTRACT PLANS AND SPECIFICATIONS. THE CONTRACTOR SHALL FOLLOW THE INSTRUCTIONS PROVIDED IN THE WELDED WIRE FORM ERECTION GUIDE PROVIDED BY TENSAR EARTH TECHNOLOGIES, INC

8.5 THE SOIL DESIGN PARAMETERS STATED IN SECTION 7.0 SHALL BE VERIFIED BY THE OWNER OR OWNER'S REPRESENTATIVE. IF ACTUAL CONDITIONS ARE FOUND TO BE OTHER THAN AS SET FORTH IN THESE PARAMETERS, THEN CONSTRUCTION SHALL NOT PROCEED AND THE RELEVANT DATA SHALL BE PROVIDED TO TENSAR EARTH TECHNOLOGIES, INC. FOR PURPOSES OF MODIFYING THE DESIGN.

8.6 PROCEEDING WITH CONSTRUCTION WITHOUT FIRST VERIFYING CONDITIONS AND PARAMETERS DISCUSSED IN SECTIONS 1.1 AND 7.0 SHALL ABSOLVE TENSAR EARTH TECHNOLOGIES, INC. FROM ALL LIABILITY FOR THE DESIGN AND CONSTRUCTION OF THIS STRUCTURE AND THE CONTRACTOR SHALL INDEMNIFY AND HOLD HARMLESS TENSAR EARTH TECHNOLOGIES, INC. FROM ALL RESULTING CLAIMS, DAMAGES, LOSSES AND EXPENSES.

8.7 IF ANY ROCK FORMATIONS AND/OR GROUNDWATER ARE ENCOUNTERED DURING CONSTRUCTION, IMMEDIATELY CONTACT TENSAR EARTH TECHNOLOGIES, INC. AT 404-250-1290 AND THE OWNER'S REPRESENTATIVE.

8.8 ANY REVISIONS TO DESIGN PARAMETERS STATED IN SECTION 7.0 OR STRUCTURE GEOMETRY SHALL REQUIRE DESIGN MODIFICATIONS PRIOR TO PROCEEDING WITH CONSTRUCTION

8.9 THIS DESIGN IS ONLY VALID FOR THE PROPOSED TENSAR RETAINING WALL(S) AS SHOWN HEREIN.

8.10 TOTAL SETTLEMENT AND DIFFERENTIAL SETTLEMENT IN EXCESS OF 1/100 SHALL BE THE RESPONSIBILITY OF THE OWNER OR OWNER'S REPRESENTATIVE. TENSAR EARTH TECHNOLOGIES ACCEPTS NO LIABILITY OR RESPONSIBILITY FOR THE EVALUATION OF SETTLEMENTS.

8.11 ON-SITE SITE ASSISTANCE WILL BE PROVIDED BY TENSAR EARTH TECHNOLOGIES, INC. AT THE REQUEST OF THE CONTRACTOR OR AS PROVIDED IN THE CONTRACT SPECIFICATIONS. TENSAR EARTH TECHNOLOGIES IS NOT RESPONSIBLE FOR HAVING PERSONNEL ON-SITE UNLESS SPECIFICALLY PROVIDED FOR IN A WRITTEN CONTRACT SIGNED BY TENSAR EARTH TECHNOLOGIES, INC. THE TENSAR REPRESENTATIVE WILL NOT HAVE THE AUTHORITY TO STOP OR START CONSTRUCTION OF THE RETAINING WALL.

9.0 REFERENCE DOCUMENTS

THE DESIGN CALCULATIONS AND CONSTRUCTION DRAWINGS PREPARED BY TENSAR EARTH TECHNOLOGIES, INC. ARE BASED UPON THE FOLLOWING DOCUMENTS

9.1 CONSTRUCTION PLAN PREPARED BY NORTH WIND, INC. FOR "THE LOS ALAMOS SITE OFFICE TA-73 AIRPORT LANDFILL," REVISION 2, PAGES 9 AND 10, DATED JUNE 2005

9.2 CONTRACT PLANS FOR U.S. DEPARTMENT OF ENERGY FOR "LOS ALAMOS SITE OFFICE TA-73 AIRPORT LANDFILLS FINAL CLOSURE DESIGN, REV. 1," W.O. NO. 13104.002.001.7000, PREPARED BY NORTH WIND AND WESTON SOLUTIONS TEAM, LAST DATED 9/22/05.

9.3 CONSTRUCTION SPECIFICATION FOR "LASO TA-73 AIRPORT LANDFILL," SECTION 02273, MECHANICALLY STABILIZED EARTH RETAINING WALL, DATED JUNE 2005.

THIS DESIGN IS BASED UPON SPECIFIC PROPERTIES OF TENSAR PRODUCTS (GEOGRIDS, DRAINAGE COMPOSITES AND EROSION MEDIA), WHICH ARE PROPRIETARY TO THE TENSAR CORPORATION 1210 CITIZENS PARKWAY, MORROW, GA, 30260. ANY SUBSTITUTION OF THE SPECIFIED PRODUCTS WILL INVALIDATE THIS DESIGN. THIS DRAWING IS BEING FURNISHED FOR USE ON THIS SPECIFIC PROJECT ONLY. ANY PARTY ACCEPTING THIS DOCUMENT DOES SO IN CONFIDENCE AND AGREES THAT IT SHALL NOT BE DUPLICATED WHOLE OR IN PART, NOR DISCLOSED TO OTHERS, WITHOUT THE CONSENT OF TENSAR EARTH TECHNOLOGIES, INC.

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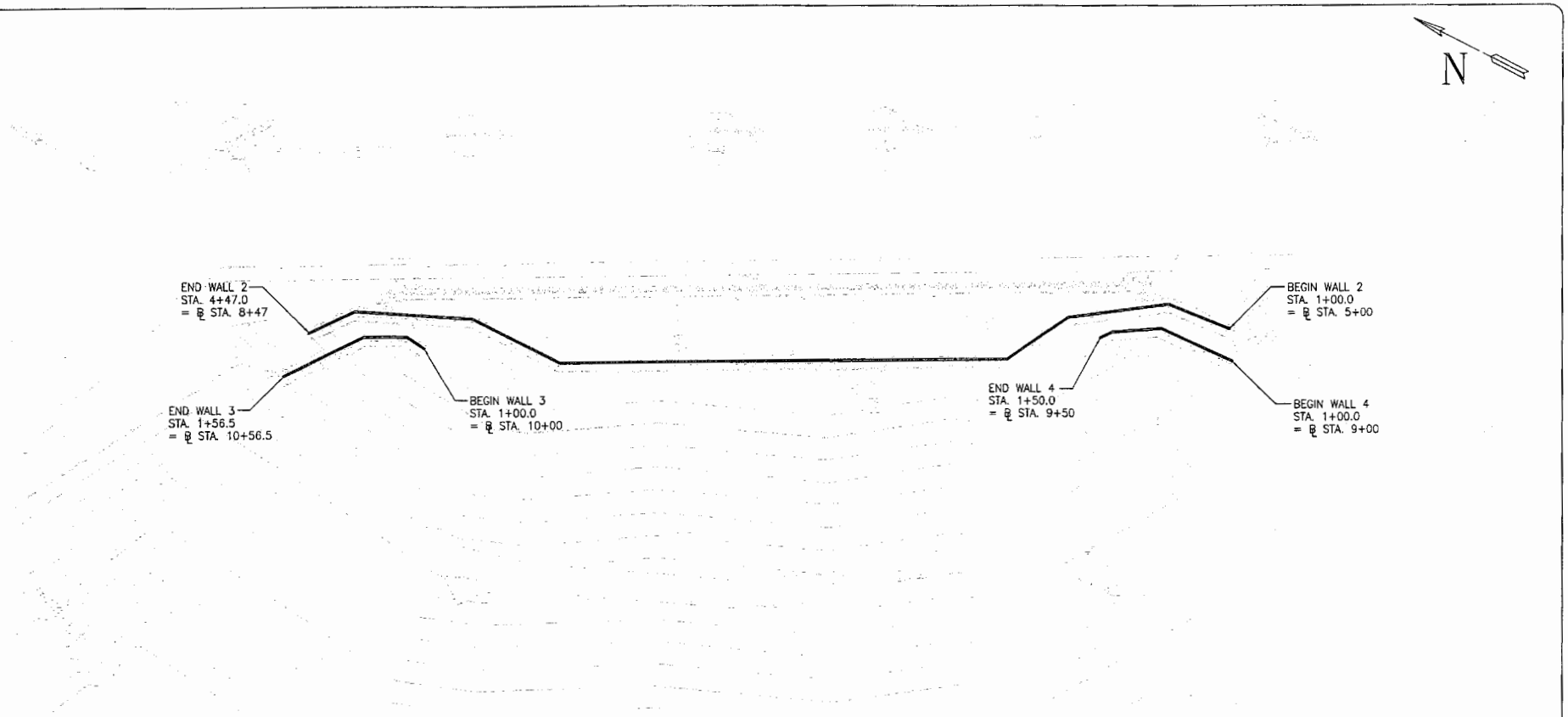
Checked by: [illegible]

LASO TA-73 AIRPORT LANDFILLS

LOS ALAMOS COUNTY, NEW MEXICO

CONSTRUCTION REQUIREMENTS

Sheet Number 2 OF 11



PLAN VIEW
NOT TO SCALE

NOTE:

1. PLAN VIEW SHOWN FOR ILLUSTRATIVE PURPOSE ONLY.
2. PLAN VIEW ADOPTED FROM CONTRACT PLANS FOR "LOS ALAMOS SITE OFFICE TA-73 AIRPORT LANDFILLS," W.O. No. 13104.002.001.7000, WALL PLAN AND WALL SECTIONS, SHEET 1 OF 3, DRAWING NO. 2006, LAST DATED 6/30/06.

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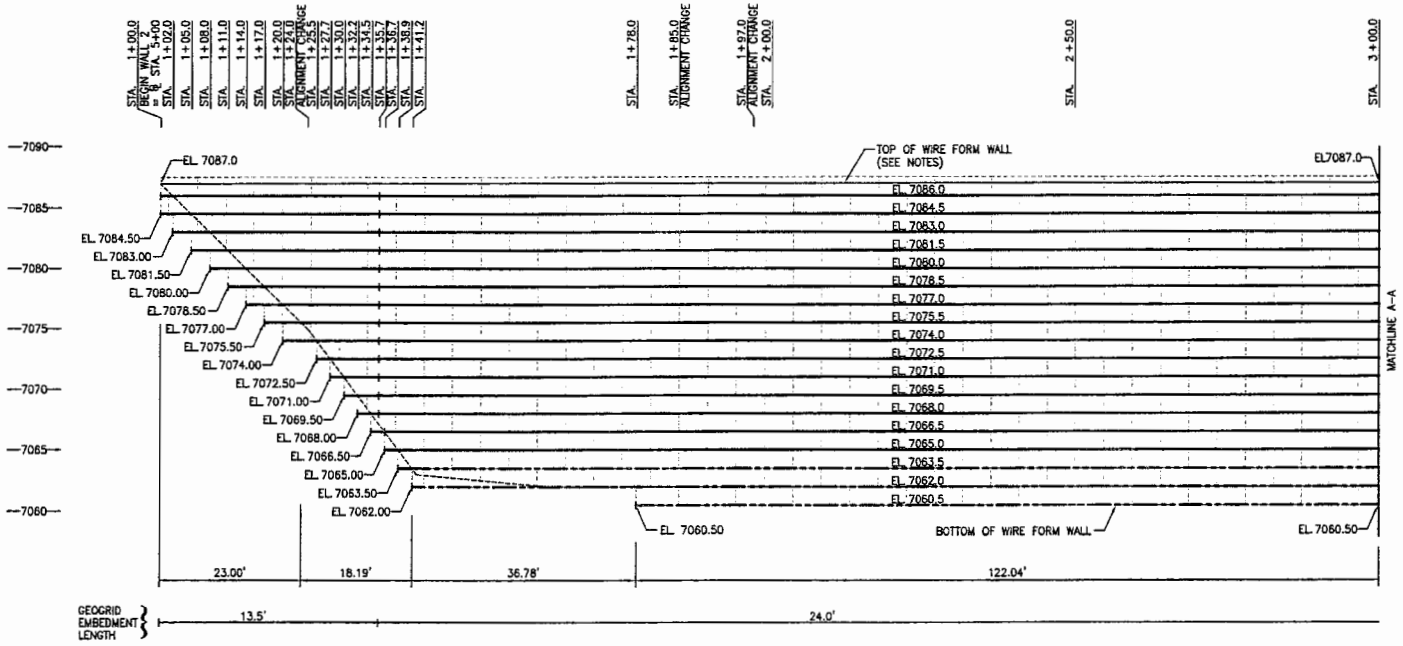
LASO TA-73 AIRPORT LANDFILLS
W.O. NO. 13104.002.001.7000
LOS ALAMOS COUNTY, NEW MEXICO

PLAN VIEW

Sheet Number
3 OF 11



NOTES:
1. SEE NESTED BASKET DETAIL ON SHEET 10 OF 11 OR TOP OF SIERRASCAPE WALL FINISHING DETAIL ON SHEET 11 OF 11.
2. FINISHED TOP OF WALL SHALL BE CONTRACTOR'S OPTION.

FRONT FACE ELEVATION VIEW - WALL 2

LEGEND

- SIERRASCAPE WIRE FORM (TYP.) (SEE CONSTRUCTION REQUIREMENTS FOR SPECIFICATIONS)
- PROPOSED GRADE
- CHANGE IN EMBEDMENT LENGTH OR GEOGRID TERMINATION
- TENSAR UX1500MSE GEOGRID
- TENSAR UX1600MSE GEOGRID
- EL XXX.X APPROX. GEOGRID ELEVATION

VERTICAL SCALE FEET 10 5 0 5
HORIZONTAL SCALE FEET 10 5 0 10 20

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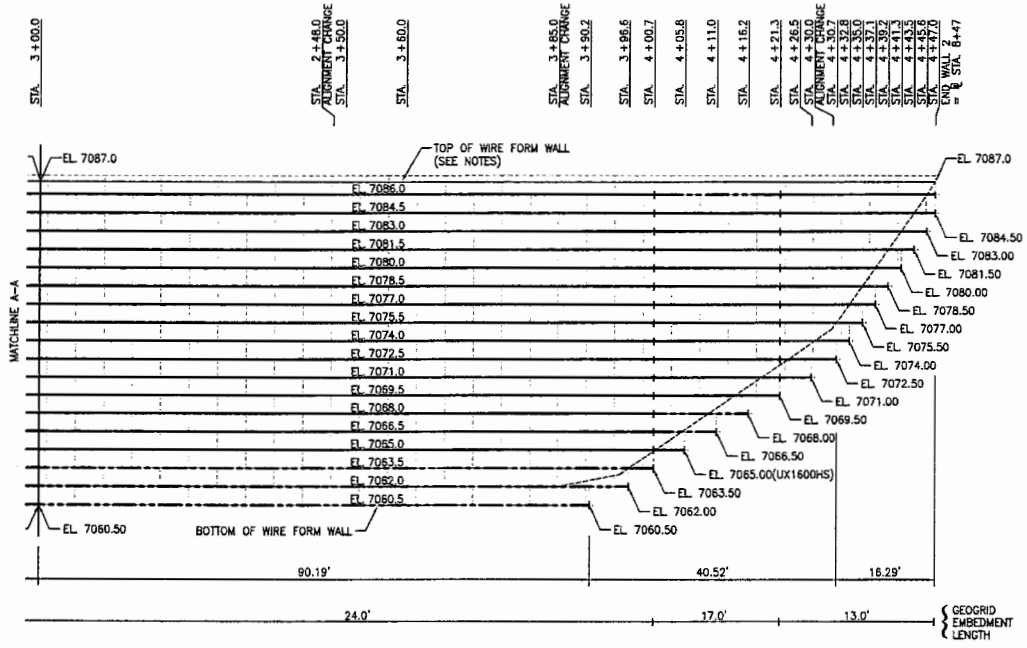
LOS ALAMOS COUNTY, NEW MEXICO

ELEVATION VIEW WALL 2

Sheet Number
4 OF 11



NOTES:
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FRONT FACE ELEVATION VIEW - WALL 2 (CONT.)

LEGEND

- SIERRASCAPE WIRE FORM (TYP.) (SEE CONSTRUCTION REQUIREMENTS FOR SPECIFICATIONS)
- PROPOSED GRADE
- CHANGE IN EMBEDMENT LENGTH OR GEOGRID TERMINATION
- TENSAR UX1500MSE GEOGRID
- TENSAR UX1600MSE GEOGRID
- EL XXX.X APPROX. GEOGRID ELEVATION

VERTICAL SCALE: FEET 10 5 0 5

HORIZONTAL SCALE: FEET 10 5 0 10 20

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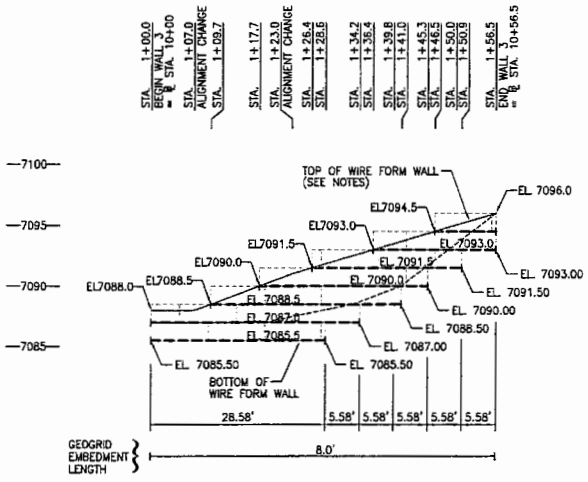
ELEVATION VIEW
WALL 2 (CONT.)

Sheet Number
5 OF 11



FRONT FACE ELEVATION VIEW - WALL 3

NOTES:
1. SEE NESTED BASKET DETAIL ON SHEET 10 OF 11 OR TOP OF SIERRASCAPE WALL FINISHING DETAIL ON SHEET 11 OF 11.
2. FINISHED TOP OF WALL SHALL BE CONTRACTOR'S OPTION.

LEGEND

- SIERRASCAPE WIRE FORM (TYP.) (SEE CONSTRUCTION REQUIREMENTS FOR SPECIFICATIONS)
- PROPOSED GRADE
- CHANGE IN EMBEDMENT LENGTH OR GEOGRID TERMINATION
- TENSAR UX1400MSE GEOGRID
- EL XXX.X — APPROX. GEOGRID ELEVATION

VERTICAL SCALE: 5 0 5 10 FEET

HORIZONTAL SCALE: 10 5 0 10 20 FEET

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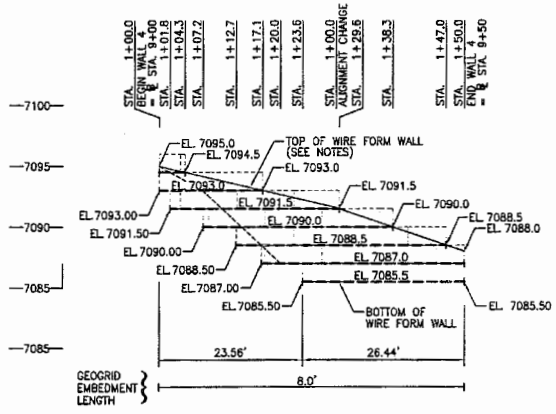
LOS ALAMOS COUNTY, NEW MEXICO

ELEVATION VIEW
WALL 3

Sheet Number
6 OF 11



FRONT FACE ELEVATION VIEW – WALL 4

NOTES:
1. SEE NESTED BASKET DETAIL ON SHEET 10 OF 11 OR TOP OF SIERRASCAPE WALL, FINISHING DETAIL ON SHEET 11 OF 11.
2. FINISHED TOP OF WALL SHALL BE CONTRACTOR'S OPTION.

LEGEND

- - - - - -	SIERRASCAPE WIRE FORM (TYP.) (SEE CONSTRUCTION REQUIREMENTS FOR SPECIFICATIONS)
————	PROPOSED GRADE
— — —+— —	CHANGE IN EMBEDMENT LENGTH OR GEOGRID TERMINATION
— — — —	TENSAR UX1400MSE GEOGRID
EL. XXX.X	APPROX. GEOGRID ELEVATION

VERTICAL SCALE FEET 0 5 10

HORIZONTAL SCALE FEET 10 5 0 10 20

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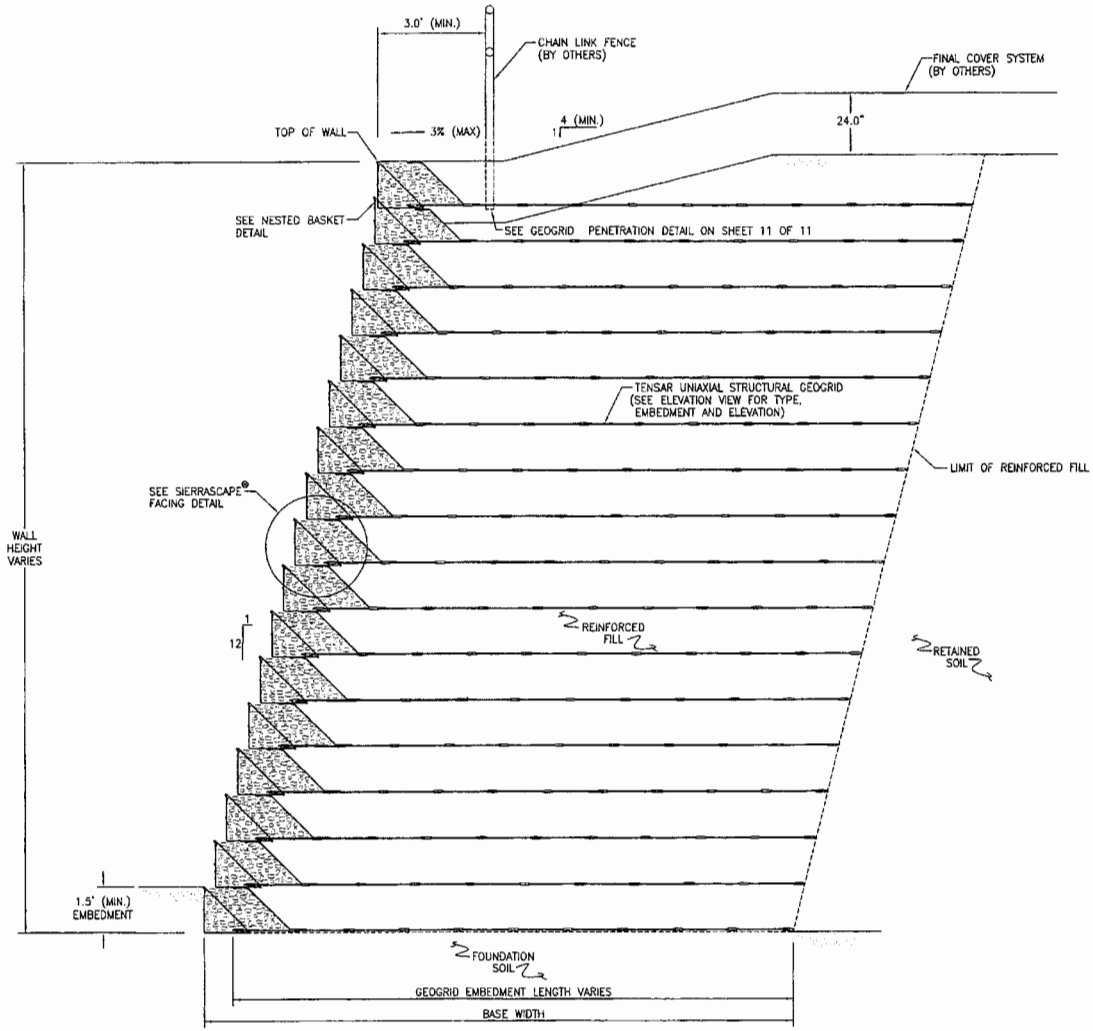
LOS ALAMOS COUNTY, NEW MEXICO

ELEVATION VIEW
WALL 4

Sheet Number
7 OF 11



TYPICAL CROSS-SECTION

NOTE:
THIS TYPICAL CROSS-SECTION IS APPLICABLE TO WALL 2 FROM STA. 1+35.7 TO STA. 4+00.7 AND WALL 3 FROM STA. 1+39.8 TO STA. 1+56.5.

SCALE
2 1 0 2 4 FEET

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SIERRASCAPE®
RETAINING WALL SYSTEMS

Tensar

Tensar Earth Technologies, Inc.
5883 Glenridge Drive, Suite 200
Atlanta, Georgia 30328
(404) 250-1290

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Project Number: D06602
File Name: D0560208.DWG
Date Drawn: 5/24/06
Scale: AS SHOWN
Designed by: CLC
Drawn by: KJK
Checked by:

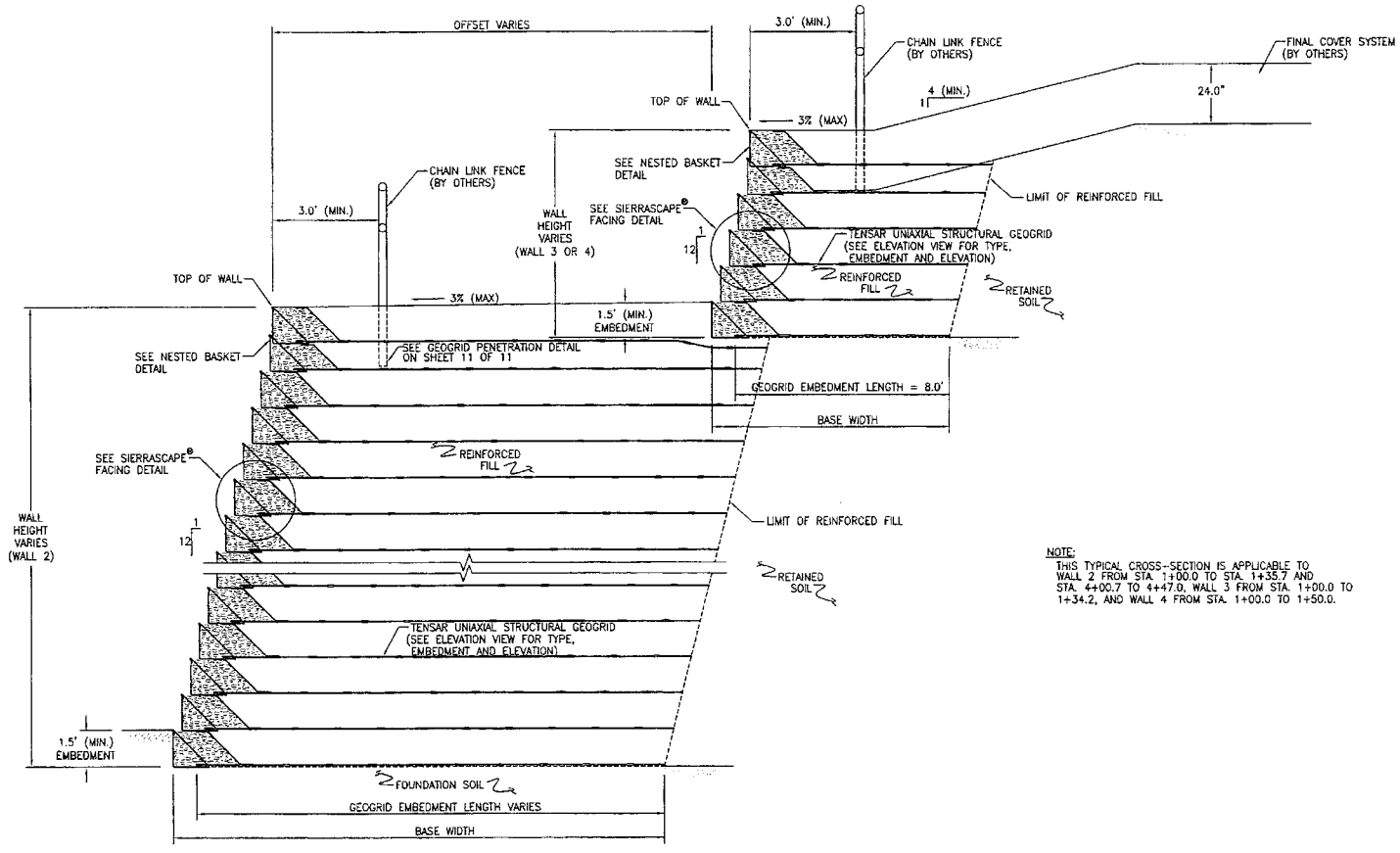
LASO TA-73 AIRPORT LANDFILLS

W.O. NO. 13104.002.001.7000

LOS ALAMOS COUNTY, NEW MEXICO

TYPICAL CROSS-SECTION

Sheet Number
8 OF 11



TYPICAL CROSS-SECTION

NOTE:
THIS TYPICAL CROSS-SECTION IS APPLICABLE TO WALL 2 FROM STA. 1+00.0 TO STA. 1+35.7 AND STA. 4+00.7 TO 4+47.0, WALL 3 FROM STA. 1+00.0 TO 1+34.2, AND WALL 4 FROM STA. 1+00.0 TO 1+50.0.

SCALE
2 1 0 2 4 FEET

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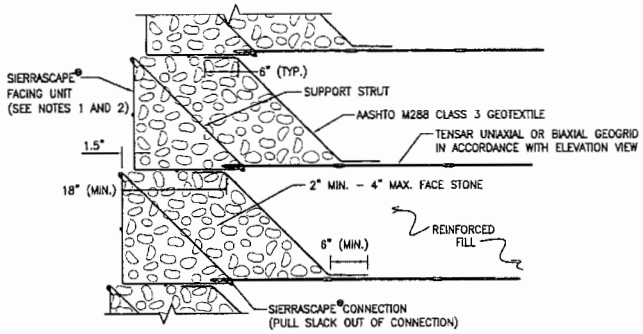
W.O. NO. 13104.002.001.7000
LOS ALAMOS COUNTY, NEW MEXICO

TYPICAL CROSS-SECTION

Sheet Number
9 OF 11

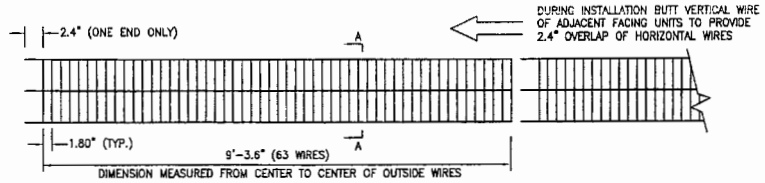


NOTES:

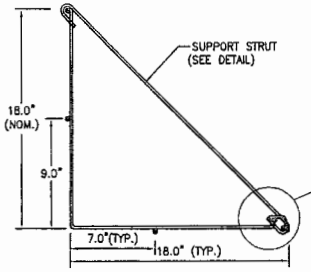
1. SEE SIERRASCAPE® FACING UNIT DETAIL FOR FACING MATERIAL AND DIMENSIONS.
2. ALL FACING UNITS SHALL BE GALVANIZED PER ASTM A123 AFTER FABRICATION.
3. OPTIONAL – A THIN LAYER (2" MIN.) OF FINER STONE (1/4"–1") MAY BE PLACED AT THE TOP OF EACH UNIT TO PROVIDE A LEVEL SURFACE FOR THE UNIT ABOVE.

SIERRASCAPE® FACING DETAIL

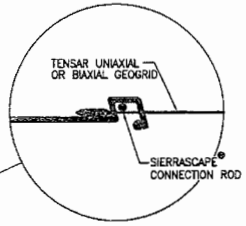
NOT TO SCALE



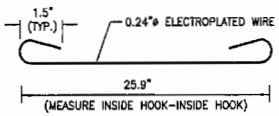
ELEVATION VIEW



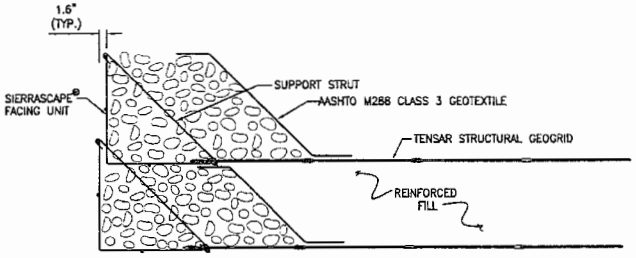
SECTION A–A



CONNECTION LOOP DETAIL



SUPPORT STRUT DETAIL

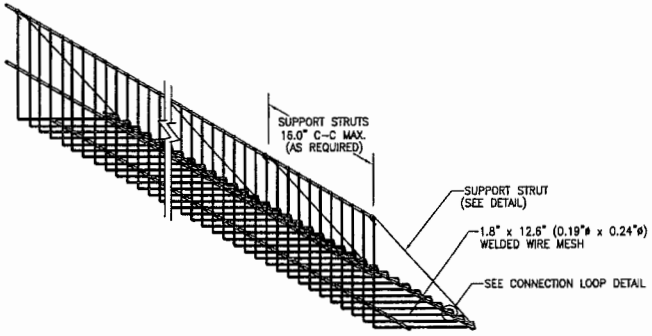


NOTES:

1. SET TOPMOST SIERRASCAPE FACING UNIT INSIDE FACING UNIT BELOW TO FOLLOW GRADE.
2. HORIZONTAL WIRES OF TOPMOST FACING UNIT MAY BE CUT TO ALLOW INSTALLATION OF STRUTS ON FACING UNIT BELOW.

NESTED BASKET DETAIL

NOT TO SCALE



NOTE:

UNLESS OTHERWISE SPECIFIED IN THE SIERRASCAPE® FACING DETAIL ALL FACING UNITS SHALL BE GALVANIZED PER ASTM A123 AFTER BENDING.

SIERRASCAPE® FACING UNIT

NOT TO SCALE

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Project Number	D06602
File Name	D0660210.DWG
Date Drawn	5/24/06
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Drawn by	KJK
Checked by	

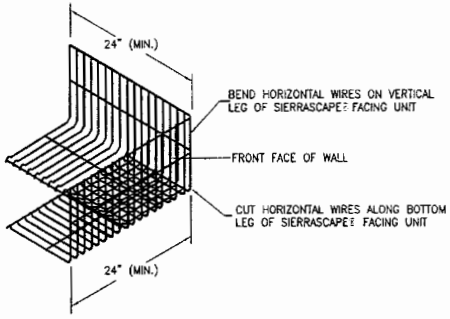
LASO TA-73 AIRPORT LANDFILLS

W.O. NO. 13104.002.001.7000

LOS ALAMOS COUNTY, NEW MEXICO

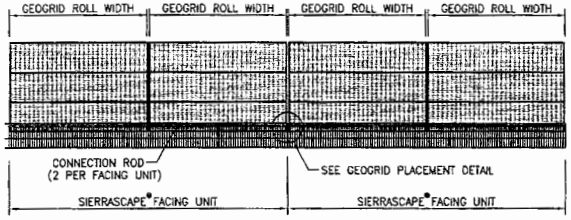
TYPICAL DETAILS

Sheet Number 10 OF 11

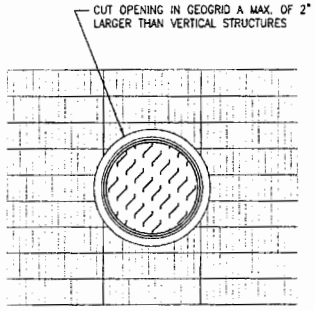


SIERRASCAPE® OUTSIDE CORNER UNIT

NOT TO SCALE

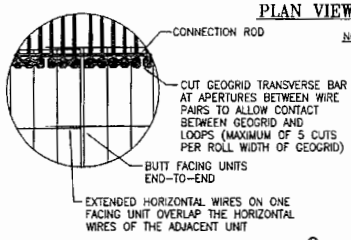


PLAN VIEW



GEOGRID PENETRATION

NOT TO SCALE

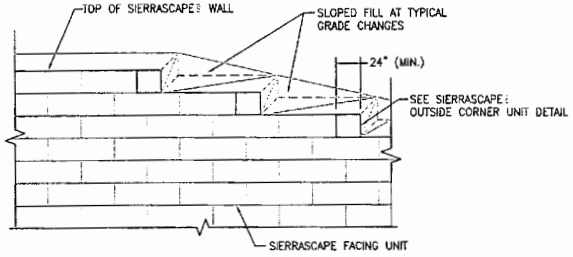


NOTES:

1. SEE SIERRASCAPE FACING UNIT DETAIL FOR FACING MATERIALS AND DIMENSIONS.
2. TWO ROLLS OF UNIAXIAL GEOGRID SHALL BE PLACED ON EACH SIERRASCAPE FACING UNIT WITH TWO GEOGRID RIBS BETWEEN EACH PAIR OF WIRE CONNECTION LOOPS.
3. DURING INSTALLATION BUTT VERTICAL WIRE OF ADJACENT FACING UNITS TO PROVIDE 2.4" OVERLAP OF HORIZONTAL WIRES.

TYPICAL SIERRASCAPE® GEOGRID COVERAGE

NOT TO SCALE

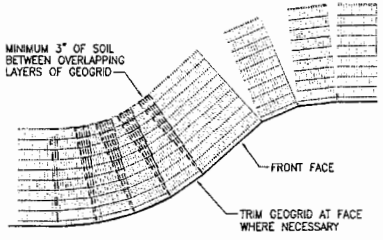


NOTES:

1. SEE SIERRASCAPE® FACING UNIT DETAIL FOR FACING MATERIALS AND DIMENSIONS.
2. USE SIERRASCAPE® FACING UNIT TO FABRICATE CONTINUOUS CORNER. PROVIDE 24" (MIN.) OF SIERRASCAPE® FACING UNIT IN BOTH DIRECTIONS AS MEASURED FROM THE CORNER BEND.
3. INSTALL ADJACENT SIERRASCAPE® FACING UNITS TO PROVIDE 4" OVERLAP OF HORIZONTAL WIRES.

TOP OF SIERRASCAPE® WALL, FINISHING DETAIL

NOT TO SCALE



GEOGRID PLACEMENT ON CURVES

NOT TO SCALE

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LASO TA-73 AIRPORT LANDFILLS

W.O. NO. 13104.002.001.7000

LOS ALAMOS COUNTY, NEW MEXICO

TYPICAL DETAILS

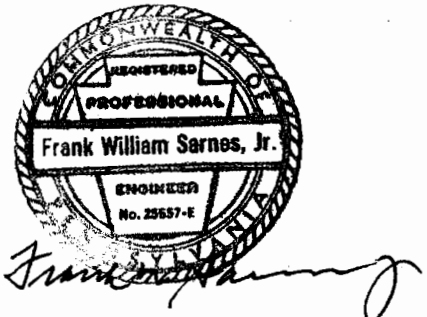
Sheet Number 11 OF 11

FOUNDATION
CALCULATIONS
FOR

8 UNIT N60-45
HANGER PAD
LOS ALAMOS, NEW MEXICO

PREPARED
FOR
WESTON SOLUTIONS, INC.
1400 WESTON WAY
WEST CHESTER, PA 19380

BY
TCPI.
436 CREAMERY WAY
EXTON, PA 19341



FRANK W. SARNES, JR., P.E.
MANAGER OF STRUCTURAL ENGINEERING
TCPI PROJECT NO. E06130
MAY, 2006

WESTON SOLUTIONS, INC.
8 UNIT N60-45
HANGER PAD
LOS ALAMOS, NEW MEXICO

FOUNDATION CALCULATIONS

Description	Page
1. Index	i
2. Introduction	1
3. Preliminary Vendor Layout Drawings	2
4. Preliminary Vendor Loads & Column Reactions	5
5. Geotechnical Parameters	11
6. Foundation Design Concept	11
7. Exterior Column Foundation Calculations	14
8. Interior Column Foundation Calculations	17
9. Anchor Bolt Embedment Calculation	20
10. Slab Calculations	21

TCPI
436 Creamery Way, Suite 100
Exton, PA 19341
(610) 524-5920 Fax (610) 524-2443

PROJECT NO. E06130
CLIENT/FACILITY WESTON - LOS ALAMOS
SUBJECT 8 UNIT N60-45 HANGER FOUNDATION
PREPARED BY FWS DATE 5/06
CHECKED BY DATE

INTRODUCTION

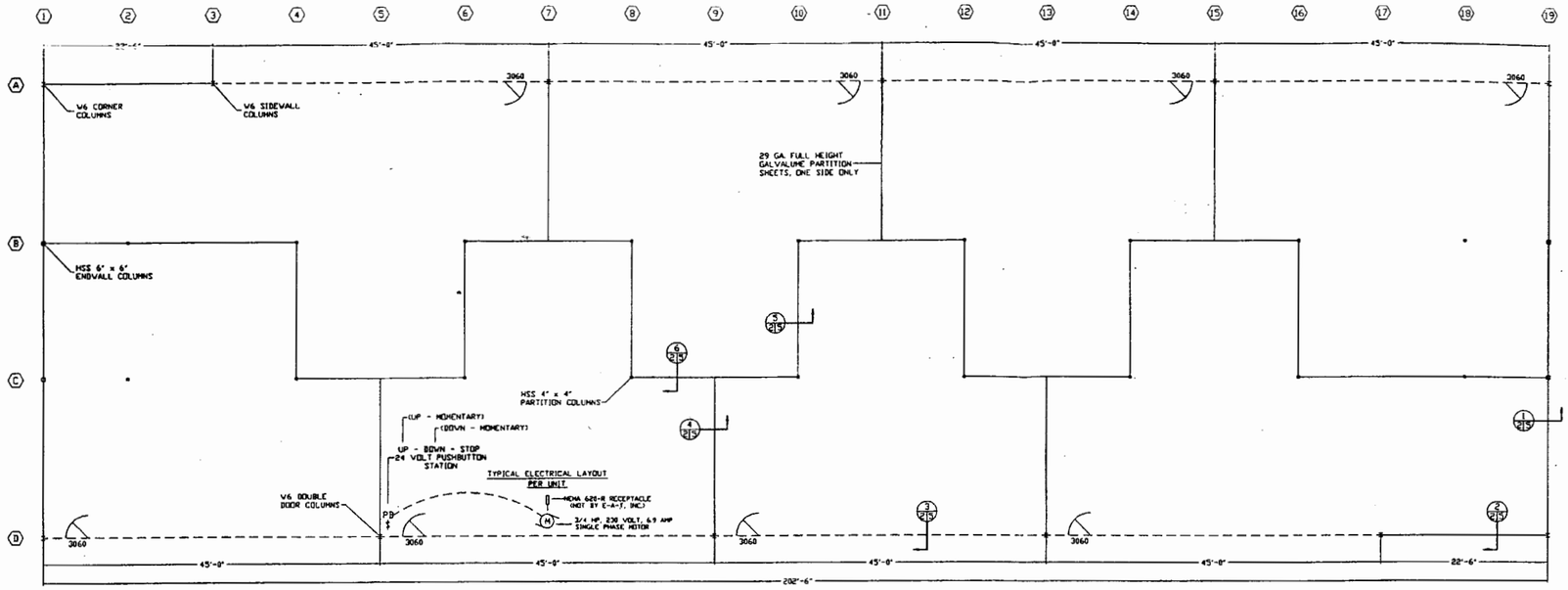
TCPI HAS BE RETAINED BY WESTON SOLUTIONS TO DESIGN THE FOUNDATION PADS FOR AN 8 UNIT PRE-ENGINEERED METAL BUILDING "TEE" HANGER TO BE ERECTED AT THE AIRPORT IN LOS ALAMOS, NM.

ALTHOUGH THE FINAL BUILDING VENDOR HAS NOT BEEN SELECTED, THE BASIS OF DESIGN WILL BE AN 8 UNIT N60-45 NESTED TEE HANGER MANUFACTURED BY ERECT-A-TUBE, HARVARD, IL.

PAGES 2 THROUGH 4 SHOW THE GENERAL LAYOUT AND COLUMN BASE PLATE AND ANCHOR BOLT SIZE AND LOCATION FOR THE 8 UNIT N60-45 HANGER.

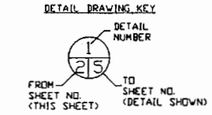
PAGES 5 THROUGH 10 SHOW THE BUILDING DESIGN PARAMETER AND THE PRELIMINARY COLUMN LOADS. THE LOADS TABULATED ON PAGES 9 & 10 ARE THE BASIS OF THE FOUNDATION CALCULATION THAT FOLLOW.

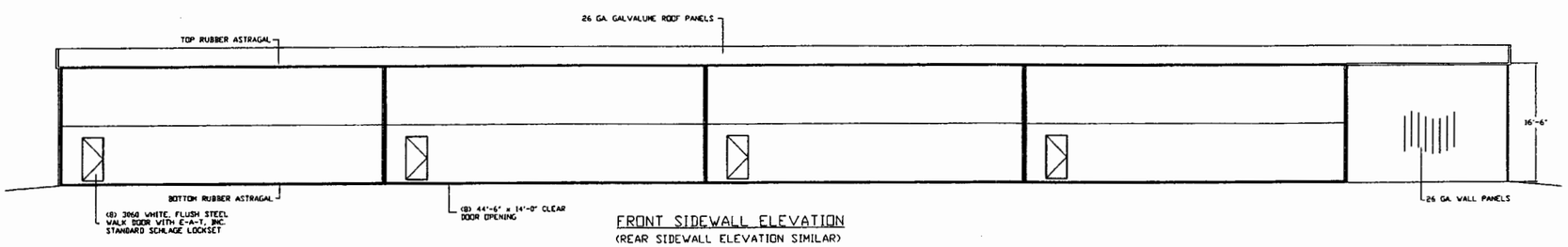
THESE LOADS MUST BE VERIFIED WITH THE CERTIFIED VENDOR PRINTS AND CALCULATIONS FROM METAL BUILDING VENDOR WHO IS FINALLY SELECTED. COLUMN AND LOAD LOCATIONS MUST ALSO BE VERIFIED



FLOOR PLAN

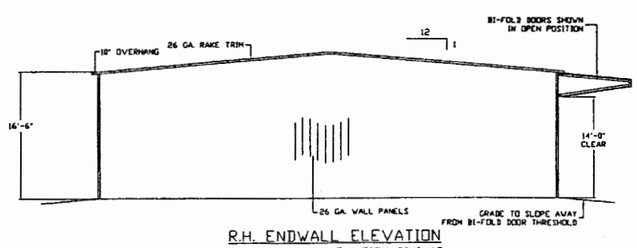
DETAIL DRAWING KEY





FRONT SIDEWALL ELEVATION

(REAR SIDEWALL ELEVATION SIMILAR)



R.H. ENDWALL ELEVATION

(L.H. ENDWALL ELEVATION SIMILAR)

GENERAL NOTES

1. ALL PRIMARY AND SECONDARY STEEL TO BE RED PRIMED. (INTENDED FOR SHORT TERM EXPOSURE ONLY)
2. LOCKSETS TO BE "SCHLAGE". KEYED DIFFERENTLY AND MASTER KEYED.
3. ROOF OVERHANG TO BE 10" FROM STEEL LINE.
4. EXTERIOR WALL PANELS AND TRIM COLORS TO BE DETERMINED BY OWNER.
5. WALK DOOR IN BI-FOLD DOORS, SIDE AND END WALLS WHERE APPLICABLE, TO BE FLUSH AND WHITE IN COLOR. (PER MANUFACTURERS STANDARD)
6. BI-FOLD DOOR PUSH BUTTON OPERATORS: MOMENTARY PRESSURE "DOOR DOWN" & "DOOR UP".
7. BI-FOLD DOOR EQUIPPED WITH MANUAL CAMLOCKS.

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701 WEST PARK STREET
HARVARD IL 60033-0100
OFFICE 815-943-4091
FAX 815-943-7756

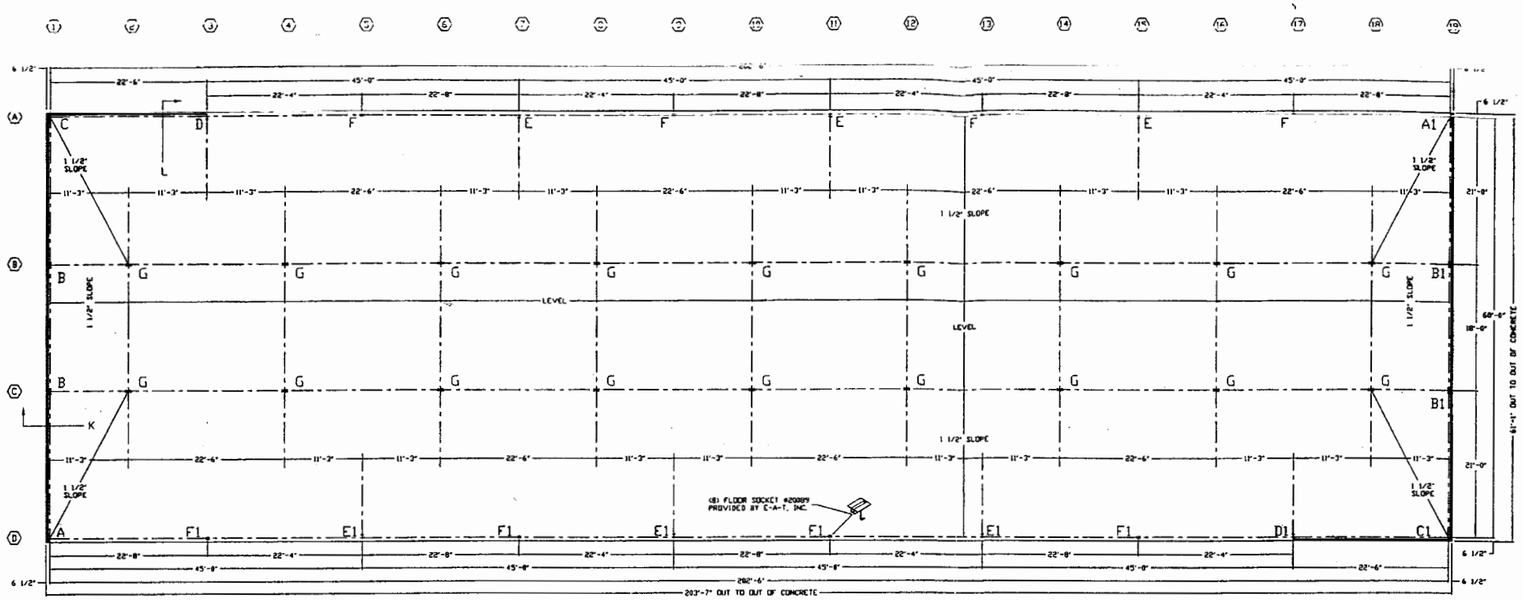
Addition and Address: X

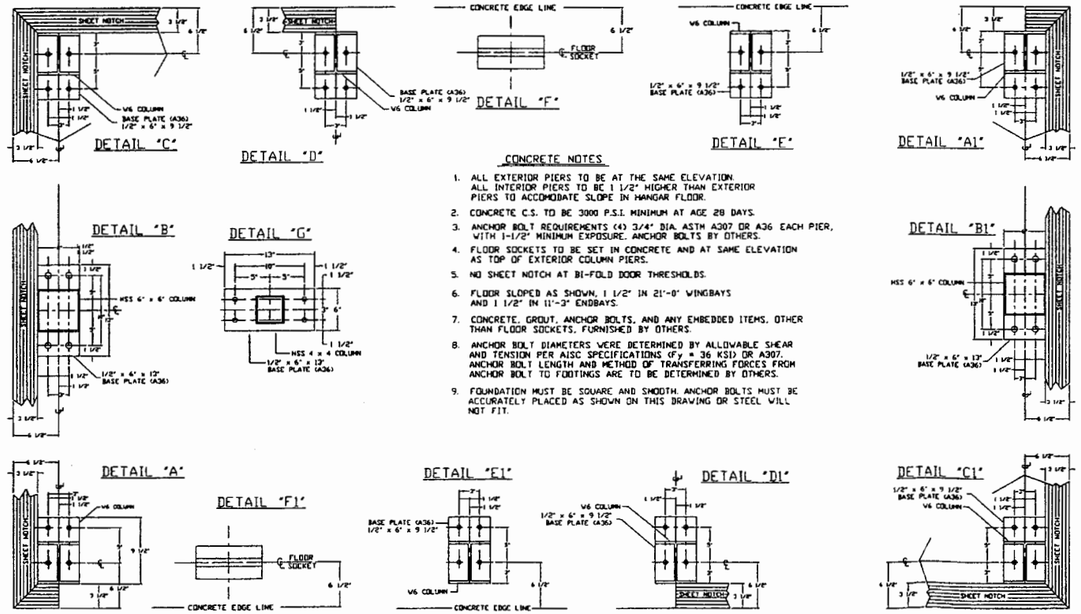
Project name and address: LOS ALAMOS, NM

8 UNIT N60-45

FLOOR PLAN AND ELEVATIONS

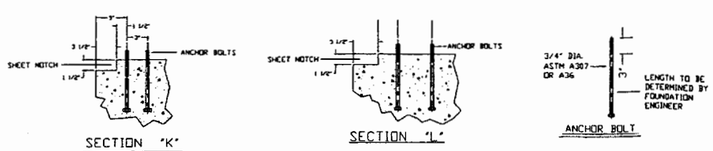
EAT Project: 5021505	Sheet: 1 OF 3
Date: 2-15-2005	
Drawn By: CRL	
Scale: NONE	





CONCRETE NOTES

1. ALL EXTERIOR PIERS TO BE AT THE SAME ELEVATION. ALL INTERIOR PIERS TO BE 1 1/2" HIGHER THAN EXTERIOR PIERS TO ACCOMODATE SLOPE IN HANGAR FLOOR.
2. CONCRETE C.S. TO BE 3000 P.S.I. MINIMUM AT AGE 28 DAYS.
3. ANCHOR BOLT REQUIREMENTS (4) 3/4" DIA. ASTM A307 OR A36 EACH PIER, WITH 1-1/2" MINIMUM EXPOSURE. ANCHOR BOLTS BY OTHERS.
4. FLOOR SOCKETS TO BE SET IN CONCRETE AND AT SAME ELEVATION AS TOP OF EXTERIOR COLUMN PIERS.
5. NO SHEET NOTCH AT BI-FOLD DOOR THRESHOLDS.
6. FLOOR SLOPED AS SHOWN, 1 1/2" IN 21'-0" WINGBAYS AND 1 1/2" IN 11'-3" ENDBAYS.
7. CONCRETE, GROUT, ANCHOR BOLTS, AND ANY EMBEDDED ITEMS, OTHER THAN FLOOR SOCKETS, FURNISHED BY OTHERS.
8. ANCHOR BOLT DIAMETERS WERE DETERMINED BY ALLOWABLE SHEAR AND TENSION PER AISC SPECIFICATIONS (Fy = 36 KSI) OR A307. ANCHOR BOLT LENGTH AND METHOD OF TRANSFERRING FORCES FROM ANCHOR BOLT TO FOOTINGS ARE TO BE DETERMINED BY OTHERS.
9. FOUNDATION MUST BE SQUARE AND SMOOTH. ANCHOR BOLTS MUST BE ACCURATELY PLACED AS SHOWN ON THIS DRAWING OR STEEL WILL NOT FIT.



SECTION "K"

SECTION "L"

ANCHOR BOLT

COLUMN REACTIONS

COLUMN	Vdown	Vup	±Hx	±Hy	DESCRIPTION
B.1,B.19,C.1,C.19					ENDWALL COLUMNS
B.2,B.18,C.2,C.18					FIRST INTERIOR COLUMNS
B.4,B.6,B.8,B.10,B.12, B.14,B.16, C.4,C.6,C.8,C.10,C.12, C.14,C.16					INTERIOR COLUMNS
A.1,D.19					CORNER COLUMNS
A.3,D.17					SINGLE DOOR COLUMNS
A.7,A.11,A.15, D.5,D.9,D.13					DOUBLE DOOR COLUMNS
A.19,D.1					CORNER/DOOR COLUMNS
FS					FLOOR SOCKETS

NOTE:

1.) ALL REACTIONS ARE IN KIPS
2.) Vup, Hx, AND Hy ARE DUE TO WIND LOAD.
3.) ALL HORIZONTAL REACTIONS CAN ACT POSITIVE OR NEGATIVE DIRECTION.
4.) ALL COLUMN BASE PLATES ARE DESIGNED FOR FOUR 3/4" DIA. ANCHOR BOLTS, FOR THIS COMPLIES WITH THE OSHA REGULATIONS OF MARCH 2003 FOR STEEL ERECTION.

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701 WEST PARK STREET
HARVARD IL 60033-0100
OFFICE 815-943-4091
FAX 815-943-7756

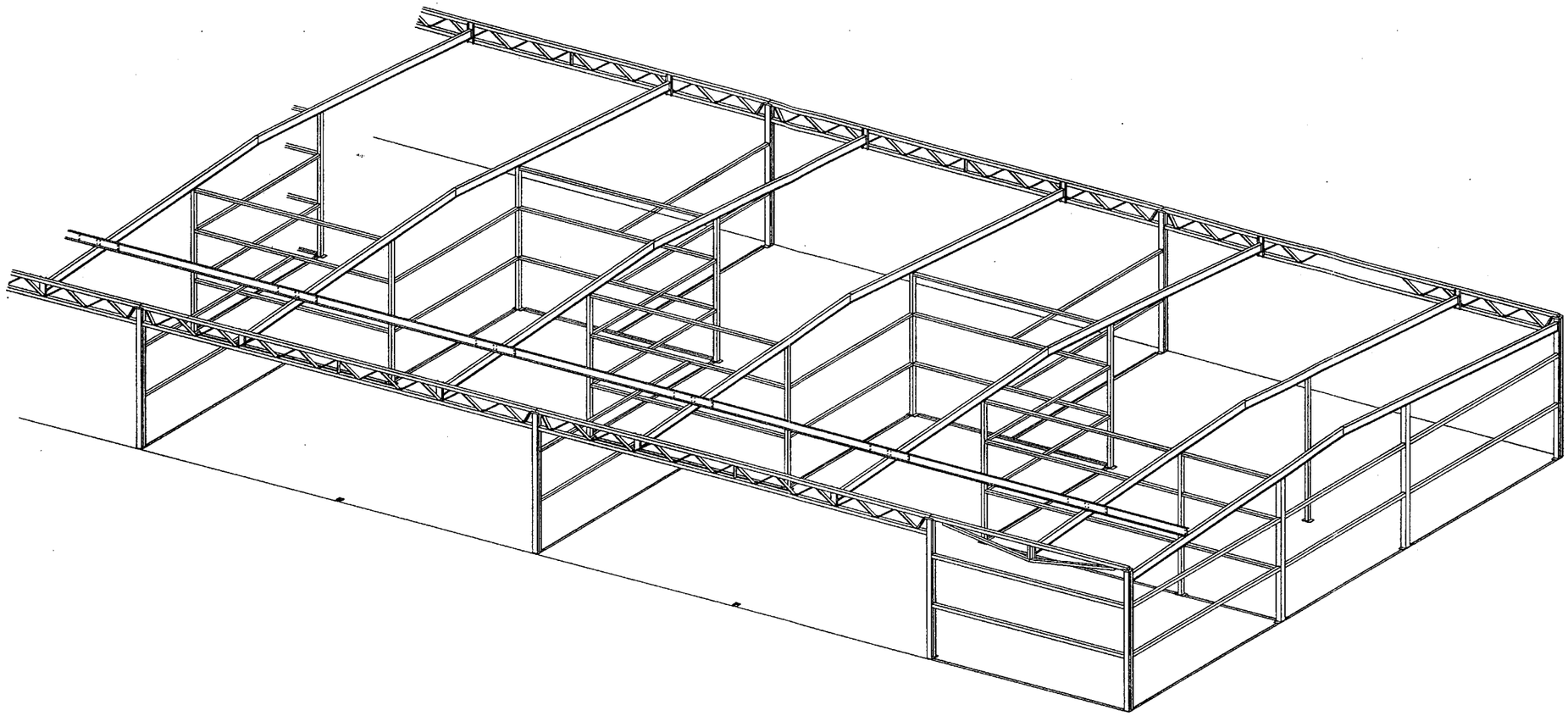
X

LOS ALAMOS, NM

8 UNIT N60-45

ANCHOR BOLT LAYOUT

Job Number	S021505
Date	2-15-2005
Drawn By	CRL
Scale	NONE
Sheet	2 OF 3



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HARVARD IL 60033-0100
OFFICE 815-943-4091
FAX 815-943-7756

Customer and address
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Project Name and address
LOS ALAMOS, NM

8 UNIT N60-45

ERECTION DRAWING

Job Number	5021505
Date	2-15-2005
Drawn By	CRL
Scale	NONE
Sheet	3 OF 3

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Job Data Worksheet

Enter values in red only on Job Data Worksheet only.

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Entry Date: 2/14/2006

Customer To:
Address:
City, State, Zip Code: Los Alamos, NM
Customer Contact:
Phone No:
Fax No:
Cell No:
Email :

Ship To: Los Alamos, NM
Address:
City, State, Zip Code: Los Alamos, NM
Jobsite Contact:
Phone No:
Fax No:
Cell No:
Email :

Model N60-45

Slope of Gable Roof System	x / 12	Roof Pitch Degrees	Secant
Roof Pitch	1.00	4.76	1.00347

Quantity of Units	8

	Decimals of a Foot
Eave Height	16.500
Width	60.000
Length	202.500
Bifold Width	45.000
Sidewall	22.500
SL - CL WF Column	0.250
Trans. Wingbay CL - CL	21.000
Trans. Tailbay CL -CL	18.000
Long. Full Tailbay CL - CL	22.500
Long. Half Tailbay CL - CL	11.250
Peak Height	19.000

Code	MPH	Exp	Exp
IBC 2003	90	3 Second Gust	C

Ground Snow Load Per Map			30.00	psf
Reducible	FALSE		1.00	
Importance Factor		I	1.00	
Exposure Factor		Ce	1.00	
Heated Building Year Round	NO	Ct	1.20	
Roof Live Load			**36.00**	**psf**
Dead Load			3.00	psf
Collateral Load	FALSE		0.00	psf
Additional Load			0.00	psf
Total Roof Load			**39.00**	**psf**

Erect-A-Tube, Inc. **Structure Calculations** **BY:** *ENK*
Nel-Struct Engineering **Date:** *14-Feb-06*
Sheet:

Project: *E-BID*
Location: *Los Alamos, NM*
Units: *8*
Model Size *N60-45*
Design Code: *IBC 2003*

Wind Analysis: 1609.6 Simplified Provisions For Low-Rise Bldgs.

Eave Height=	16.50	ft.			
Roof Pitch=	1.00		TO	12	in.
Building Width=	60.00	ft.			
Building Length=	202.50	ft.			
Roof Angle=	5	deg.			
Mean Roof Height=	17.75	ft.			

1.) Determine wind speed and exposure catagory

V3s=	90.00	mph	Fig. 1609...
Exposure Catagory=	C		Sec. 1609.4

2.) Determine if "simplified Provisions" applies:

17.75	less than	Least horizontal dimension=	60.00	ft.		.....if yes then cont.
5	less than	30 deg.	.....If yes than cont.			

3.) Determine horizontal loads for MWFRS — Table 1609.6.2.1(1)

Note:...(-) wall pressures are taken as zero

			REF TABLE
Horizontal Loads-Transverse Direction...			
End Zone of wall projection=	12.8	psf	*HP A*
End Zone of roof projection=	0.0	psf	
Interior Zone of wall projection=	8.5	psf	*HPB*
Interior Zone of roof projection=	0.0	psf	
Horizontal Loads-Longitudinal Direction...			
End Zone of wall projection=	12.8	psf	*HP A*
End Zone of roof projection=	0.0	psf	
Interior Zone of wall projection=	8.5	psf	*HPB*
Interior Zone of roof projection=	0.0	psf	

Note:...(-) roof pressures are taken as zero

4.) Determine vertical loads for MWFRS — Table 1609.6.2.1(1)

Vertical Loads-Transverse Direction...			
End Zone of windward roof=	-15.4	psf	*VP E*
End Zone of leeward roof=	-8.8	psf	*VP F*
Interior Zone of windward roof=	-10.7	psf	*VP G*
Interior Zone of leeward roof=	-6.8	psf	*VP H*
Vertical Loads-Longitudinal Direction...			
End Zone of windward roof=	-15.4	psf	*VP E*
End Zone of leeward roof=	-8.8	psf	*VP F*
Interior Zone of windward roof=	-10.7	psf	*VP G*
Interior Zone of leeward roof=	-6.8	psf	*VP H*

5.) Determine height and exposure adjustment

adjustment=	1.28	Table 1609.6.2.1(4)

6.) Adjusted horizonatal loads... **[FINAL PRESSURES]**

Horizontal Loads-Transverse Direction...

End Zone of wall projection=	16.4	psf
End Zone of roof projection=	0.0	psf
Interior Zone of wall projection=	10.9	psf
Interior Zone of roof projection=	0.0	psf

Horizontal Loads-Longitudinal Direction...

End Zone of wall projection=	16.4	psf
End Zone of roof projection=	0.0	psf
Interior Zone of wall projection=	10.9	psf
Interior Zone of roof projection=	0.0	psf

7.) Adjusted vertical loads...

Vertical Loads-Transverse Direction...

End Zone of windward roof=	-19.7	psf
End Zone of leeward roof=	-11.3	psf
Interior Zone of windward roof=	-13.7	psf
Interior Zone of leeward roof=	-8.7	psf

Vertical Loads-Longitudinal Direction...

End Zone of windward roof=	-19.7	psf
End Zone of leeward roof=	-11.3	psf
Interior Zone of windward roof=	-13.7	psf
Interior Zone of leeward roof=	-8.7	psf

8.) End Zone Calculation...

"a" is lessor of:	6.00	ft.	*OR*	6.60	ft.
but not less than:	2.40	ft.	*OR*	3	ft.
"a"=	6.00	ft.			
End Zone Width=	12.00	ft.			

Erect-A-Tube, Inc.
Nel-Struct Engineering

Structure Calculations

BY: *ENK*
Date: *14-Feb-06*
Sheet:

Project: *0-Jan-00*
Job Number: *E-BID*
Units: *8*
Model Size *N60-45*
Design Code: *IBC 2003*

Building Information

Live Load=	36.00	psf			
Dead Load=	3.00	psf			
Wind Roof Pressure=	19.74	psf	WW Roof Pres	13.72	psf
Windward Wall Pressure=	16.41	psf			
Leeward Wall Pressure=	0.00	psf			
Distance Grid A to B=	21.0	ft			
Distance Grid B to C=	18.0	ft			
Distance Grid C to D=	21.0	ft			
Grid Number Separation=	11.25	ft			
Eave Height=	16.50	ft			
Peak Height=	19.00	ft			
Door Truss Weight=	50	#/ft			
Truss Weight per Column=	1.13	kips			
Endwall Column Loadings...					
W(LL+DL)=	0.219	k/ft			
W(WL-DL)=	0.094	k/ft			
Endwall Columns (Vdown)=	4.28	kips			
Endwall Columns (Vup)=	1.84	kips			
Eave (Vdown)=	2.30	kips			
Eave (Vup)=	0.99	kips			
First Interior Column Loadings...					
W(LL+DL)=	0.656	k/ft			
W(WL-DL)=	0.181	k/ft			
First Interior Columns (Vdown)=	12.83	kips			
First Interior Columns (Vup)=	3.53	kips			
Eave (Vdown)=	6.91	kips			
Eave (Vup)=	1.90	kips			
Interior Column Loadings...					
W(LL+DL)=	0.878	k/ft			
W(WL-DL)=	0.241	k/ft			
Interior Columns (Vdown)=	17.11	kips			
Interior Columns (Vup)=	4.70	kips			
Eave (Vdown)=	9.21	kips			
Eave (Vup)=	2.53	kips			
Corner Columns...					
V(down)=	5.76	kips			
V(up)=	1.94	kips			
Single Door Columns...					
V(down)=	12.67	kips			
V(up)=	3.48	kips			
Double Door Columns...					
V(down)=	18.43	kips			
V(up)=	5.06	kips			
Corner Door Columns...					
V(down)=	9.6	kips			
V(up)=	3.0	kips			
Longitudinal Bracing Pressures...					
Trib. Area=	266.25	sq.ft.			
Hx=	4.37	kips			
uplift=	3.20	kips			

5

Lateral Bracing Pressures...

Trib. Area=	185.63	sq.ft.
Hy=	3.05	kips
uplift=	2.79	kips

Summary of Building Reactions.....

Key	Description	Vdown	Vup	Hx	Hy
EC	Endwall Columns	4.28	1.84	2.64	1.00
FIC	First Interior Columns	12.83	6.32	4.37	3.05
IC	Interior Columns	17.11	7.49	4.37	3.05
CC	Corner Columns	5.76	1.94	1.42	1.52
SDC	Single Door Columns	13.79	3.48	1.00	3.05
DDC	Double Door Columns	20.68	5.06	1.00	3.05
CDC	Corner Door Columns	10.68	2.98	1.42	1.52
FS	Floor Sockets	N/A	N/A	N/A	3.05

Note: Any values less than 1 kip, use 1 kip.

ERECT-A-TUBE, INC.

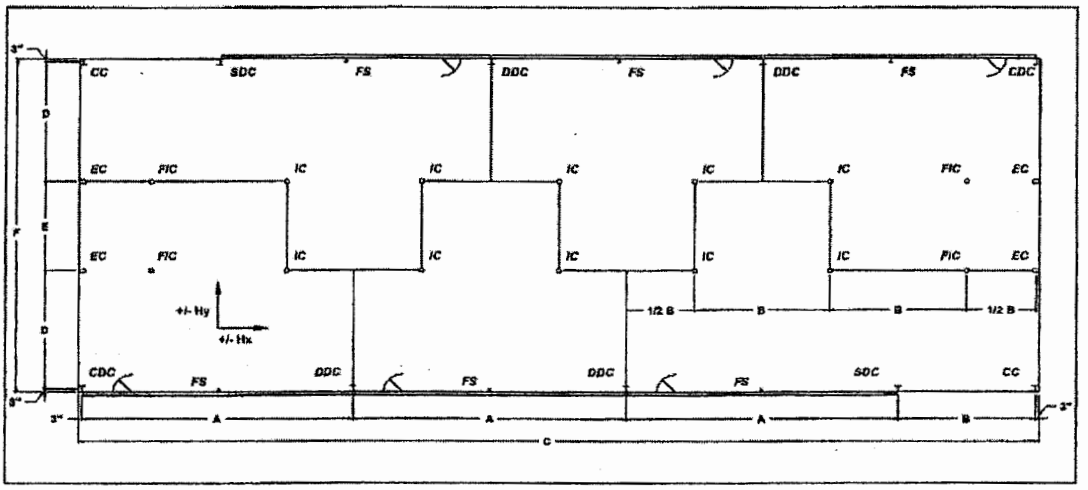
701 W. PARK STREET P.O. BOX 100
HARVARD, ILLINOIS 60033-0100
815-943-4091 FAX 815-943-7756

Customer Name:
Project Name: Los Alamos, NM
Project Location: Los Alamos, NM

Date: 2/14/2006
Job No: E-BID
Model: 8 Unit N60-45

Dim.	Feet	Description
A	45.00	Bifold Width
B	22.50	Sidewall Length
C	203.00	Sidewall SL - SL
D	21.00	Trans. Wingbay CL - CL
E	18.00	Trans. Tailbay CL -CL
F	60.50	Endwall Width SL - SL
	16.50	Eave Height
	1:12	Roof Pitch
Wind Speed	90 mph, 3 second gust	
Exposure	C	

IBC 2003	Model Building Code	
30.00	psf Ground Snow Load Per Map	
1.00	Reducible	
1.00	Importance Factor	I
1.00	Exposure Factor	Ce
1.20	Unheated Building	Ct
36.00	psf Roof Live Load	
3.00	psf Dead Load	
0.00	psf Collateral Load	
0.00	psf Additional Load	
39.00	psf Total Roof Load	



Out to out of concrete foundation	61.083 ft. by 203.583 ft.

Qty. of Piers	34
Qty. of FS	8

Summary of Building Reactions.....

Key	Description	Vdown	Vup	Hx	Hy
EC	Endwall Columns	4.28	1.84	2.64	1.00
FIC	First Interior Columns	12.83	6.32	4.37	3.05
IC	Interior Columns	17.11	7.49	4.37	3.05
CC	Corner Columns	5.76	1.94	1.42	1.52
SDC	Single Door Columns	13.79	3.48	1.00	3.05
DDC	Double Door Columns	20.68	5.06	1.00	3.05
CDC	Corner Door Columns	10.68	2.98	1.42	1.52
FS	Floor Sockets	N/A	N/A	N/A	3.05

General Notes

1. All reaction values are in kips.
2. Any values less than a kip, use 1 kip.
3. Vup, Hx and Hy are due to wind load.
4. All horizontal reactions can act positive or negative direction.
5. All column base plates are design for four 3/4" diameter anchor bolts, for this complies with the OSHA Regulations of March 2003 for steel erection.
6. All anchor bolts not provided by Erect-a-Tube, Inc.
7. Floor sockets are an embedment supplied by Erect-A-Tube, Inc.
8. Concrete C.S. to be 3,000 p.s.i. minimum at age 30 days. Refer to bid specifications.
9. This data sheet is for estimating purposes only. Not for construction or final design. It shall be the project A/E or general contractor to confirm with local building offical for the loading for the proposed hangar facility.
10. The six unit layout is for illustration only.

TCPI
436 Creamery Way, Suite 100
Exton, PA 19341
(610) 524-5920 Fax (610) 524-2443

PROJECT NO. E06130
CLIENT/FACILITY WESTON - LOS ALAMOS
SUBJECT 8 UNIT N60-45 HANGER FDN
PREPARED BY FWS DATE 5/06
CHECKED BY DATE

GEOTECHNICAL PARAMETERS

THE HANGERS AND FOUNDATIONS ARE TO CONSTRUCTED ON A MAJOR FILL AREA. THE FILL WILL NOT BE STRUCTURAL FILL BUT RATHER AN ASSORTMENT OF MATERIAL INCLUDING SOME SOLID WASTE. AS A RESULT, SOIL BEARING CAPACITY WILL BE SOMEWHAT LOW AND DIFFERENTIAL SETTLEMENT IS A CONCERN.

ANDREW HARPUR AND HIS STAFF AT WESTON SOLUTIONS HAVE PERFORMED EXTENSIVE ANALYSIS ON THE FILL USING SETTLEMENT MODELS. THEY HAVE RECOMMENDED THAT

MAXIMUM ALLOWABLE
SOIL BEARING CAPACITY = 2000 PSF

BE USED FOR DESIGN. THEY HAVE ALSO INFORMED US THAT AT THE PROJECT SITE

MAXIMUM FROST DEPTH = 20 INCHES

FOUNDATION DESIGN CONCEPT

WE WOULD NORMALLY DESIGN A STRUCTURE LIKE THIS WITH ISOLATED COLUMN FOOTINGS AND PIER WITH AN INDEPENDENT FLOATING SLAB ON GRADE FOR THE HANGER FLOOR.

DUE TO THE POTENTIAL FOR SIGNIFICANT DIFFERENTIAL SETTLEMENT, A DIFFERENT APPROACH IS PRUDENT FOR THIS PROJECT

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A MAT FOUNDATION APPROXIMATELY 2FT THICK WAS CONSIDERED BUT WOULD BE TOO EXPENSIVE.

THE SELECTED ALTERNATE IS A 6" SLAB ON GRADE REINFORCED WITH RIB BEAMS IN TWO DIRECTIONS. THE RIBS WILL BE LOCATED ON THE COLUMN LINES AND BE OF SUFFICIENT SIZE AND HAVE SUFFICIENT REINFORCING STEEL SO THEY CAN ALSO FUNCTION AS THE COLUMN FOOTINGS. IN SOME CASES, SECTIONS OF THE FLOOR SLAB WHICH ARE INTEGRAL WITH THE RIBS WILL BE USED TO HELP DISTRIBUTE THE COLUMN LOADS TO THE UNDERLYING SOIL

THE SKETCH ON P13 ILLUSTRATES THE CONCEPT. NOTE THAT THE COLUMNS ARE LOCATED AT THE INTERSECTION OF THE STIFFENING RIBS.

SECTION A IS THE PERIMETER RIB AROUND THE EXTERIOR OF THE BUILDING. IT CARRIES ALL OF THE PERIMETER COLUMNS. ON P10, THE SCHEMATIC COLUMN LOCATION PLAN AND THE LOAD TABLE SHOW THAT THE DOUBLE DOOR COLUMNS (DDC) IS THE MOST HEAVILY LOADED PERIMETER COLUMN.

THE DESIGN CALCULATIONS FOR SECTION A ARE SHOWN ON PAGES 14 THROUGH 16

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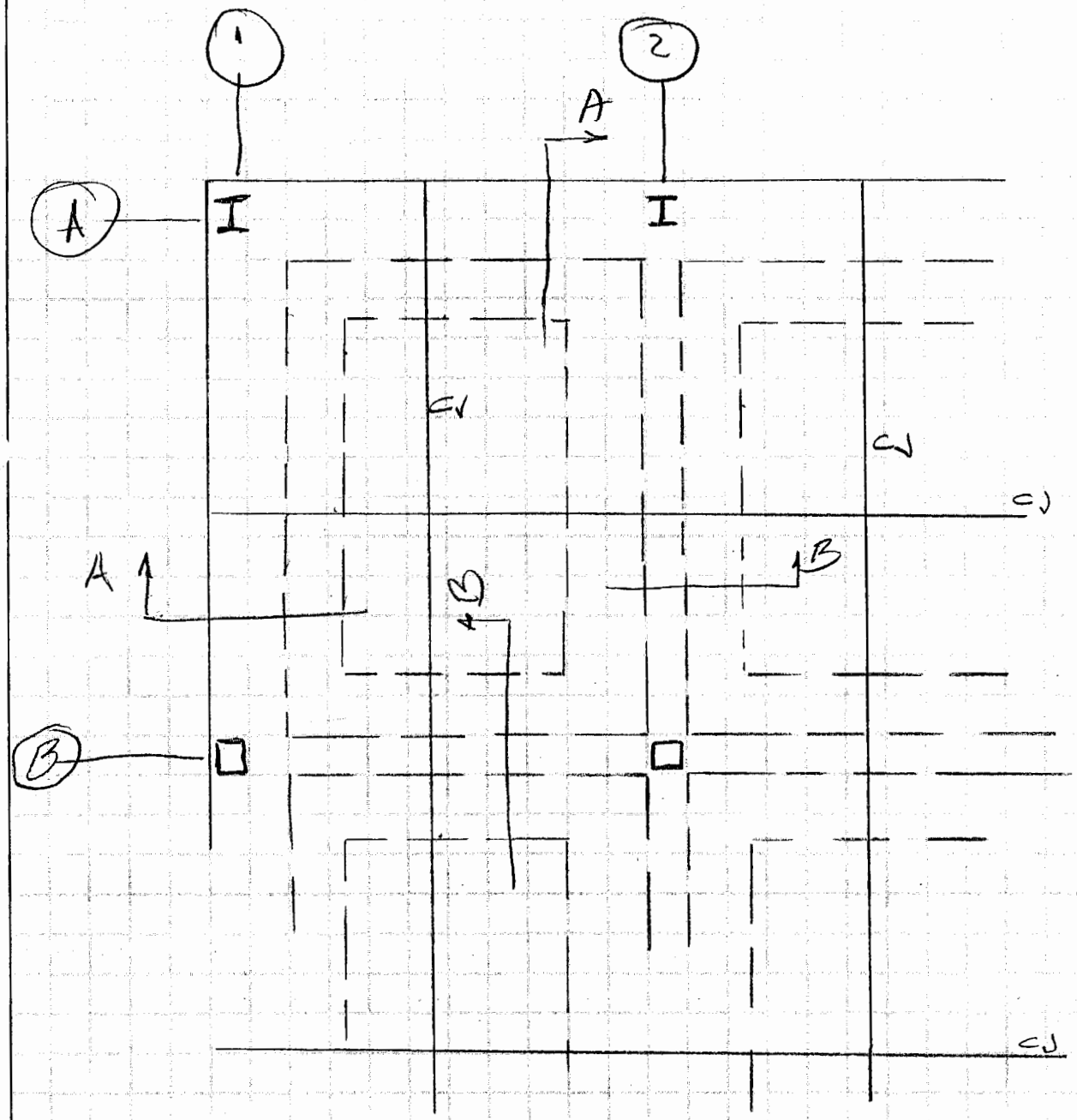

PLAN

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PROJECT NO. E 06130
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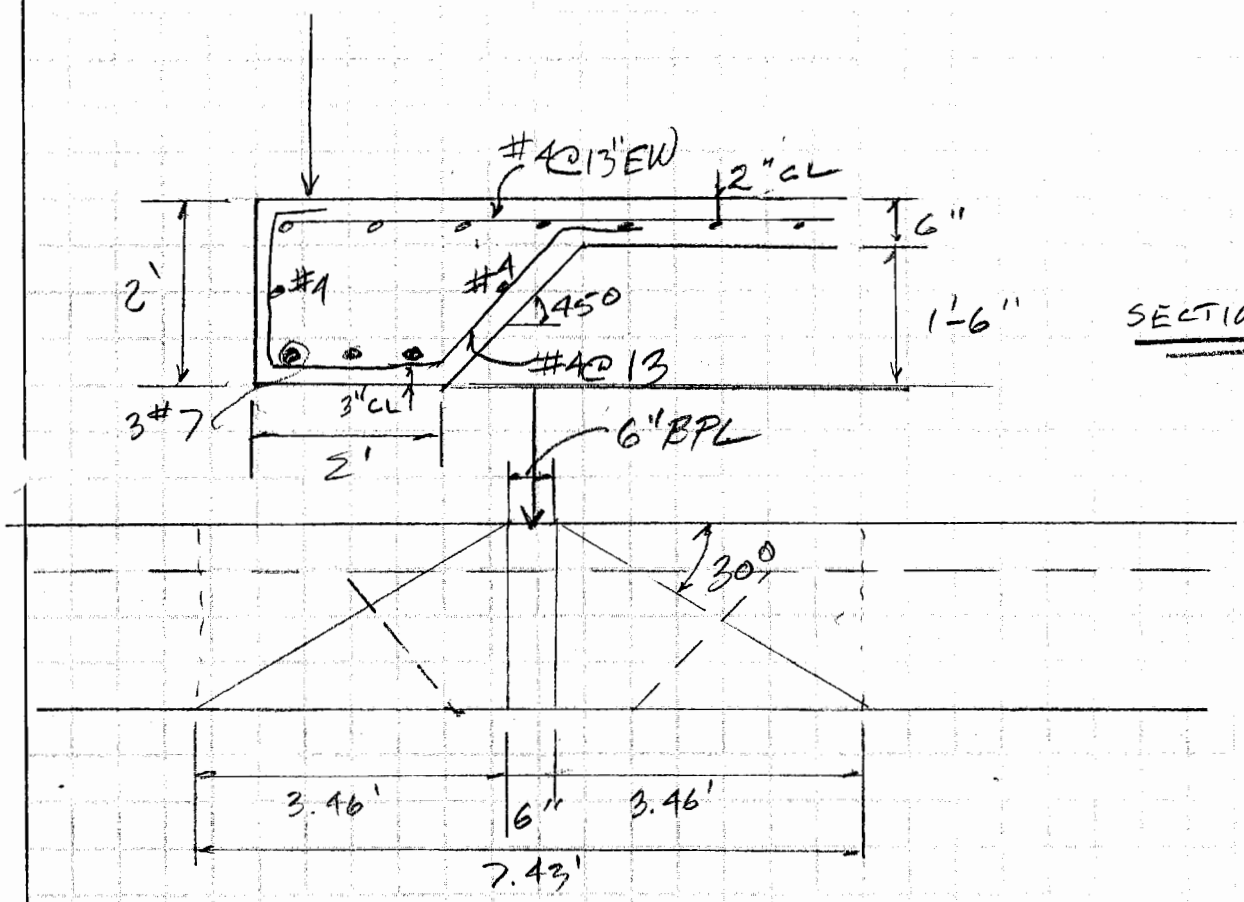
CHECKED BY RWS DATE 5/06

DDC ↓ 21.68^K ↑ 5.06^K $H_x = 1^K$ $H_y = 3.05^K$
MAX EXTERIOR COLUMN



SECTION A

$P = 21.68^K / 7.43 \times 2 = 1.46\ KSF < 2\ KSF$ - ALLOWABLE SOIL PRESSURE

$W = [2(7.43)(2) + \frac{1}{2}(1.5)(1.5)(7.43)].15 = 5.71^K = 5.06^K$ OK

$M = 1.46(2)\frac{(3.46)^2}{2} = 17.5^{K'}$ $M_u = 1.4(17.5) = 24.5^{K'} = 10.21/10'W$

$f'_c = 3000$ $f_y = 60{,}000$ $d = 20"$
F-7.3.2 USE MIN A_s

$A_s = \frac{3\sqrt{3000}}{60{,}000}(24)(20) = 1.31\ IN^2$ $\frac{200(24)(20)}{60{,}000} = 1.60\ IN^2$
USE 3#7 = 1.8 in^2 OK

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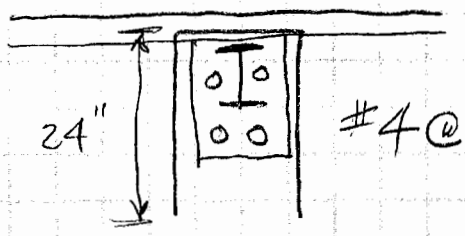
MAX HORIZONTAL FORCE = $H_y = \pm 3.05^k$. MUST ADD A TIE AT PERIMETER TO TRANSFER OUTWARD FORCE BACK INTO SLAB REINFORCEMENT. FOR #4 TIES

$T_{4H} = 2 \times 0.2 \times 24\ ksi$
$= 9.6^k > 3.05^k$ OK



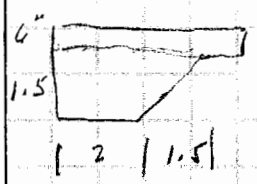
#4 @ EXTERIOR COLUMNS

MAXIMUM UPLIFT FORCE = 5.06^k

NEED SUFFICIENT DEAD WEIGHT TO RESIST THIS UPLIFT. UPLIFT IS DUE TO WIND.

ASSUME 4' x 8' AREA IS ENGAGED

DEAD WEIGHT

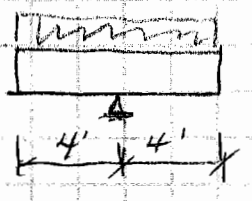


SLAB	$4 \times 8 \times 75$ psf =	2400 lbs
PERIMETER	$8 \times (1.5 \times 2 + 0.5 \times 1.5^2) \times 150$ =	4950 lbs
		7350 lbs

$F.S. = \frac{7.35}{5.06} = 1.45$ OK

ABOVE IGNORES ADDED DL FROM PERPENDICULAR RIB SO IT IS CONSERVATIVE

CHECK NEGATIVE BENDING OF RIB



$w = \frac{7.35}{8} = 0.92$ KLF ON 4 FT CANTILEVER

$M_u = 1.7(0.92)\left(\frac{4^2}{2}\right) = 12.5^{KF}$

$d \approx 24 - 2 - \frac{1}{2} = 21.5''$

ASSUME $jd = 0.95d = 20.43''$

$A_{s_{REQ}} = \frac{M_u}{\phi F_y jd} = \frac{12.5 \times 12}{(0.9)(60)(20.43)} = 0.25\ in^2$

$A_{s_{PROVIDED}} = 3 - \#4's = 3 \times 0.2 = 0.61\ in^2 > 0.25\ in^2$ OK

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SUBJECT 8 UNIT NCO-45 HANGER FDN
PREPARED BY TRB DATE 5/06
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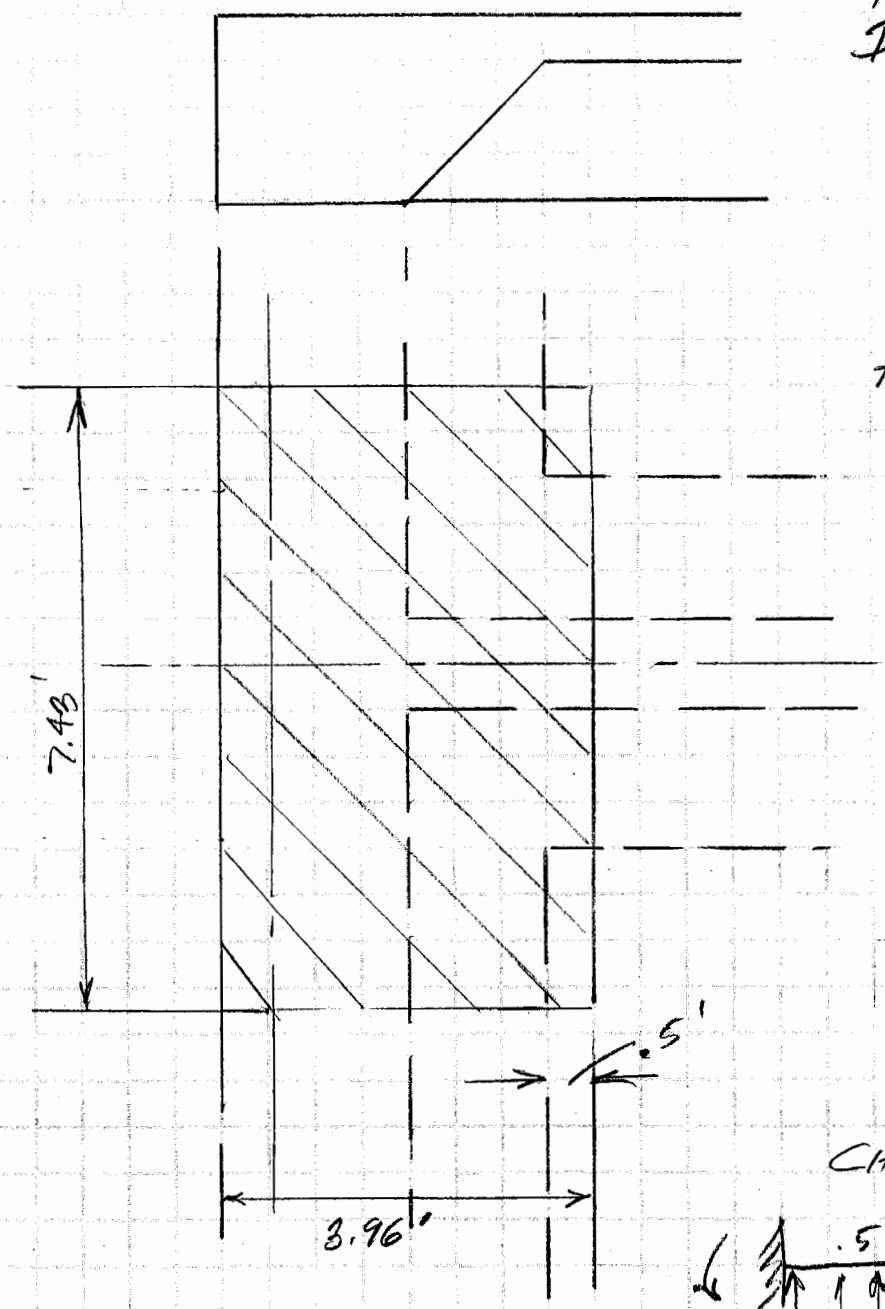
EXTERIOR COLUMN



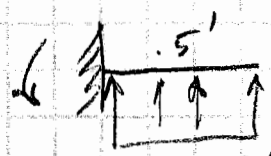
ASSUME LOAD DIST. OVER AREA

$$P = \frac{21.68^K}{7.43 \times 3.96} = 737 \text{ PSF}$$

THIS SHOWS THAT INTEGRAL SLAB HELPS TO REDUCE PRESSURES APPLIED TO THE SOIL AND WILL HAVE A POSITIVE IMPACT ON SETTLEMENT

FOR THIS CONCEPT TO WORK SLAB MUST HAVE SUFFICIENT MOMENT CAPACITY

CHECK SLAB



$$M = \frac{.737(.5)^2}{2} = .1^{K'}$$

ACI SP17 F 7.1.1

$d = 2.75''$ $A_s = 0.18$ $M_u = 1^{K'}$ OK

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CLIENT/FACILITY WESTON - LOS ALAMOS
SUBJECT SUMIT N60-45 HANGER FDN
PREPARED BY FWS DATE 5/06
CHECKED BY _____ DATE _____

SECTION B IS THE TYPICAL INTERIOR RIB. LOADS FROM INTERIOR COLUMNS ARE CARRIED BY A CRUCIFORM FORMED BY THE INTERSECTION OF TWO RIBS.

ON p10, THE SCHEMATIC COLUMN LOCATION PLAN AND THE LOAD TABLE SHOW THAT THE INTERIOR COLUMN (IC) IS THE MOST HEAVILY LOADED INTERIOR COLUMN

THE DESIGN CALCULATIONS FOR SECTION B ARE SHOWN ON PAGES 18 AND 19

THE CALCULATIONS ON p20 INVESTIGATED ANCHOR BOLT EMBEDMENT REQUIREMENTS BASED ON THE SMALLEST EDGE DISTANCE AT A PERIMETER COLUMN. ANCHOR BOLTS FOR INTERIOR COLUMNS DO NOT HAVE ANY EDGE DISTANCE PROBLEMS WITH A 10 INCH EMBEDDED LENGTH

FOR THE NESTED TEE HANGER, THE MAXIMUM AIRCRAFT WEIGHT HAS BE DEFINED AS 5200 lbs ON TWO WING WHEELS AND A NOSE WHEEL WITH A MAX TIRE PRESSURE OF 45 PSI. CONSERVATIVELY PLACING THE FULL WEIGHT ON THE TWO WING WHEELS, THE CALCULATIONS ON p21 SHOW THAT A 6" SLAB REINFORCED WITH # 4's @ 18" o.c. EW IS MORE THAN ADEQUATE.

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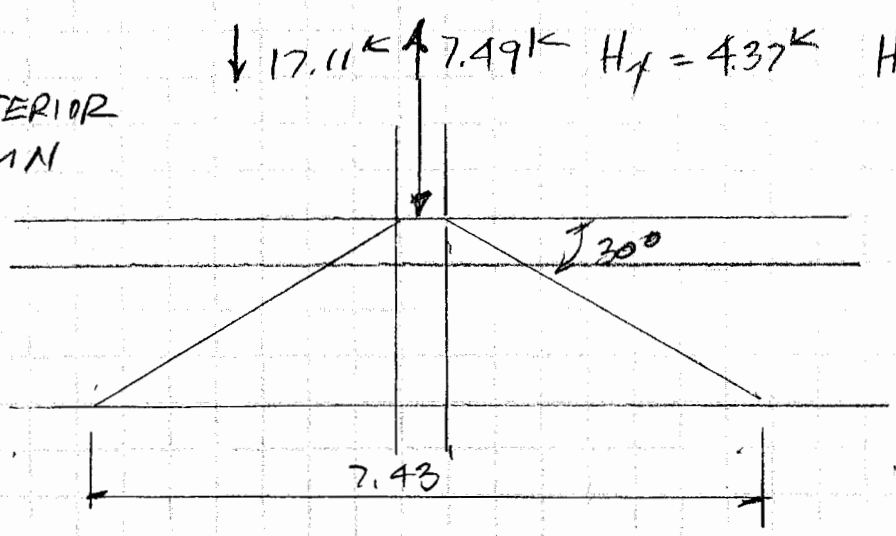
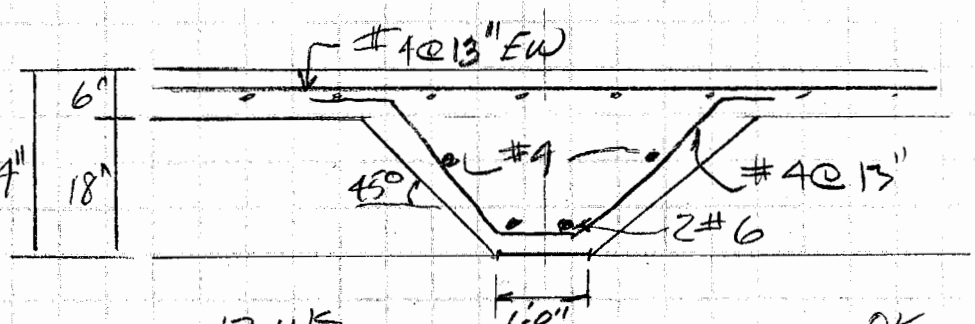
PROJECT NO. E06130
CLIENT/FACILITY WESTON - LOS ALAMOS
SUBJECT 8 UNIT - N60-45 HANGER FDN
PREPARED BY TRB DATE 5/06
CHECKED BY FWS DATE 5/06

IC
MAX INTERIOR
COLUMN





SECTION B

$$P = \frac{17.11^K}{7.43 \times 6.43} = 360 PSF < 2000 \text{ OK}$$

$$W = 7.43(1)(2) + (1.5)(1.5)(7.43) + 6.43(1)(2) + (1.5)(1.5)6.43$$
$$= 14.86 + 9.68 + 12.86 + 14.47$$
$$= 51.87 CF (.15) = 7.78^K > 7.49 \text{ OK}$$

BASED ON SECTION A

USE $A_{s\,MIN} = \frac{3\sqrt{3000}}{60000}(12)(20) = 0.66 \text{ in}^2$

$\frac{200(12)(20}{60,000} = 0.80 \text{ in}^2$ $2\#6 = 0.88 \text{ in}^2$

CHECK FACTOR OF SAFETY AGAINST MAX UPLIFT = 7.49K

DEAD WEIGHT:

SLAB	8 x 8 x 75 psf =	4800 lbs
N-S RIB	8 x (1.5 x 2 + 0.5 x 1.5²) x 150 =	4950 lbs
E-W RIB	(8 - 2.5)(1.5 x 2 + 0.5 x 1.5²) x 150 =	3400 lbs
		13150 lbs

$FS = \frac{13.15}{7.49} = 1.75$ OK

REBAR OK BASED ON SEC A

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436 Creamery Way, Suite 100
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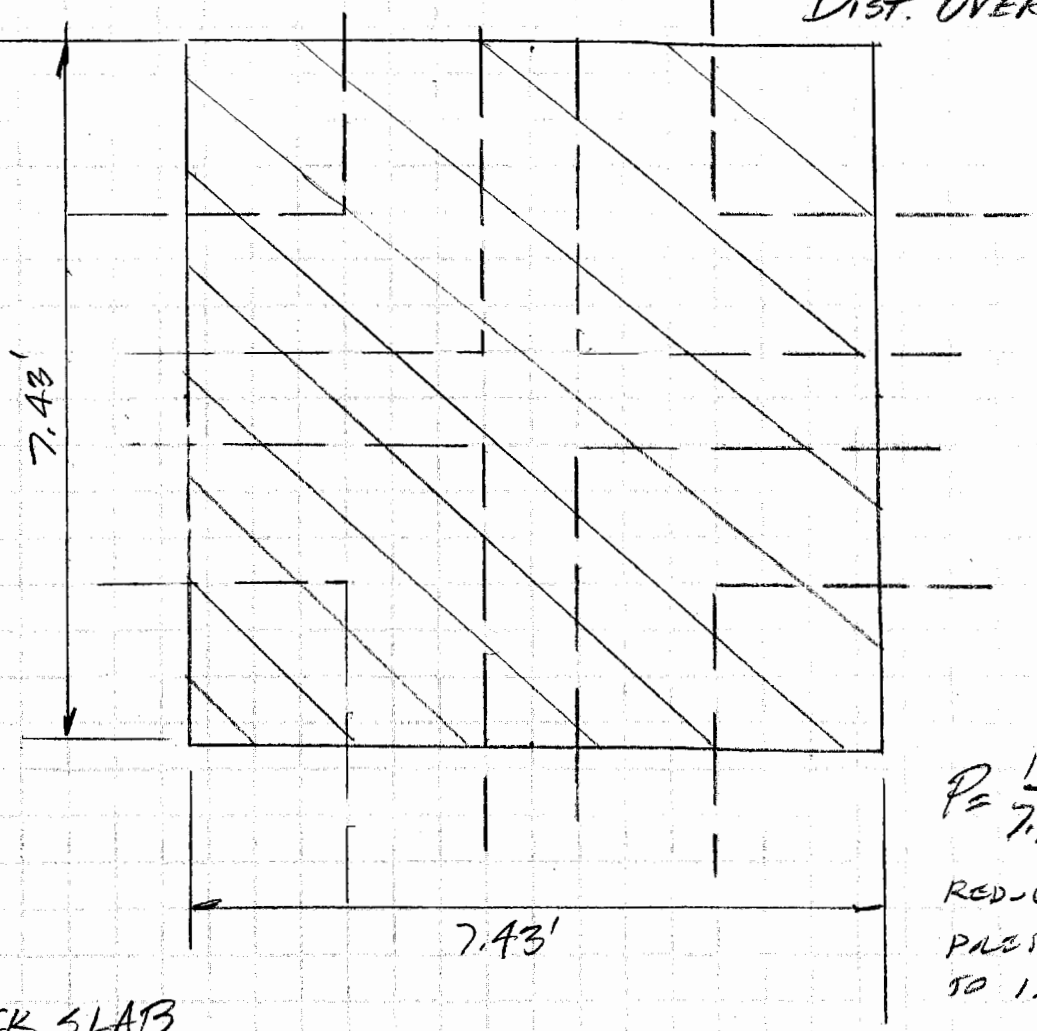
PROJECT NO. E06130
CLIENT/FACILITY WESTON – LOS ALAMOS
SUBJECT 8 UNIT - H60-45 HANGER FDN
PREPARED BY TRB DATE 5/06
CHECKED BY RWS DATE 5/06

INTERIOR COLUMN

ASSUME LOAD DIST. OVER ▨ AREA

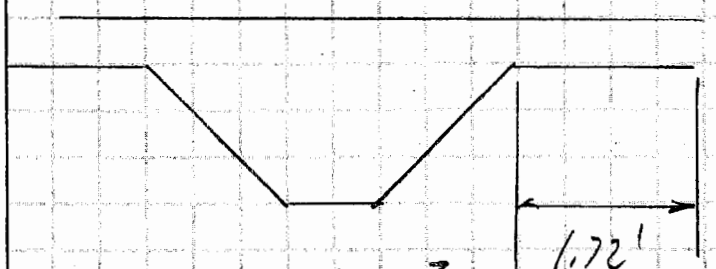


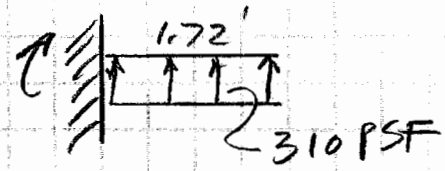
$P = \frac{17.11^K}{7.43^2} = 310 PSF$

REDUCED SOIL PRESSURE DUE TO INTEGRAL SLAB.

$7.43/2 = 3.72$
-2
$1.72'$

CHECK SLAB





$M = \frac{.310(1.72)^2}{2} = .5^{K'}$

$d = 2.75''$ $A_s = 0.18$ $M_u = 1^{K'}$ OK
ACI SP-17 F7.1.1

TCPI
436 Creamery Way, Suite 100
Exton, PA 19341
(610) 524-5920 Fax (610) 524-2443

PROJECT NO. E06130
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SUBJECT 8 UNIT N60-45 HANGER FDN
PREPARED BY TRB DATE 5/06
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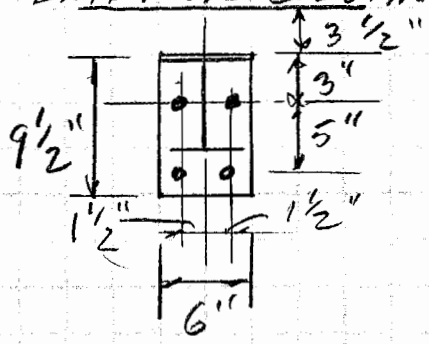
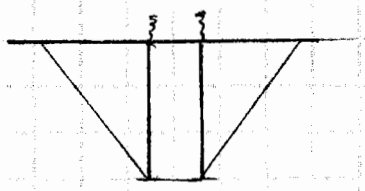
EXTERIOR COLUMN BASE PL



$P_{up} = 5.06^K \quad H_x = 1.00^K \quad H_y = 3.05^K$

ASSUME 2 BOLTS EFFECTIV

$N = 5.06/2 \times 1.7 = 4.3^K$

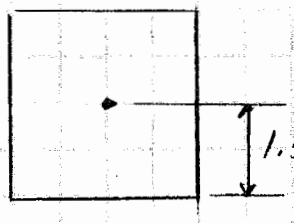


$f = \frac{4300}{\pi (3/8)^2} = 9600 PSI$ OK

.14
.45 IN²

EDGE DISTANCE = 6 1/2"

$A_{NO} = 30 \times 30 = 900 IN^2$



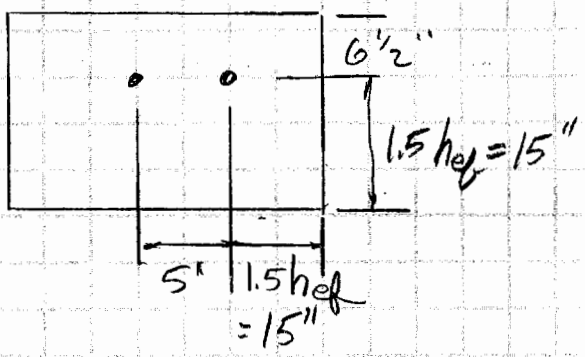
TRY $h_{ef} = 10"$

$1.5(10) = 15"$

$N_b = 24\sqrt{4000}\,(10)^{1.5} = 48^K$

$\psi_2 = 0.7 + .3\,\frac{6.5}{1.5(10)} = 0.83$

$A_N = 35 \times 21.5 = 752.5 IN^2$



$N_{cb} = \frac{752.5}{900}(0.83)\,48 = 33^K$ OK

USE 10"

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PROJECT NO. E06130
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SUBJECT 8 UNIT N60-45 HANGAR PAD
PREPARED BY TRB DATE 5/06
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SLAB THICKNESS

WHEEL LOAD = 5200/2 = 2600# TIRE PRESSUR = 45 PSI

ACI 360

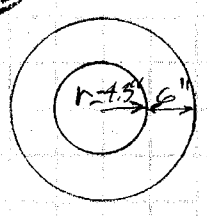
PCA METHOD

CONTACT AREA = $\frac{2600}{45}$ = 58 IN^2 r = 4.3 IN^2

f'_c = 3000 PSI

f_t = 300 PSI

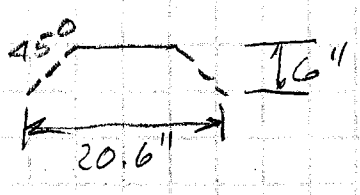
TRY 6" SLAB



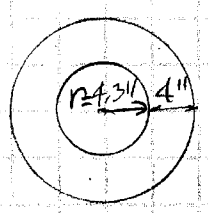
r = 10.3" A = π (10.3)^2 = 333 IN^2 = 2.31 SF

P = $\frac{2600}{2.31}$ = 1.12 KSF < 2.0 KSF

OK

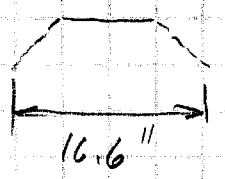


TRY 4" SLAB



r = 8.3 A = π (8.3)^2 = 216.3 IN^2 = 1.50 SF

P = $\frac{2600}{1.50}$ = 1.730 KSF < 2.0 KSF OK



USE 6" SLAB
As = .0018 (6) (12) = 0.13 IN^2
#4 @ 13"

CLIENT/SUBJECT TA-73 LOS ALAMOS AIRPORT LANDFILL CLOSURE W.O. NO 13104.002.001

TASK DESCRIPTION Elastic Settlement Evaluation (100% Design Submittal) TASK NO. 7000

PREPARED BY A. Harpur DEPT 1495 DATE 4/10/06

MATH CHECK BY C. Dorman DEPT 1495 DATE 4/19/06

METHOD REV. BY B. Keshian DEPT 1495 DATE 4/19/06

BACKGROUND

As part of the closure of the Los Alamos Airport Landfill existing waste will be relocated from the east and north slopes and placed on the flat top area of the landfill. The relocated waste will be placed in a controlled manner, i.e., placed in thin lifts and compacted using dozers, rollers, etc. In order to facilitate the expansion of the airport an asphalt and concrete cap will be installed on the flat top area. The asphalt cap will extend over most of the flat top area. The concrete cap will be limited to the footprint of the six proposed airplane hangars. A review of the original settlement calculations by NMED precipitated concerns with settlement due to loading imposed by the concrete foundation slabs, asphalt cap and aircraft. NMED also requested clarification on comments contained in the original calculation pertaining to elastic settlement.

Calculations have been completed to address the potential elastic settlement of the concrete pad, asphalt, aggregate and relocated cover soil/waste due to aircraft loadings. Additional calculations have been completed to evaluate the elastic settlement of the undisturbed waste as a result of placing fill material (relocated cover soil/waste) and hangar loading.

ANALYSIS

At this time the concrete foundation pad design has not been finalized. Preliminary calculations suggest that the majority of the slab will be no more than 6 inches thick. The slab may be thickened at column locations. The anticipated concrete foundation slab and the proposed asphalt cap cross-sections are shown on Figure 1. The properties of the materials shown in Figure 1 are summarized in Table 1.

Table 1
Typical Material Properties

Material	Thickness (feet)	Unit Weight (pcf)	Modulus of Elasticity (psf)	Poisson's Ratio	Internal Friction Angle (°)
Concrete	0.5	150	449,570,675	0.2	50
Asphalt	0.33	140	228,800,000	0.35	40
Aggregate	0.5	130	186,000	0.3	37.4
Relocated waste/soil	0.5 (min)	125	144,000	0.4	34

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Based on current and anticipated airport usage, aircraft that will be stored at the airport will be limited to small single and twin-engine aircraft. For purposes of these analyses the specification of a Piper Aztec twin-engine aircraft will be utilized. The relevant aircraft specifications are summarized in Table 2.

Table 2
Aircraft Specifications

Gross weight	5,200 lbs
Number of front wheels	1
Tire pressure	27 psi
Number of rear wheels	2
Tire pressure	45 psi

The elastic settlement of the capping materials listed in Table 1 was evaluated using the following equation.

$$\Delta H = \frac{\left(\Delta\sigma_z - \nu_s\left(\Delta\sigma_x + \Delta\sigma_y\right)\right)H}{E_s}$$

where:

ΔH = estimated settlement (feet)
$\Delta\sigma_z$ = change in vertical stress (psf)
$\Delta\sigma_x = \Delta\sigma_y$ = change in horizontal stress (psf)
$\Delta\sigma_x = \Delta\sigma_y = K_o * \Delta\sigma_z$
K_o = at-rest earth pressure coefficient = 1-sin ϕ
ϕ = internal friction angle of compressible layer
H = thickness of compressible layer (feet)
υ_s = Poisson's ratio
Es = modulus of elasticity (psf)

The unit weights and thicknesses of the materials listed in Table 1 were used to generate the loads used in the calculations. The weight of the aircraft was conservatively assumed to be distributed between only the two rear tires. The following equations were used to determine the effective circular area circumscribed by the aircraft tires and the stress imposed by the aircraft load at various depths below the ground surface.

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$$a_r = \sqrt{\frac{P}{p \times \Pi}}$$

where:

a_r = radius of contact of the tire (inches)
P = weight per tire (lbs)
p = tire inflation pressure (psi)

$$\sigma_z = q\left[1 - \frac{z^3}{\left(b^2 + z^2\right)^{\left(\frac{3}{2}\right)}}\right]$$

where:

σ_z = stress at depth z below the ground surface (psi)
q = tire inflation pressure (psi)
z = depth below ground surface (inches)
b = a_r = radius of contact of the tire (inches)

For ease of computation, the calculations were input to a spreadsheet. The stress attenuation spreadsheet is presented as Attachment 1. The ground contact stress, which was equal to the tire inflation pressure, was attenuated to the mid-height of each sublayer for the purpose of completing the calculations. Sublayers were developed by dividing the subsurface materials into sublayers of equal thickness. (Introducing sublayers increased the precision of the analyses.) The stress at the mid-height of each sublayer beneath both the concrete and asphalt areas is presented in Attachment 1.

The settlement calculation spreadsheets are presented as Attachments 2 and 3 for the cap cross-sections shown in Figure 1. The analyses were completed assuming various thickness of relocated cover soil/waste for both cross-sections. Based on Drawing 2001, the thickness of relocated waste and interim cover soil could vary between 0.3 and 7.4 feet. The change in deformation with thickness of relocated interim cover soil/waste is shown on Figure 2 for both concrete and asphalt caps.

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In addition to evaluating impacts of aircraft loading on the deformation of the asphalt and concrete cap sections and underlying fill materials, an analysis was completed to assess the magnitude of settlement anticipated under the hangar slabs. The magnitude of settlement was estimated using two procedures; the Gibson and Lo Model and the Power Creep Law due to the load imposed by the hangar slab and structure as well as the fill materials (aggregate and relocated interim cover soil and waste). Both models allow the calculation of elastic (immediate) settlement and secondary compression. Only the Gibson and Lo Model allows the two components of settlement (elastic and secondary compression) to be estimated separately.

Gibson and Lo Model

$$S(t) = H\,\Delta\sigma\left[a + b\left(1 - \exp\left[-(\lambda/b)\,t\right]\right)\right]$$

where:

$S(t)$ = settlement at any time, feet.
H = initial thickness of compressible layer, feet.
$\Delta\sigma$ = change in overburden stress acting on the compressible layer (kPa).
a = elastic settlement parameter, (1/kPa).
b = secondary compression parameter, (1/kPa).
λ/b = rate of secondary compression, (1/day)

Power Creep Law

$$S(t) = H\,\Delta\sigma\,m\left(t/t_r\right)^n$$

where:

$S(t)$ = settlement at any time, feet.
H = initial thickness of compressible layer, feet.
$\Delta\sigma$ = change in overburden stress acting on the compressible layer (kPa).
m = reference compressibility, (1/kPa).
n = rate of compression
t = time, days.
t_r = reference time, 1 day.

The procedures followed to estimate settlement of the site due to the load induced by placing fill and constructing the hangars were based the methodology developed by Edil, et al, see Appendix 1. Edil et al evaluated four landfills and developed settlement parameters for use in the models listed above. The four sites exhibited different characteristics. Site A contained fresh refuse with areas of no filling, limited

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filling and active filling. Site B contained both old refuse with no filling and fresh refuse with active filling. Site C consisted of old refuse that was relocated and compacted. Site D consisted of experimental cells and an area of old refuse on which a surcharge load was placed. Sites A, B and C were located in southeastern Wisconsin, southern Michigan and western Connecticut, respectively. The location of Site D was not disclosed. The location of the sites from which the data were obtained is relevant to the analysis with respect to magnitude of secondary compression. The amount of moisture within a waste mass impacts the rate and degree of degradation and so precipitation at the subject sites, among other factors, would have impacted the magnitude of secondary compression. State precipitation data for the three identified sites as well as for New Mexico are listed in Table 3. As can be seen, precipitation in New Mexico is significantly less than precipitation in any of the other states. Precipitation in Los Alamos is less than half that reported for Site C, which most closely represents site conditions.

Table 3
Annual Rainfall

Site	State	Annual Rainfall (inches)
A	Wisconsin	30.89
B	Michigan	32.23
C	Connecticut	44.39
---	New Mexico	8.91
Los Alamos(1)	New Mexico	18.7

Source: The World Almanac 1988
(1) Data obtained from http://spectre.nmsu.edu/county_docs/LA_Climatology

Based on the descriptions of the sites, Site A, which contained fresh waste was eliminated from consideration. Site B was also eliminated as it contained both old and fresh waste. Site C or D, which both contained old waste were determined to more appropriate as they more closely represented the conditions at the Los Alamos landfill. The Los Alamos landfill operated from about 1943 until 1973, a period of 30 years. From the time it opened until 1965 the waste was burned at the edge of the landfill and then pushed into the landfill by heavy equipment. Intentional burning ceased in 1965 and the landfill was operated as a conventional disposal facility until 1973. The landfill has been inactive for a period of over 30 years. Based on the description of the landfill and considering its age, it is reasonable to assume the properties for either Site C or D for the analysis. Given the age of the landfill, it has likely settled under its self-weight and so could be considered to be in a somewhat compact state.

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Two components of settlement can occur within a soil mass; load induced void ratio reduce settlement (elastic or immediate settlement) and secondary compression which occurs as a result of biological decay of waste. Given the age of the landfill and the climatic conditions, it is reasonable to assume that secondary compression of the waste is essentially complete. The dry climate and the existing soil cap have limited the amount of water available to cause biological decay in the past. There is no evidence of leachate seeping from any location around the landfill nor has leachate been detected in any monitoring wells. The new asphalt and concrete cap will further limit the amount of water that will be available to promote biological decay. Therefore, secondary compression, while estimated, was reasonably assumed to be complete.

To reinforce the assumption with respect to secondary compression, results of CPT borings completed through the landfill indicated the majority of the material encountered classified in Zone 6 or higher. The classification ratings for Zones 1 through 12 are summarized in Table 4.

Table 4
Soil Behavior Type Zone Number Classification

Zone	Description
1	Sensitive fine grained
2	Organic material
3	Clay
4	Silty clay
5	Clayey silt
6	Silty sand
7	Sand with some silt
8	Fine sand
9	Sand
10	Gravelly sand
11	Very stiff fine grained
12	Sand to clayey sand

While the CPT data suggest the materials exhibit predominantly granular signatures, it must be acknowledged that the correlations used to establish the zones are based on soil data and not waste or debris. Nonetheless, it is reasonable to assume that the results of the CPT borings completed through the

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landfill provide a reasonable approximation as to the expected behavior of the materials. Assuming the materials exhibit the properties of granular soils as suggested by CPT results, the premise that elasticity settlement theory is applicable is reasonable and therefore secondary compression is not a significant concern.

The thickness of fill and the thickness of undisturbed waste are presented on Figure 3. Settlement potential of the undisturbed waste based on the two models described above is presented in Attachment 4.

RESULTS

The estimated elastic settlement of the concrete pad, aggregate base and 1/2-foot of relocated interim cover soil due to the load imposed by the aircraft was calculated to be 0.069 inches.

The estimated elastic settlement of the asphalt pavement, aggregate base and 1/2-foot of relocated interim cover soil due to the load imposed by the aircraft was calculated to be 0.084 inches.

The analyses completed for various thicknesses of relocated waste and interim cover soil for both cross-sections indicated that deformation increased as the thickness of relocated waste and interim cover soil increased. This is expected behavior. Under the maximum anticipated thickness of relocated interim cover soil/waste the anticipated settlement is expected to be less than 0.3 inches.

The magnitude of elastic settlement expected in the existing, undisturbed waste was estimated to range between 0.03 to 1.61 inches based on Site C parameters or 0.08 and 4.85 inches based on Site D parameters. The results are summarized in Attachment 5.

The combined magnitude of total elastic settlement (compression of the concrete hangar slabs, fill materials and undisturbed waste) was estimated to range between 0.21 and 5.08 inches. The calculated settlements at the two ends and in the center of each hangar are shown on Figure 4. The figure depicts settlements assuming both Site C and Site D parameters.

The difference in predicted settlement under the concrete slab and asphalt cap, given the same subsurface conditions are negligible.

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CONCLUSIONS

Based on a qualitative review of the available site data, namely CPT logs, precipitation records, and descriptions of site operations, it was concluded that settlement of the site will be primarily due to elastic behavior of the materials. The majority of the anticipated settlement is expected to occur during construction as the relocated waste and interim cover soil materials are placed and soon thereafter. The majority of the settlement will be from the deformation of the undisturbed waste with minimal additional settlement from the deformation of the relocated materials, which will be compacted, the aggregate or the concrete and asphalt. Since most of the settlement will occur during and soon after placement of the relocated materials, minimal long-term settlement is expected after installation of the concrete and asphalt caps. A significant potion of the anticipated settlement is expected to occur within several weeks to a few months after placement of the fill materials.

The analyses assume instantaneous placement of the load (fill materials, aggregate, etc.). However, the load will be placed over a period of weeks or months. Since the full load will not and cannot be placed instantaneously the full magnitude of elastic settlement will not be realized until after placement of all materials. This is not of significant concern expect within the footprint of Hangar 6 where the differential settlement across the slab may be as much as 3.5 inches. This magnitude of differential settlement could negatively impact the integrity of the concrete slab and it is therefore recommended that Hangar 6 be eliminated. The footprint of the proposed Hangar 6 should instead be capped with MatCon™, which is a much more flexible than concrete.

Construction of the hangar slabs, which will like be installed prior to the MatCon™ pavement, should start at the western end of the site and proceed in an easterly direction. This will maximize the time available for the east end of the site, where the waste thickness is greatest, to settle under the load imposed by the relocated fill materials.

Because the intent of the design is to construct the cover system to lines and grades rather than to specific elevations, settlement that occurs during construction will not impact planned activities. The intent is to relocate all excavated waste and place a minimum of 6 inches of interim cover soil over the relocated waste. The site will be graded as excavation progresses to ensure the minimum slope requirement is achieved. Post-construction settlement is anticipated to be minimal and will be addressed as part of O&M activities.

In order to quantify the magnitude of settlement it is recommended that at the start of construction

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settlement plates be installed at select locations in order to monitor the response of the landfill to the placement of fill materials. These settlement plates should be set on or close to the existing ground surface and should be monitored at least weekly during active filling. The ground surface elevation adjacent to the settlement plates should also be recorded as part of the monitoring. The settlement plates may be abandoned prior to the installation of MatCon™ with prior approval of the engineer.

DRAFT

ATTACHMENTS

1. Stress Attenuation – Twin Engine Plane
2. Elastic Settlement of Concrete Hangar Slab
3. Elastic Settlement of Asphalt Cap
4. Elastic Settlement of Undisturbed Waste
5. Total Anticipated Settlement of Hangar Slabs

DRAFT

Attachment 1

STRESS ATTENUATION - TWIN ENGINE PLANE

Equipment Piper Aztec, twin-engine
Unladen weight: lbs
GVW: 5,200 lbs
Tire size:
Tire width: inches
Tire pressure 45 psi rear

Assume load is transferred evenly between 2 rear tires.
No load transferred to front tire.

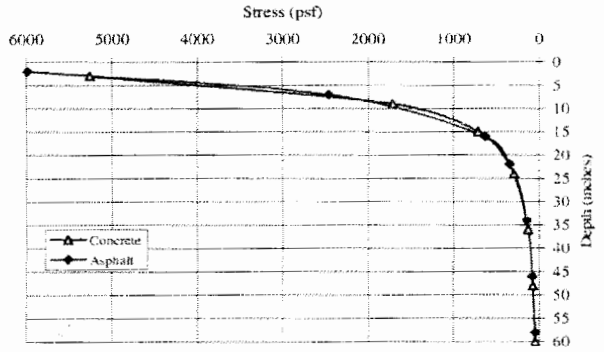
	Unloaded		Loaded	
	Front	Rear	Front	Rear
% of load per axle	70%	30%	0%	100%
Weight/axle (lbs)	0	0	0	5,200
No. of tires/axle	2	2	2	2
Weight/tire (lbs)	0	0	0	2,600
Radius of Contact (in	0.00	0.00	0.00	4.29

$$a_r = \sqrt{\frac{P}{p \times \Pi}}$$

$$\sigma_z = q\left[1 - \frac{z^3}{\left(b^2 + z^2\right)^{\frac{3}{2}}}\right]$$

Soil Thickness (inches)	(feet)		σ_z (psf)
		6" Concrete Pad	
3	0.25	Mid-height of concrete	5259.5
9	0.75	Mid-height of aggregate	1712.6
15	1.25	Mid-height of .5' cover soil	720.4
24	2.00	Mid-height of 2' cover soil	298.4
36	3.00	Mid-height of 4' cover soil	135.5
48	4.00	Mid-height of 6' cover soil	76.8
60	5.00	Mid-height of 8' cover soil	49.3
		4" Asphalt Pavement	
2	0.17	Mid-height of asphalt	5990.7
7	0.58	Mid-height of aggregate	2462.4
16	1.33	Mid-height of cover soil	640.4
22	1.83	Mid-height of 2' cover soil	352.5
34	2.83	Mid-height of 4' cover soil	151.6
46	3.83	Mid-height of 6' cover soil	83.6
58	4.83	Mid-height of 8' cover soil	52.8

STRESS ATTENUATION vs. DEPTH



Attachment 2
Elastic Settlement of Concrete Hangar Slab

ESTIMATION OF SETTLEMENT DUE TO ELASTIC SETTLEMENT OF GRANULAR FOUNDATION SOILS UNDER A NON-CIRCULAR FOUNDATION

$$\Delta H = \frac{\left(\Delta\sigma_z - \nu_s\left(\Delta\sigma_x + \Delta\sigma_y\right)\right)H}{E_s}$$

Case	Layer	Description	Mid-height of stratum	$\Delta\sigma_{z\ applied}$	ν_s	K_o	$\Delta\sigma_x$	$\Delta\sigma_y$	$H_{granular}$	$N_{average}$	ϕ	E_s	ΔH	
			(ft)	(psf)			(psf)	(psf)	(feet)	blows/ft		(psf)	(feet)	(inch)
A	1	Concrete	0.25	5,297.0	0.3	0.23	1239.3	1239.3	0.5	50	50.0	449,570,675	0.00	0.000
														0.000
B	1	Concrete	0.25	5,334.5	0.3	0.23	1248.0	1248.0	0.5	50	50.0	449,570,675	0.00	0.000
	2	Aggregate	0.75	1,820.1	0.3	0.39	715.6	715.6	0.5	25	37.4	186,000	0.00	0.045
														0.045
C	1	Concrete	0.25	5,334.5	0.2	0.23	1248.0	1248.0	0.5	50	50.0	449,570,675	0.00	0.000
	2	Aggregate	0.75	1,852.6	0.3	0.39	728.4	728.4	0.5	25	37.4	186,000	0.00	0.046
	3	Cover Soil (0.5')	1.25	891.3	0.4	0.44	393.2	393.2	0.5	18	34.0	144,000	0.00	0.024
														0.070
D	1	Concrete	0.25	5,334.5	0.2	0.23	1248.0	1248.0	0.5	50	50.0	449,570,675	0.00	0.000
	2	Aggregate	0.75	1,852.6	0.3	0.39	728.4	728.4	0.5	25	37.4	186,000	0.00	0.046
	3	Cover Soil (2')	2.0	563.4	0.4	0.44	248.6	248.6	2	18	34.0	144,000	0.01	0.061
														0.106
E	1	Concrete	0.25	5,334.5	0.2	0.23	1248.0	1248.0	0.5	50	50.0	449,570,675	0.00	0.000
	2	Aggregate	0.75	1,852.6	0.3	0.39	728.4	728.4	0.5	25	37.4	186,000	0.00	0.046
	3	Cover Soil (4')	4.0	528.0	0.4	0.44	232.9	232.9	4	18	34.0	144,000	0.01	0.114
														0.160
F	1	Concrete	0.25	5,334.5	0.2	0.23	1248.0	1248.0	0.5	50	50.0	449,570,675	0.00	0.000
	2	Aggregate	0.75	1,852.6	0.3	0.39	728.4	728.4	0.5	25	37.4	186,000	0.00	0.046
	3	Cover Soil (6')	4.0	591.8	0.4	0.44	261.1	261.1	6	18	34.0	144,000	0.02	0.191
														0.237
G	1	Concrete	0.25	5,334.5	0.2	0.23	1248.0	1248.0	0.5	50	50.0	449,570,675	0.00	0.000
	2	Aggregate	0.75	1,852.6	0.3	0.39	728.4	728.4	0.5	25	37.4	186,000	0.00	0.046
	3	Cover Soil (8')	4.0	689.3	0.4	0.44	304.1	304.1	8	18	34.0	144,000	0.02	0.297
														0.343

$\Delta\sigma_{z\ applied}$ = attenuated load of aircraft, plus weight of concrete, plus weight of aggregate plus weight of relocated soil/waste
- the stress should be attenuated to the mid-height of the layer of interest

$H_{granular}$ = estimated thickness of granular material as a function of footing width

$$\phi = \sqrt{20N} + 15^\circ$$

Elastic Modulus as a funcion of N from Table5-5, p.26 "Foundation Analysis and Design", 4th ed., by J.E. Bowles

$E_s = 57{,}000\ (f'_c)^{1/2}$ - concrete

$E_s = 300*(N+6)/50*1000$ in psf for silty sand - aggregate and cover soil

Erect-A-Tube 8 unit N60-45 hangar

Column		Vdown	
Name	Number	(kips)	
EC	4	4.28	17.12
FIC	4	12.83	51.32
IC	10	17.11	171.1
CC	2	5.76	11.52
SDC	2	13.79	27.58
DDC	4	20.68	82.72
CDC	2	10.68	21.36
FS	6	0	0
		Total	**382.72**

Hangar Dimensions

Width =	61.1	ft
Length =	203.6	ft
Thickness =	0.5	ft
Area =	12,435	ft^2

Misc. Data

Concrete =	150	pcf
Slab weight =	932,660	lbs
Contact Stress =	**106**	psf

Attachment 3
Elastic Settlement of Asphalt Cap

Case	Layer	Description	Mid-height of stratum	$\Delta\sigma_{z\ applied}$	ν_s	K_o	$\Delta\sigma_x$	$\Delta\sigma_y$	$H_{granular}$	$N_{average}$	ϕ	E_s	ΔH	
			(ft)	(psf)			(psf)	(psf)	(feet)	blows/ft		(psf)	(feet)	(inch)
A	1	Asphalt	0.17	6,014.1	0.35	0.36	2148.3	2148.3	0.333	50	40.0	28,800,000	0.00	0.001
														0.001
B	1	Asphalt	0.25	6,037.5	0.35	0.36	2156.7	2156.7	0.333	50	40.0	28,800,000	0.00	0.001
	2	Aggregate	0.58	2,541.5	0.3	0.39	999.2	999.2	0.5	25	37.4	186,000	0.01	0.063
														0.063
C	1	Asphalt	0.25	6,037.5	0.35	0.36	2156.7	2156.7	0.333	50	40.0	28,800,000	0.00	0.001
	2	Aggregate	0.58	2,606.5	0.3	0.39	1024.8	1024.8	0.5	25	37.4	186,000	0.01	0.064
	3	Cover Soil (0.5')	1.08	782.9	0.4	0.44	345.4	345.4	0.5	18	34.0	144,000	0.00	0.021
														0.086
D	1	Asphalt	0.25	6,037.5	0.35	0.36	2156.7	2156.7	0.333	50	40.0	28,800,000	0.00	0.001
	2	Aggregate	0.58	2,606.5	0.3	0.39	1024.8	1024.8	0.5	25	37.4	186,000	0.01	0.064
	3	Cover Soil (2')	1.83	589.1	0.4	0.44	259.9	259.9	2	18	34.0	144,000	0.01	0.064
														0.128
E	1	Asphalt	0.25	6,037.5	0.35	0.36	2156.7	2156.7	0.333	50	40.0	28,800,000	0.00	0.001
	2	Aggregate	0.58	2,606.5	0.3	0.39	1024.8	1024.8	0.5	25	37.4	186,000	0.01	0.064
	3	Cover Soil (4')	4.00	515.7	0.4	0.44	227.5	227.5	4	18	34.0	144,000	0.01	0.111
														0.176
F	1	Asphalt	0.25	6,037.5	0.35	0.36	2156.7	2156.7	0.333	50	40.0	28,800,000	0.00	0.001
	2	Aggregate	0.58	2,606.5	0.3	0.39	1024.8	1024.8	0.5	25	37.4	186,000	0.01	0.064
	3	Cover Soil (6')	4.00	570.2	0.4	0.44	251.6	251.6	6	18	34.0	144,000	0.02	0.184
														0.249
G	1	Asphalt	0.25	6,037.5	0.35	0.36	2156.7	2156.7	0.333	50	40.0	28,800,000	0.00	0.001
	2	Aggregate	0.58	2,606.5	0.3	0.39	1024.8	1024.8	0.5	25	37.4	186,000	0.01	0.064
	3	Cover Soil (8')	4.00	664.4	0.4	0.44	293.1	293.1	8	18	34.0	144,000	0.02	0.287
														0.351

$\Delta\sigma_{z\ applied}$ = load of proposed structure or load on individual footing - the stress should be attenuated to the mid-height of the layer of interest

$H_{granular}$ = estimated thickness of granular material as a function of footing width

$$\phi = \sqrt{20N} + 15^\circ$$

Elastic Modulus as a funcion of N from Table5-5, p.26 "Foundation Analysis and Design", 4th ed., by J.E. Bowles

E_s = 28,800,000 psf - asphalt

E_s = 300*(N+6)/50*1000 in psf for silty sand - aggregate and cover soil

N = blow counts

Attachment 4
Elastic Settlement of Undisturbed Waste

					Gibson and Lo (Site C - Connecticut)					Gibson and Lo (Site D - unknown)					Power Creep Law (Site C)			Power Creep Law (Site D)		
Location	Waste thickness (feet)	Fill thickness (feet)	Δσ (psf)	t (days)	a (1/kPa)	b (1/kPa)	λ (1/day)	ΔH (inches)		a (1/kPa)	b (1/kPa)	λ (1/day)	ΔH (inches)		m (1/kPa)	n (tr = 1 day)	ΔH (inches)	m (1/kPa)	n (tr = 1 day)	ΔH (inches)
Source	Figure	Dwg. 2001		(25 years)				elastic only	plus secondary				elastic only	plus secondary						
Hangar 1																				
North	10	3.5	606	9125	5.90E-05	4.03E-04	1.11E-03	0.21	1.61	1.78E-04	3.00E-03	2.63E-03	0.62	11.07	3.09E-05	0.367	3.04	6.04E-05	0.582	42.28
Center	10	4	668.5	9125	5.90E-05	4.03E-04	1.11E-03	0.23	1.78	1.78E-04	3.00E-03	2.63E-03	0.68	12.21	3.09E-05	0.367	3.36	6.04E-05	0.582	46.64
South	1	4.8	768.5	9125	5.90E-05	4.03E-04	1.11E-03	0.03	0.20	1.78E-04	3.00E-03	2.63E-03	0.08	1.40	3.09E-05	0.367	0.39	6.04E-05	0.582	5.36
Hangar 2																				
North	14	6	918.5	9125	5.90E-05	4.03E-04	1.11E-03	0.44	3.42	1.78E-04	3.00E-03	2.63E-03	1.32	23.48	3.09E-05	0.367	6.46	6.04E-05	0.582	89.72
Center	20	5.5	856	9125	5.90E-05	4.03E-04	1.11E-03	0.58	4.55	1.78E-04	3.00E-03	2.63E-03	1.75	31.26	3.09E-05	0.367	8.59	6.04E-05	0.582	119.45
South	10	2.8	518.5	9125	5.90E-05	4.03E-04	1.11E-03	0.18	1.38	1.78E-04	3.00E-03	2.63E-03	0.53	9.47	3.09E-05	0.367	2.60	6.04E-05	0.582	36.18
Hangar 3																				
North	25	4.1	681	9125	5.90E-05	4.03E-04	1.11E-03	0.58	4.52	1.78E-04	3.00E-03	2.63E-03	1.74	31.09	3.09E-05	0.367	8.55	6.04E-05	0.582	118.79
Center	25	3.6	618.5	9125	5.90E-05	4.03E-04	1.11E-03	0.52	4.11	1.78E-04	3.00E-03	2.63E-03	1.58	28.24	3.09E-05	0.367	7.76	6.04E-05	0.582	107.89
South	25	0.5	231	9125	5.90E-05	4.03E-04	1.11E-03	0.20	1.53	1.78E-04	3.00E-03	2.63E-03	0.59	10.55	3.09E-05	0.367	2.90	6.04E-05	0.582	40.29
Hangar 4																				
North	27	3.8	643.5	9125	5.90E-05	4.03E-04	1.11E-03	0.59	4.62	1.78E-04	3.00E-03	2.63E-03	1.78	31.73	3.09E-05	0.367	8.72	6.04E-05	0.582	121.23
Center	30	3	543.5	9125	5.90E-05	4.03E-04	1.11E-03	0.55	4.33	1.78E-04	3.00E-03	2.63E-03	1.67	29.78	3.09E-05	0.367	8.19	6.04E-05	0.582	113.76
South	30	1.5	356	9125	5.90E-05	4.03E-04	1.11E-03	0.36	2.84	1.78E-04	3.00E-03	2.63E-03	1.09	19.50	3.09E-05	0.367	5.36	6.04E-05	0.582	74.52
Hangar 5																				
North	32	2.8	518.5	9125	5.90E-05	4.03E-04	1.11E-03	0.56	4.41	1.78E-04	3.00E-03	2.63E-03	1.70	30.30	3.09E-05	0.367	8.33	6.04E-05	0.582	115.77
Center	42	3.8	643.5	9125	5.90E-05	4.03E-04	1.11E-03	0.92	7.18	1.78E-04	3.00E-03	2.63E-03	2.77	49.36	3.09E-05	0.367	13.57	6.04E-05	0.582	188.57
South	40	1.8	393.5	9125	5.90E-05	4.03E-04	1.11E-03	0.53	4.18	1.78E-04	3.00E-03	2.63E-03	1.61	28.74	3.09E-05	0.367	7.90	6.04E-05	0.582	109.82
Hangar 6																				
North	42	6.8	1018.5	9125	5.90E-05	4.03E-04	1.11E-03	1.45	11.36	1.78E-04	3.00E-03	2.63E-03	4.38	78.12	3.09E-05	0.367	21.48	6.04E-05	0.582	298.47
Center	53	5.8	893.5	9125	5.90E-05	4.03E-04	1.11E-03	1.61	12.58	1.78E-04	3.00E-03	2.63E-03	4.85	86.48	3.09E-05	0.367	23.77	6.04E-05	0.582	330.41
South	45	1.3	331	9125	5.90E-05	4.03E-04	1.11E-03	0.50	3.96	1.78E-04	3.00E-03	2.63E-03	1.53	27.20	3.09E-05	0.367	7.48	6.04E-05	0.582	103.93

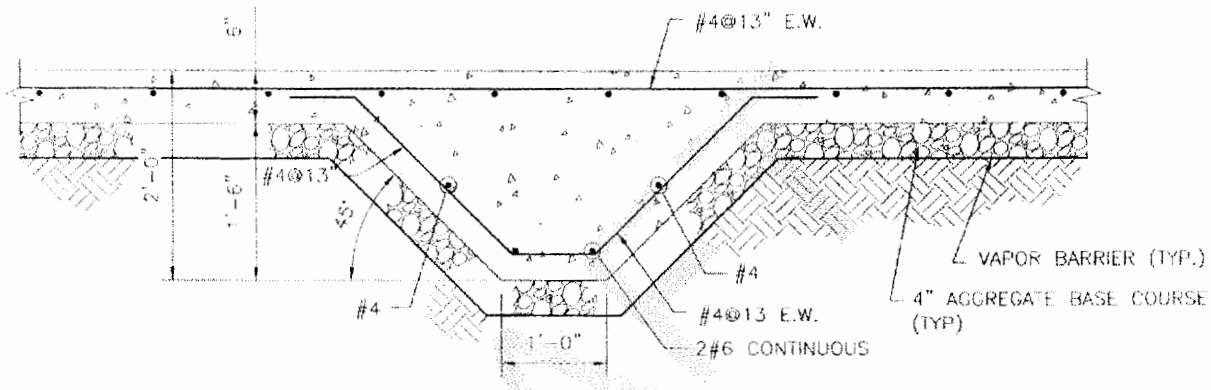
Site C values			Site D values			Site C values		Site D values	
a (1/kPa)	b (1/kPa)	λ (1/day)	a (1/kPa)	b (1/kPa)	λ (1/day)	m	n	m	n
1.00E-04	4.70E-04	9.70E-04	7.50E-05	1.90E-03	4.00E-03	6.48E-05	0.264	4.69E-05	0.593
1.30E-05	3.50E-04	8.40E-04	8.00E-05	4.90E-03	1.90E-03	1.10E-05	0.409	4.85E-05	0.666
1.20E-04	4.30E-04	1.20E-03	3.80E-04	2.20E-03	2.00E-03	5.14E-05	0.304	8.57E-05	0.486
5.20E-05	2.50E-04	1.40E-03				2.75E-05	0.314		
2.00E-05	5.40E-04	8.40E-04				1.40E-05	0.465		
4.90E-05	3.80E-04	1.40E-03				1.67E-05	0.443		
average =	**5.90E-05**	**4.03E-04**	**1.11E-03**	**1.78E-04**	**3.00E-03**	**2.63E-03**	**3.09E-05**	**0.367**	**6.04E-05**	**5.82E-01**

Waste thickness = estimated thickness of waste based on isopach map presented in the VCM Plan
Fill thickness = fill required to achieve subgrade elevation. Values estimated by visual inspection of Drawing 2001
Δσ (psf) = weight of hangar structure and slab (106 psf) plus the weight of aggregate (125 pcf*.5ft) plus the weight of fill based on a unit weight of 125 pcf at varying thicknesses.

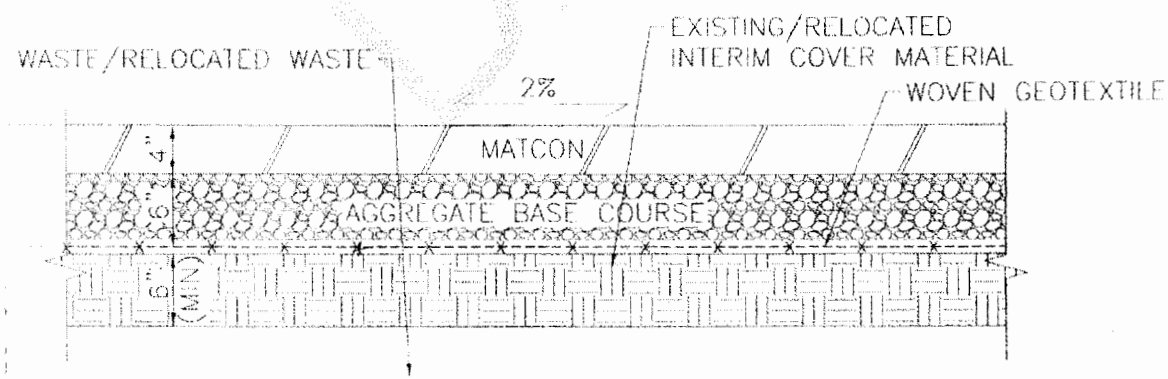
Attachment 5
Total Anticipated Settlement of Hangar Slabs

Location	Waste thickness (feet)	Fill thickness (feet)	Δσ (psf)	ΔH (inches)				
Source	VCM Plan Figure	Dwg. 2001		Concrete hangar & fill	Waste (Site C)	Total (Site C)	Waste (Site D)	Total (Site D)
Hangar 1				(see Fig. 2)				
North	10	3.5	606	0.14	0.21	0.35	0.62	0.76
Center	10	4	668.5	0.16	0.23	0.39	0.68	0.85
South	1	4.8	768.5	0.19	0.03	0.22	0.08	0.27
Hangar 2								
North	14	6	918.5	0.24	0.44	0.68	1.32	1.56
Center	20	5.5	856	0.22	0.58	0.80	1.75	1.97
South	10	2.8	518.5	0.12	0.18	0.30	0.53	0.65
Hangar 3								
North	25	4.1	681	0.16	0.58	0.74	1.74	1.91
Center	25	3.6	618.5	0.15	0.52	0.67	1.58	1.73
South	25	0.5	231	0.07	0.20	0.27	0.59	0.66
Hangar 4								
North	27	3.8	643.5	0.15	0.59	0.74	1.78	1.93
Center	30	3	543.5	0.13	0.55	0.68	1.67	1.80
South	30	1.5	356	0.09	0.36	0.45	1.09	1.19
Hangar 5								
North	32	2.8	518.5	0.12	0.56	0.69	1.70	1.82
Center	42	3.8	643.5	0.15	0.92	1.07	2.77	2.92
South	40	1.8	393.5	0.10	0.53	0.63	1.61	1.71
Hangar 6								
North	42	6.8	1018.5	0.28	1.45	1.73	4.38	4.66
Center	53	5.8	893.5	0.23	1.61	1.84	4.85	5.08
South	45	1.3	331	0.09	0.50	0.59	1.53	1.61

Figure 1
Cross-section of Hangar Slab and Asphalt Cap

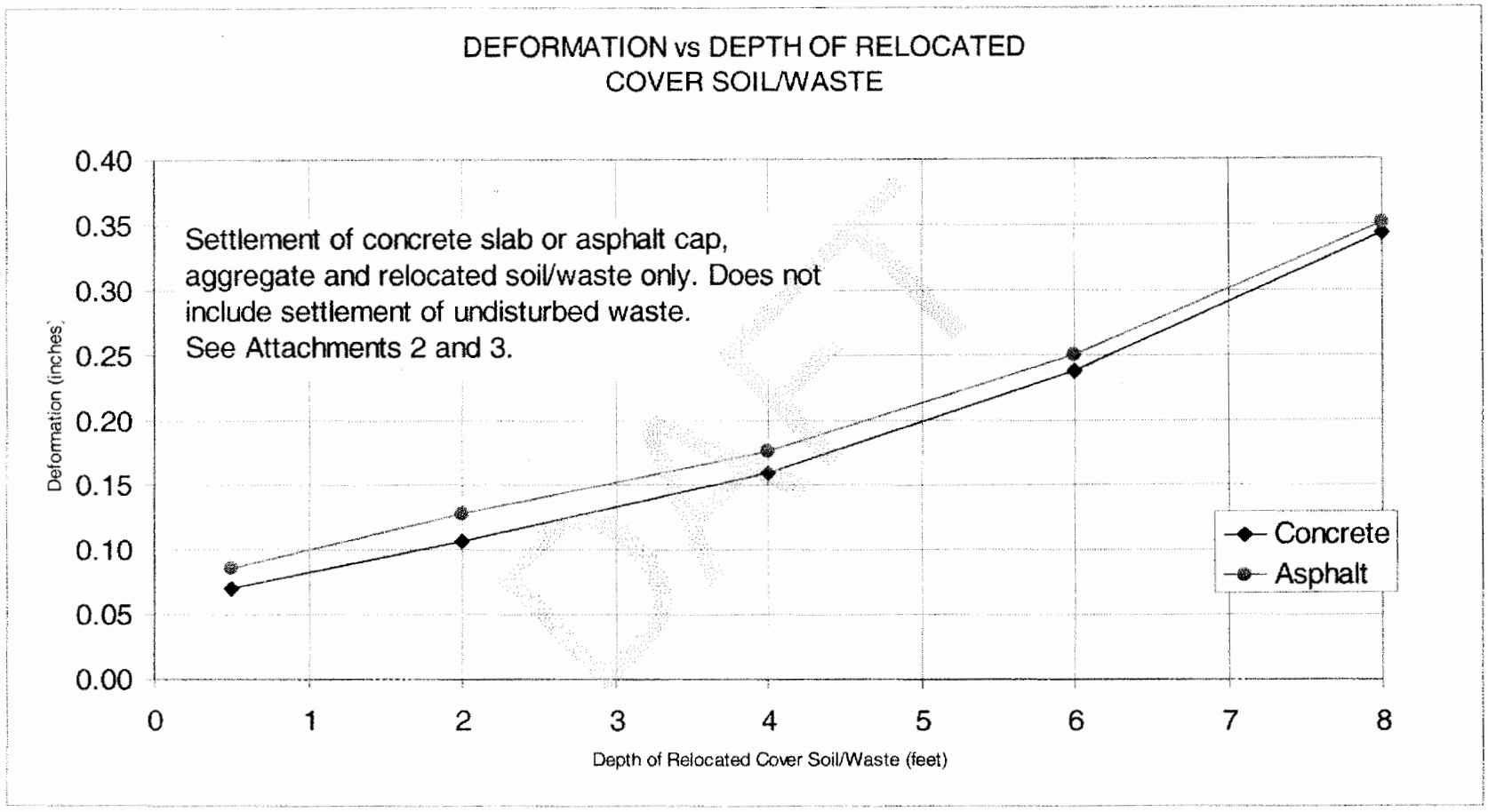


Typical Hangar Slab



Typical MatCon™ Pavement

Figure 2

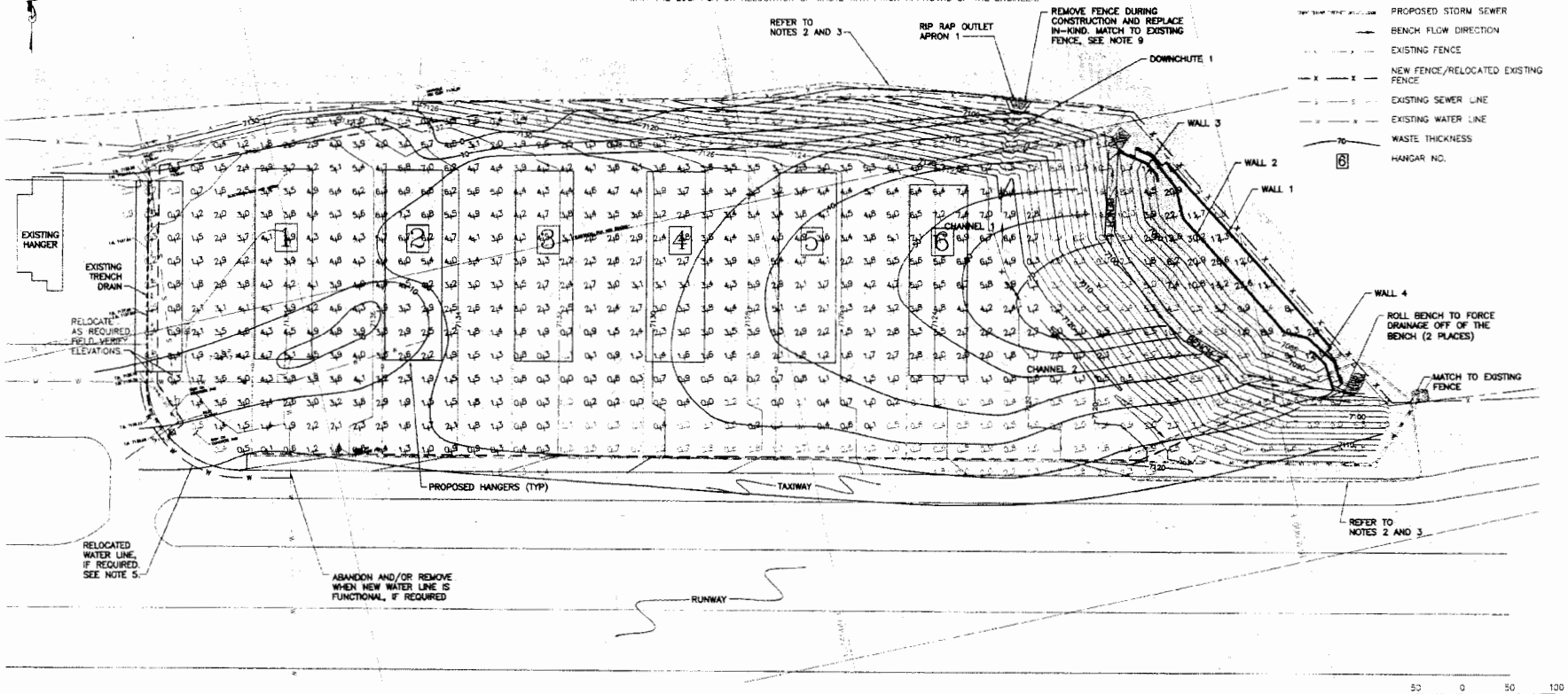

DEFORMATION vs DEPTH OF RELOCATED COVER SOIL/WASTE
Settlement of concrete slab or asphalt cap, aggregate and relocated soil/waste only. Does not include settlement of undisturbed waste. See Attachments 2 and 3.
Deformation (inches)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
1
2
3
4
5
6
7
8
Depth of Relocated Cover Soil/Waste (feet)
Concrete
Asphalt

NOTES:

1. CONTRACTOR ACCESS TO THE PROJECT SITE IS FROM ROUTE NMSR 502.
2. THE NATURAL GRADES OF THE ORIGINAL HANGING VALLEY PRIOR TO BEGINNING OF WASTE DISPOSAL, ARE NOT SHOWN ON THIS DRAWING. THE GRADING PLAN SHOWN FOR THE EAST SLOPE WILL BE REVISED AS NEEDED IF NATIVE GROUND IS ENCOUNTERED DURING EXCAVATION. SLOPES ON WASTE WILL BE CONSTRUCTED AS SHOWN, HOWEVER SLOPES ON NATIVE GROUND, IF ENCOUNTERED, WILL BE ASSESSED BY THE ENGINEER AND MAY BE STEEPER THAN SHOWN. NATIVE ROCK WILL NOT BE EXTENSIVELY EXCAVATED. ALL REVISED GRADES WILL BE REVIEWED BY THE ENGINEER.
3. THE CONTRACTOR SHALL FURNISH AN INTERIM SURVEY OF THE SURFACE OF NATIVE SOIL EXPOSED AS A RESULT OF WASTE EXCAVATION FROM THE EAST SLOPE FOR REVIEW BY THE ENGINEER. THE SURVEY SHALL INCLUDE THE EXPOSED NATIVE SOIL SURFACE, THE EXCAVATED WASTE SURFACE, AND THE UNDISTURBED NATIVE SOIL ACROSS THE EAST SLOPE OF THE LANDFILL.
4. THE CONTRACTOR SHALL NOT ORDER/PURCHASE STORMWATER INLETS 1 TO 13 AND MANHOLE 1 AND ASSOCIATED PIPE UNTIL WASTE HAS BEEN EXCAVATED FROM THE SOUTH EAST CORNER OF THE LANDFILL, AND THE ENGINEER HAS REVIEWED THE TOPOGRAPHIC SURVEY OF THE EXCAVATED SURFACE. THE CONTRACTOR MUST RECEIVE APPROVAL FROM THE ENGINEER PRIOR TO ORDERING/PURCHASING THIS MATERIAL.
5. CONTRACTOR TO FIELD VERIFY PRESENCE/LOCATION EXISTING WATERLINE AND COORDINATE RELOCATION WITH ENGINEER AND AIRPORT MANAGER.
6. TOP PLAN BELOW DEPICTS EXCAVATION OR FILL REQUIRED FROM EXISTING GRADES TO THE ELEVATIONS OF THE BOTTOM OF CAP WHICH IS THE TOP OF THE EXISTING/RELOCATED INTERIM COVER MATERIAL.
7. THE CONTRACTOR SHALL REMOVE ALL WASTE IN THE AREA WEST OF THE LANDFILL CAP BETWEEN THE EDGE OF CAP AND EDGE OF PAVEMENT AND RELOCATE IT WITHIN THE LIMIT OF THE FINAL COVER SYSTEM. ALL WASTE SHALL BE RELOCATED SUCH THAT THE LIMIT OF WASTE SHALL BE OFF-SET INSIDE THE LIMIT OF FINAL COVER SYSTEM A MINIMUM DISTANCE OF 1-FOOT. THIS AREA SHALL BE BACKFILLED WITH EXISTING/RELOCATED INTERIM FILL. THE CONTRACTOR SHALL PROTECT THE EXISTING PAVEMENT, TRENCH DRAIN AND STORM SEWER DURING THIS ACTIVITY.
8. THE CONTRACTOR SHALL ENSURE THAT ALL WASTE LOCATED OUTSIDE OF THE FINAL COVER SYSTEM INCLUDING THE AREA ALONG THE SOUTH SIDE OF THE LANDFILL IS RELOCATED WITHIN THE LIMIT OF THE FINAL COVER SYSTEM. ALL WASTE SHALL BE RELOCATED SUCH THAT THE LIMIT OF WASTE SHALL BE OFF-SET INSIDE THE LIMIT OF FINAL COVER SYSTEM A MINIMUM DISTANCE OF 1-FOOT. ANY EXCAVATIONS BEYOND THE EDGE OF CAP SHALL BE BACKFILLED WITH EXISTING/RELOCATED INTERIM FILL.
9. THE CONTRACTOR SHALL DETERMINE THE EXTENT OF FENCE RELOCATION/REPLACEMENT REQUIRED. WORK SHALL BE COORDINATED WITH THE AIRPORT MANAGER.
10. THE CONTRACTOR SHALL CONTINUOUSLY MONITOR WASTE EXCAVATION AND WASTE PLACEMENT. WASTE PLACEMENT SHALL BE SEQUENCED IN A MANNER THAT WILL ASSURE THE MINIMUM REQUIRED SLOPES INDICATED ON THIS DRAWING ARE ACHIEVED. BECAUSE THE VOLUME OF WASTE TO BE RELOCATED CANNOT BE ACCURATELY QUANTIFIED AND BECAUSE SETTLEMENT IS ANTICIPATED TO OCCUR DURING CONSTRUCTION, THE ELEVATIONS SHOWN ON THIS DRAWING MAY HAVE TO BE ADJUSTED. THE LIMIT OF THE FINAL COVER SYSTEM MAY BE ADJUSTED IN THE FIELD CONSISTENT WITH THE LOCATION OR RELOCATION OF WASTE WITH PRIOR APPROVAL OF THE ENGINEER.
11. FOR STORM SEWER PLAN AND PROFILE, SEE DRAWING 2003.
12. FOR GAS COLLECTION SYSTEM PLAN, SEE DRAWING 2010.
13. FOR HANGER LAYOUT PLAN, SEE DRAWING 2024.

LEGEND

- 0.8 FILL (IN FEET)
- 0.4 CUT (IN FEET)
- PROPERTY BOUNDARY
- LIMIT OF LANDFILL FINAL COVER SYSTEM
- 7130 TOP OF PREPARATORY SURFACE
- 7130 EXISTING GROUND SURFACE
- 7143.60 PROPOSED SPOT ELEVATION
- PROPOSED STORM SEWER
- BENCH FLOW DIRECTION
- EXISTING FENCE
- NEW FENCE/RELOCATED EXISTING FENCE
- EXISTING SEWER LINE
- EXISTING WATER LINE
- 70 WASTE THICKNESS
- 6 HANGAR NO.



50 0 50 100
SCALE: 1"=50'-0"

A	12/08	BK	ISSUED FOR CONSTRUCTION
2	12/08	BK	REVISED PER NMED COMMENTS
1	11/08	BK	FINAL ISSUED TO NMED FOR PERMIT REVIEW
0	10/08	AH	90% ISSUED TO DOE FOR REVIEW

LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

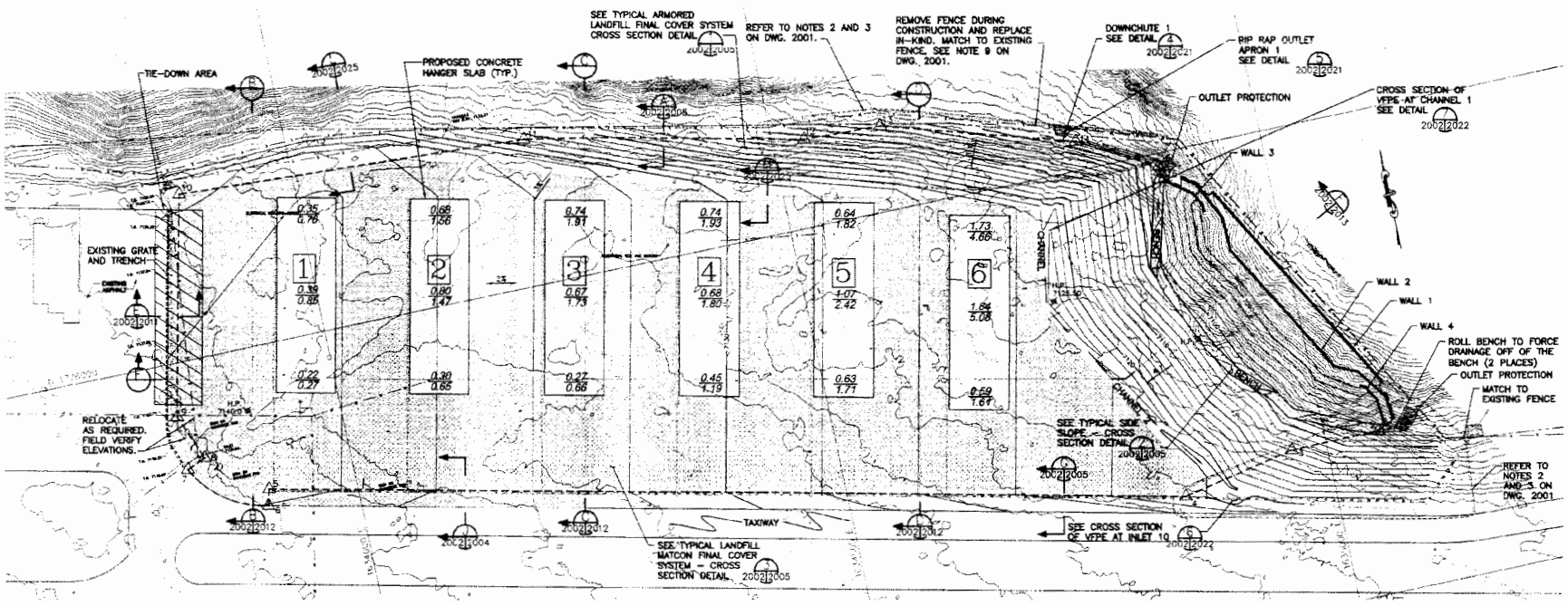
North Wind | WESTON SOLUTIONS TEAM

CHECKED	PWM	6/22/05	
DES. ENG.	SW	6/22/05	
PROJ. ENG.	AH	6/22/05	
PROJ. MGR.	BK	6/22/05	
APPROVED	BK	5/23/05	

CLIENT APPROVALS

FIGURE 3
WASTE AND CUT/FILL THICKNESS

DRAWN GDM DATE 02/06/04 SHEET NO. FIGURE 3 A
SCALE AS SHOWN DWG NO. 131C4.002.001 REV. NO. OF



PLAN

1"=50'

NOTES:

1. FOR STORM SEWER PLAN AND PROFILE, SEE DRAWING 2003.
2. FOR GAS COLLECTION SYSTEM PLAN, SEE DRAWING 2010.
3. FOR HANGER LAYOUT PLAN, SEE DRAWING 2024.
4. THE LIMIT OF THE FINAL COVER SYSTEM MAY BE ADJUSTED IN THE FIELD CONSISTENT WITH THE LOCATION OR RELOCATION OF WASTE WITH PRIOR APPROVAL OF THE ENGINEER.
5. ALL WASTE SHALL BE RELOCATED SUCH THAT THE LIMIT OF WASTE SHALL BE OFF-SET INSIDE THE LIMIT OF THE FINAL COVER SYSTEM A MINIMUM DISTANCE OF 1-FOOT.

TOP OF CAP CONTROL POINTS

NO.	NORTHING	EASTING
1	1775673.657	1635063.617
2	1775669.858	1635056.092
3	1775668.462	1634962.619
4	1775644.003	1634844.563
5	1775850.718	1633907.199
6	1775833.912	1633902.975
7	1775886.577	1633827.472
8	1775896.792	1633847.19[illegible]
9	1775944.609	1633827.924
10	1776170.355	1633878.790
11	1776151.45[illegible]	1634246.793
12	1776095.652	1634933.580
13	1776087.664	1634614.[illegible]25
14	1776030.101	1634806.330
15	1775995.718	1634888.25[illegible]
16	1775973.[illegible]70	1634892.218

LEGEND

- PROPERTY BOUNDARY
- LIMIT OF LANDFILL FINAL COVER SYSTEM
- 7130 TOP OF CAP ELEVATION
- (7130) EXISTING GROUND SURFACE
- 7147.70 PROPOSED SPOT ELEVATION
- △1 CONTROL POINT
- BENCH FLOW DIRECTION
- EXISTING FENCE
- NEW FENCE/RELOCATED EXISTING FENCE
- EXISTING SEWER LINE
- EXISTING WATER LINE
- PAVED AREA
- CONCRETE HANGER PAD
- PROPOSED STORM SEWER PIPE
- 6 HANGAR NO.
- 0.22 SETTLEMENT IN INCHES (SITE C CLASSIFICATION)
- 0.27 SETTLEMENT IN INCHES (SITE D CLASSIFICATION)

50 0 50 100

SCALE: 1"=50'

NO	DATE	APPR	REVISION
A	1/28/05	BK	ISSUED FOR CONSTRUCTION
3	1/28/05	BK	REVISED PER NMED COMMENTS
1	1/28/05	BK	FINAL ISSUED TO NMED FOR PERMIT REVIEW
C	1/5/05	AH	90% ISSUED TO COE FOR REVIEW

LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

North Wind | WESTON SOLUTIONS TEAM

		DATE	CLIENT APPROVAL	DATE
CHECKED	PWM	6/22/05		
DES. ENG.	SW	6/22/05		
PROJ. DR.	AH	6/22/05		
PROJ. MGR.	BK	6/22/05		
APPROVED	BK	6/22/05		
APPROVED				

FIGURE 4
TOTAL ANTICIPATED SETTLEMENT

DRAWN	DATE	DWG. NO.	REV. NO.
GPL	02/06/04	FIGURE 4: A	
SCALE 1"=50'	REQ. NO. 13104.002.001	SHT.	OF

G:\LAC\PROJECT\104.002.001\ENV\FINAL\VICDSF2.DWG

APPENDIX A

Settlement of Municipal Refuse
(Edil, Ranguette and Wuellner)

DRAFT

WESTON SOLUTIONS

Geotechnics of WASTE FILLS

Theory and Practice

Landva/Knowles, editors

ASTM

STP 1070

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CONCLUSIONS

The results of the investigation of the 1988 slope stability failure at the Kettleman Hills Class I hazardous waste repository teach valuable lessons about the safe design and construction of lined waste landfills. These include:

(1) Multi-layer liner systems which have been devised for the safe containment and removal of landfill leachate may contain liner interfaces with low shear strength, including friction angles as low as 8 degrees or less.

(2) Simple direct shear tests can be used to determine reliable values for interface strength properties.

(3) Because of the variability in interface strengths that is associated with different geosynthetic liner system components and compacted clays used in composite double liner systems, values of interface strength should be determined specifically for each project using samples of the actual materials and representative placement, loading, and wetting conditions.

(4) In situations involving low shear strengths such as may occur in liner systems, three-dimensional effects may be important in evaluating stability.

(5) The repository filling operations should be planned in such a way that an adequate factor of safety can be maintained at all times and for all fill heights. This can be done by means of systematic analyses of stability for different fill geometries.

(6) While the concept embodied in (5) is simple in principle, it is presently difficult in detail owing to (1) the lack of a suitable generalized method for doing three-dimensional stability analyses, and (2) uncertainties about the effects of seismic loadings on the response and stability of lined landfills. Both of these issues need further study.

ACKNOWLEDGMENTS

The authors thank Clarence K. Chan, Richard C. Sisson, Makram Jaber, Mu Hsiung Chang, and Peter G. Nicholson of the University of California, Berkeley Geotechnical Group who assisted in the testing.

REFERENCES

[1] Seed, R. B., Mitchell, J. K. and Seed, H. B., "Slope Stability Failure Investigation: Landfill Unit B-19, Phase I-A, Kettleman Hills, California," Geotechnical Engineering Report No. UCB/GT/88-01, University of California, Berkeley, CA, July, 1988, 96 pp.

[2] Martin, J. P., Koerner, R. M. and Whitty, J. E., "Experimental Friction Evaluation of Slippage Between Geomembranes, Geotextiles and Soils," Proceedings International Conference on Geomembranes, Denver, Colorado, Jun 20-23, 1984, pp. 191-196.

Tuncer B. Edil[1], Valeri J. Ranguette[2] and William W. Wuellner[3]

SETTLEMENT OF MUNICIPAL REFUSE

REFERENCE: Edil, T. B., Ranguette, V. J., and Wuellner, W. W., **"Settlement of Municipal Refuse,"** Geotechnics of Waste Fills - Theory and Practice, ASTM STP 1070, Arvid Landva and G. David Knowles, Eds., American Society for Testing and Materials, Philadelphia, 1990.

ABSTRACT: Refuse settlement in sanitary landfills is a complex process, which is dominated by secondary compression. Two mathematical models are used to model refuse settlement at four different sites. A data bank of empirical parameters was obtained and the trends observed.

KEYWORDS: refuse, settlement, settlement model, empirical settlement parameters, compression, rate of compression, landfill

INTRODUCTION

Refuse settlement in sanitary landfills, though frequently a troublesome and unpredictable problem offers at the same time a significant opportunity to the landfill operator for increasing the potential disposal capacity. Although filled to design grades, after closure landfill surfaces rapidly settle below the approved final grades. While this phenomenon is understood, a suitable model to predict this behavior has not been available or generally accepted. Consequently, valuable air space (volume), previously approved by regulatory agencies, may not be fully used. More accurate prediction of this settlement may permit a range of opportunities including better estimates of the remaining life of existing landfills, and improved predictability of surficial refuse movement and its impact on cover integrity, future vertical expansions, and ultimate use of the landfill surface.

The mechanics of compression of refuse are many and complex. Settlement-time curves from sanitary landfills differ from those for typical clay settlement curves; however, they are similar to those from organic soils and peats. This paper outlines an analysis approach using two different mathematical functions for the refuse settlement-time relationship. These relationships, which have previously been used to predict peat and soil settlement incorporate the significant factors controlling refuse settlement.

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[2]Geotechnical Engineer, Warzyn Engineering Inc., Madison, Wisconsin
[3]Group Manager, Construction Services, EWI Engineering Associates, Madison, Wisconsin

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The mathematical models were applied to the settlement data obtained from four different landfills and the parameters characterizing the compression of refuse were calculated. The dependency of the refuse settlement parameters on the stress level and the strain rate was evaluated for a range of conditions such as age of refuse, active filling or post-closure and leachate extraction. The limited data preclude broad generalization of the models for a variety of conditions; however, their versatility and utility as a tool for estimating the settlement of refuse, especially during active filling or post-closure, are demonstrated.

MECHANICS OF REFUSE SETTLEMENT

The mechanics of refuse settlement are many and complex, even more so than for a soil due to the extreme heterogeneity of, and large voids present in, the refuse fill. The main mechanisms involved in refuse settlement are the following:

1. Mechanical (distortion, bending, crushing and reorientation; similar to consolidation of organic soils);
2. Ravelling (movement of fines into large voids);
3. Physical-chemical change (corrosion, oxidation and combustion); and
4. Bio-chemical decomposition (fermentation and decay, both aerobic and anaerobic processes).

The factors affecting the magnitude of settlement are many and are influenced by each other. These factors include: 1) initial refuse density or void ratio; 2) content of the decomposable materials in the refuse; 3) fill height; 4) stress history; 5) leachate level and fluctuations thereof; and 6) environmental factors (such as moisture content, temperature and gases present or generated within the landfill).

It should be noted that refuse settles substantially both under its own self weight as well as under the weight of a new load (for example, the placement of new refuse over existing refuse). A factor complicating the computation of stress changes due to these weights is the introduction of cover soil to refuse fill. The addition of cover soil makes the measurement and interpretation of unit weight values more difficult. As a result, two types of refuse unit weight can be defined: 1) Actual refuse unit weight (weight of refuse per unit volume of refuse); and 2) Effective refuse unit weight (weight of refuse plus cover per unit volume of landfill), [1].

In themselves, actual refuse unit weights are highly erratic. Within a landfill, refuse unit weights typically vary from 5 to 11 kN/cu m. Moisture contents typically range from 10 to 50 percent, on a percent of dry weight basis [1-3].

Settlement of refuse fill is characteristically irregular. Initially, there is a large settlement within one or two months of completing construction, followed by a substantial amount of secondary compression over an extended period of time. The magnitude of settlement decreases over time and with increasing depth below the surface of the fill. Under its own weight, refuse settlement typically ranges from 5 to 30 percent of the original thickness, with most of the settlement occurring in the first year or two.

PREVIOUS REFUSE SETTLEMENT STUDIES

Various methods of analysis and prediction of post-construction refuse fill settlement are reported by several investigators [2-5]. Settlement due to compression of refuse fill under external surface load can be plotted in terms of strain (ratio of settlement to initial fill height) versus the logarithm of effective stress (pressure). Settlement magnitude can be predicted based on the settlement coefficient, the slope of the straight line connecting two selected stresses [2, 4]. The problems with this method include: 1) for older fills, the initial fill height is usually unknown; 2) effective stress is a function of refuse density, which usually cannot be determined accurately; and 3) the strain-log stress relationship is not a straight-line relationship; therefore, the settlement coefficient, which is proportional to settlement magnitude, varies as the stresses (pressures) within the fill change.

Another approach, is to calculate settlement rate as settlement magnitude per unit time interval. Yen and Scanlon [5] collected settlement platform data from several landfill sites and calculated settlement rate as the ratio of change in platform elevation to elapsed time between surveys. Since the settlement platform data for these sites covered periods of up to nine years following the end of construction, they were able to plot settlement rate versus log time and determine the best-fit linear relationship by the least-squares method.

Yen and Scanlon compared their data with Sowers' field observations and noted that the rate of settlement decreases with time logarithmically [5]. Sowers noted the time-dependent secondary compression of refuse and reported values of the coefficient of secondary compression, α (based on Buisman's definition for soils) for some sanitary landfills. Sowers noted that the α values for refuse were comparable to those of peat and organic soils and dependent on how favorable the conditions were for decomposition [2, 3].

PROPOSED REFUSE SETTLEMENT MODELS USED

The conventional approach to soil compression requires a separation of primary and secondary compression and treatment of each with different mathematical expressions. In the long term, secondary compression of refuse is larger than other compression, and it is often difficult to make a distinction between primary and secondary compression. Therefore, a simple model combining all stages of compression is needed. Two such models are investigated in this study.

Gibson and Lo Model

The rheological model proposed by Gibson and Lo [6] for the long-term (secondary) compression of soils was found to be rather useful in predicting the settlement of peats [7]. Peat, like refuse, involves mechanisms of compression different than those in inorganic clays. Both peat and refuse have relatively large void spaces that compress quickly during initial and primary settlement, but by far the largest compression is due to the slow and continuous process of secondary settlement, where the particle structures begins to break down. Encouraged by the simplicity and usefulness of the rheological model proposed by Gibson and Lo we decided to apply the same model to field refuse settlement records.

This rheological model is shown in Fig. 1a, and it represents the average compression characteristics in the one-dimensional compression of the refuse fill shown in Fig. 1b. The applied increment of stress can be either the self-weight of the refuse or it may be imposed on the refuse surface.

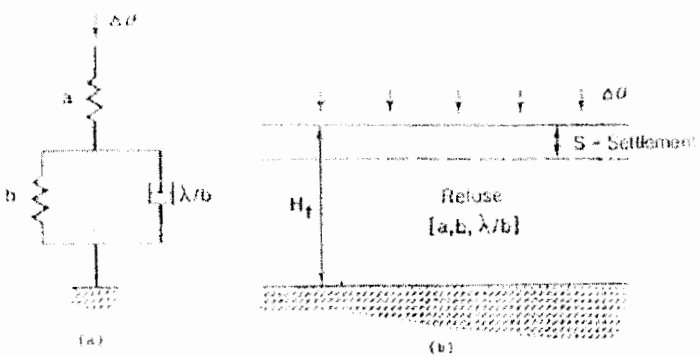

Figure 1 Rheological Model

When a stress increment, $\Delta\sigma$, acts on the model, the Hookean spring, with a spring constant of a, compresses instantaneously. This is analogous to primary compression. The compression of the Kelvin element, with a spring (spring constant of b) parallel to a dashpot (viscosity of λ/b) is retarded by the Newtonian (linear) dashpot. This is similar to the continuous process of secondary compression under sustained effective stress. The sustained load is transferred progressively to the Hookean spring from the Newtonian dashpot. After a long time, (i.e., in the secondary compression range), the full effective stress will be taken by the two springs, thus the dashpot will sustain no load. The time-dependent settlement can be expressed as:

$$S(t) = H\,\epsilon(t) = H\,\Delta\sigma\,\{a + b(1 - \exp[-(\lambda/b)\,t]\} \qquad (1)$$

where
- S = settlement
- H = initial height of refuse
- ϵ = strain (settlement divided by the layer thickness, i.e., S/H)
- $\Delta\sigma$ = compressive stress
- a = primary compressibility parameter
- b = secondary compressibility parameter
- λ/b = rate of secondary compression
- t = time since load application

Power Creep Law

One of the simplest forms of a relation for time-dependent deformation under constant stress and one that has been extensively used in representing the transient creep behavior of many engineering materials is the power creep law. According to this law, the time-dependent settlement can be expressed as:

$$S\,(t) = H\,\epsilon(t) = H\,\Delta\sigma\,m(t/t_r)^n \qquad (2)$$

where
- m = reference compressibility
- n = rate of compression
- t_r = reference time introduced into the equation to make time dimensionless (t_r = 1 day in this study)

Other terms are as defined before.

Determination of Model Parameters

An interactive spread sheet program was developed at the University of Wisconsin-Madison on a personal computer in fitting Eqs 1 and 2 to the settlement-time records from various fills. The program uses the method of the logarithm of strain rate ($\Delta\epsilon/\Delta t$) versus time in determining the parameters, a, b, and λ [7, 8] and the method of the logarithm of strain (ϵ) versus logarithm of time in determining parameters m and n from the settlement-time record.

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Accordingly, the settlement-time record is incrementalized and the operator chooses the range over which these functions give a linear plot. From this portion of the plots, model parameters are calculated. The program provides a plot of the actual strain versus time, along with the calculated strain (from the calculated model parameters) versus time so that the quality of curve-fitting can be visually evaluated.

SITES MODELED

Data from four different existing refuse fills were analyzed. All four of these sites are municipal landfills. It was assumed that the refuse in each of these four sites is about the same composition. The sites are in northern climates, thus there is sufficient rainfall to promote the degradation of the refuse which affects settlement. Table 1 summarizes the known values of refuse thickness, settlement, data collection duration, and refuse placement conditions.

Site A

This refuse site is in southeastern Wisconsin. Placement of the refuse fill at this site began in the early 1970's. The settlement data was collected using settlement platforms surveyed periodically from 1984 to 1986. The age of the refuse fill below each platform varied but was estimated to be between 0 to 4 years at the time the data were obtained. The data collection at this site continued for approximately 1.8 years. For this study two categories of loading conditions were considered. The first category is called "minimal filling". This category represents a condition of settlement under essentially self weight during data collection. The second category is called "active filling", since additional refuse and daily cover were added during data collection. Thus, the second category represents a condition of settlement under both self weight and the placement of additional fill above the platforms [9]. The leachate level was about 7.6 m above the base of the landfill during data collection. Near Platforms 7 and 9, there was occasional leachate extraction.

Site B

This refuse site is in southern Michigan. The refuse fill has been placed in the landfill since 1969. In 1985 an expansion area was constructed on top of the existing fill. The settlement data collection began in 1985, during placement of the additional fill in the expansion area. Again, two differing conditions existed during this 1.2 year study. The first was the old refuse that was already in place below the settlement platform. After the placement of new refuse, settlement was monitored at varying horizontal distances of between 50 to 250 feet from the expansion

TABLE 1 -- REFUSE SETTLEMENT DATA

Platform Number	Refuse Thickness (m)	Settlement (m)	Time Duration (yr)	Placement Condition
SITE A				
1	13.73	0.52	1.6	Fresh Refuse: No filling
2	8.01	0.59	1.6	Fresh Refuse: No filling
3	9.25	1.11	1.6	Fresh Refuse: No filling
4	9.84	1.19	1.8	Fresh Refuse: No filling
15	26.74	0.37	1.5	Fresh Refuse: Minimal filling < 1m
16	25.15	0.43	1.3	Fresh Refuse: Minimal filling < 1m
7	36.28	1.89	1.7	Fresh Refuse: Minimal filling < 1m
9	34.72	1.12	1.5	Fresh Refuse: Minimal filling < 1m
8	36.75	3.20	1.5	Fresh Refuse: Active filling > 6m
10	37.38	2.99	1.7	Fresh Refuse: Active filling < 6m
11	19.66	2.10	1.4	Fresh Refuse: Active filling < 6m
12	27.94	1.94	0.7	Fresh Refuse: Active filling < 6m
13	23.46	0.72	1.1	Fresh Refuse: Active filling > 6m
14	19.86	1.62	1.3	Fresh Refuse: Active filling > 6m
17	22.28	2.74	1.1	Fresh Refuse: Active filling > 5m
SITE B				
S-4	15.24	0.09	1.2	Old Refuse: No filling
S-5	15.24	0.21	1.2	Old Refuse: No filling
S-6	15.24	0.94	1.2	Fresh Refuse: Active filling
SITE C				
84-2	10.06	0.65	4.0	Old Refuse: Relocated/Compacted
84-3	10.06	0.58	4.0	Old Refuse: Relocated/Compacted
84-4	11.58	0.60	4.1	Old Refuse: Relocated/Compacted
84-5	5.49	0.33	4.1	Old Refuse: Relocated/Compacted
84-6	10.06	0.61	3.9	Old Refuse: Relocated/Compacted
84-7	11.58	0.52	3.3	Old Refuse: Relocated/Compacted
SITE D				
SP1	3.05	0.38	0.9	Old Refuse: Surcharge
SP2	3.05	0.64	0.9	Old Refuse: Surcharge
SP3	3.05	0.44	0.9	Old Refuse: Surcharge

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area. The second condition was the active filling of fresh refuse directly above the settlement platform [10].

Site C

This refuse site is in western Connecticut. A 40 to 50 year old "town dump" was excavated and relocated at a new site. This site was monitored for 5 years. The only settlement that occurred was due to the self weight of the compacted refuse [11].

Site D

Site D consisted of (a) experimental cells that were constructed to monitor settlement and (b) an area of old refuse below the settlement platform when an embankment load was added. The duration for this study was 1 year [12].

MODELING

The settlement platforms were placed as shown in Fig. 2. The refuse thickness (H_o) is the initial thickness of the refuse below the settlement plate. Additional refuse was placed above the settlement platform (h). The times of placement of the additional refuse above the platforms were unavailable for the four sites. It was assumed that the additional refuse above the platform was placed at time zero, when the data collection was started. The average applied stress ($\Delta\sigma$) in the layer of refuse below the platform was calculated as follows:

$$\Delta\sigma = \gamma h + 1/2(\gamma H_o) - 1/2(\gamma+\gamma_w-\gamma_{sat})(H_w^2/H_o) \qquad (3)$$

where:

$\Delta\sigma$ = average applied stress
γ = moist unit weight of refuse
γ_{sat} = saturated unit weight of refuse
γ_w = unit weight of leachate (water)
H_o = initial height of refuse below platform
h = height of refuse above platform
H_w = height of leachate above base liner

A moist unit weight of 10.7 kN/m^3 and a saturated unit weight of 14.6 kN/m^3 were used in computing the average applied stress at each of the sites.

The programs that were used to model the Gibson and Lo model and the power creep law plotted predicted strain versus log time, along with the actual strain versus log time for the data that was input. Emphasis was placed on the later portion of the curve in the case of the Gibson and Lo model, where secondary compression occurs, and there is a constant effective stress. In the case of the power creep law, the whole range of the data was considered in

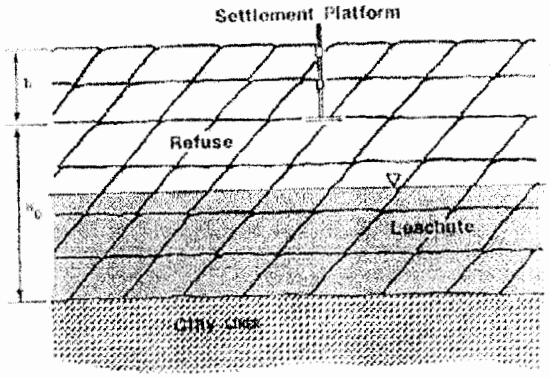

Figure 2 Typical Settlement Platform

curve-fitting. The curve fitting predictions were generally accurate, with a few exceptions of the early data not fitting the computed curve, especially for the Gibson and Lo model. Fig. 3 shows typical curves fitted to the data using the two methods.

A few of the settlement records could not be analyzed with these models. It is believed that these records violated the assumption of constant stress change. Overall, the power creep law gave a better representation of the data in 65% of the cases than the Gibson and Lo model. For the remaining 35% of the cases, it was comparable to the Gibson and Lo model, except only one case.

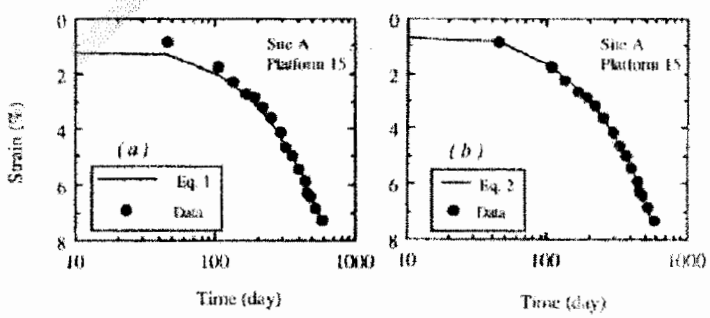

Figure 3 Strain-time curves by a) the rheological model and b) the power creep law fitted to the measured data

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REFUSE COMPRESSION MODEL PARAMETERS

Gibson and Lo Model Parameters

The three empirical parameters of the Gibson and Lo model derived for the four sites are summarized in Table 2 and plotted in Figs. 4, 5 and 6. The curves in these figures are trends not actual relations. Fig. 4 plots a, the primary compressibility as a function of stress. The amount of primary compression decreases with an increase in stress. For the "active" filling in Site A, a higher value was obtained indicating more primary settlement was occurring during placement of the fresh refuse. In Fig. 5 the secondary compressibility, b, is shown to decrease with increasing stress. Generally, the "active" filling sites show lower amounts of secondary settlement than for the "minimal" filling sites. This is due to the fact that the "active" filling cases were still experiencing substantial primary settlement. Undisturbed old refuse from sites B and C has a lower secondary compressibility compared to fresh refuse or old refuse recently surcharged (Sites A and D and Platform S6 from Site B). The rate of secondary compression, λ/b, as a function of average strain rate is illustrated in Fig. 6. Average strain rate is defined as total strain divided by elapsed time during data collection. As expected, as the average strain rate increases, so does the rate of secondary compression. This behavior was also observed for peat soils [7] and indicates that the dashpot is essentially nonlinear in the model. The implification of this is that the parameters obtained from a fill must be extrapolated with care to another fill with different refuse thickness and applied stress even if the composition and location are similar. There was not any observable effect of leachate extraction on the parameters, perhaps because of its limited scope.

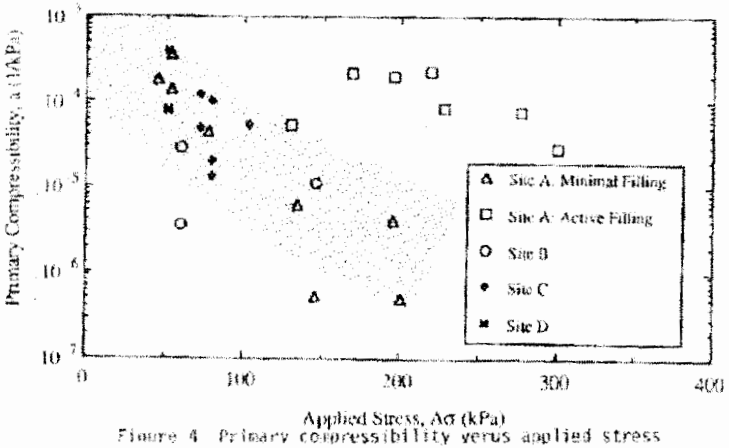

Figure 4 Primary compressibility versus applied stress

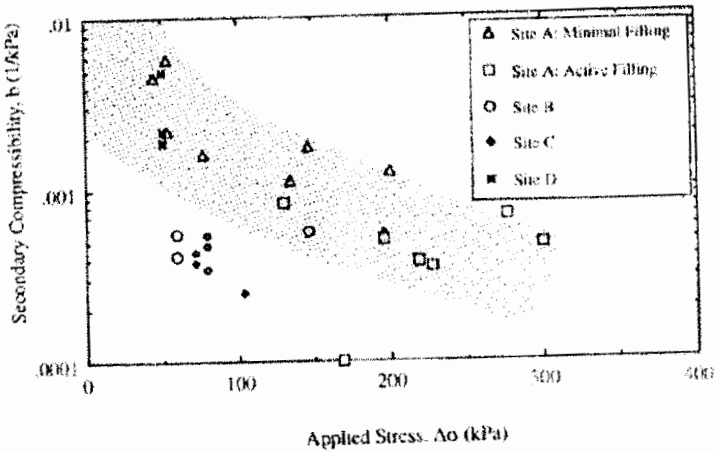

Figure 5 Secondary compressibility versus applied stress

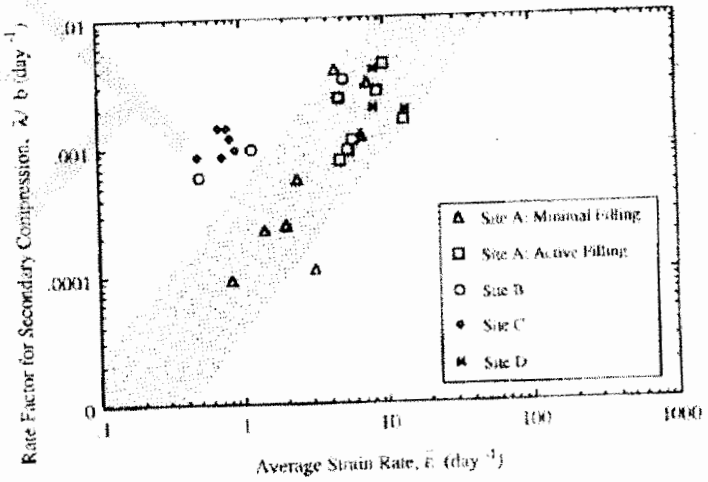

Figure 6 Rate of secondary compression versus average strain rate

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TABLE 2 — [illegible]

Platform Number	Applied Stress (kPa)	Average Waste (kg/m³)	Sites A, 1a: Z (1/kPa)	Sites A, 1a: B (1/kPa)	Sites A, 1a: C/B (1/kPa)	Power Creep: m (1/kPa)	Power Creep: n (t_{50} = 1 day)
SITE A							
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SITE B							
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SITE C							
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SITE D							
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Power Creep Law Parameters

The two empirical parameters of the power creep law derived for the four sites are given in Table 2. These parameters did not indicate any discernible trends with the respect to applied stress or average waste in each site within the range of variation of these factors. Reference compressibility, m has an average value of about 2.5×10^{-3} 1/kPa and it is about 1.7 times higher for old refuse (3.4×10^{-3} 1/kPa) than fresh refuse (2.0×10^{-3} 1/kPa). It shows no discernible patterns with respect to placement conditions of the refuse. However, it is quite variable, especially in Sites A and B. Rate of compression, n has an average of 0.05 and indicates some patterns with respect to age and placement conditions of the refuse. For instance, old relocated refuse from Site C that was compacted during placement had the lowest average n = 0.37 and, in general, fresh refuse had an average n value of nearly 1.5 times as that of old refuse. The variability of n is not as great as that of m; however, it is more variable in Site A than the other three sites.

COMPARISON OF THE MODELS

For Site A, the first year of data obtained was used to predict the amount of settlement that could be expected at the end of the data collection period which was about two years. The results obtained using both models are compared with the actual measurements in Table 3. The Sitana and Lo model predicted the amount of settlement at the end of two years within 2 to 18% of the actual settlement that occurred for wetted filling and 4 to 21% for active filling. The power creep law predictions for the same conditions were 0 to 56 and 3 to 148, respectively.

TABLE 3 — COMPARISON OF PREDICTED SETTLEMENT

Platform Number	Settlement (%): Actual	Settlement (%): Sitana & Lo	Settlement (%): Power Creep	Percent Deviation (%): Sitana & Lo	Percent Deviation (%): Power Creep
Wetted Filling					
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Active Filling					
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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CONCLUSIONS

From the limited data, the following conclusions can be made:

1. Refuse settlement can be modeled satisfactorily with either a rheological model as presented in the Gibson and Lo theory or the power creep law.

2. Power creep law provides a better representation of the settlement data than the rheological model. However, the rheological model has parameters that can be assigned physical meaning and reflect the effects of certain refuse placement conditions.

3. While active filling is ongoing, primary compression is significant compared to secondary compression; and

4. Once filling has stopped, secondary compression is more evident.

Further landfill sites need to be instrumented for data collection and analyzed to develop a data bank of ranges for the empirical parameters for different stages of the landfill life.

ACKNOWLEDGMENTS

The authors would like to thank Waste Management of Wisconsin, Inc. and Debra L. Nelson of Warzyn Engineering Inc., for supplying some of the field data used in preparation of this paper.

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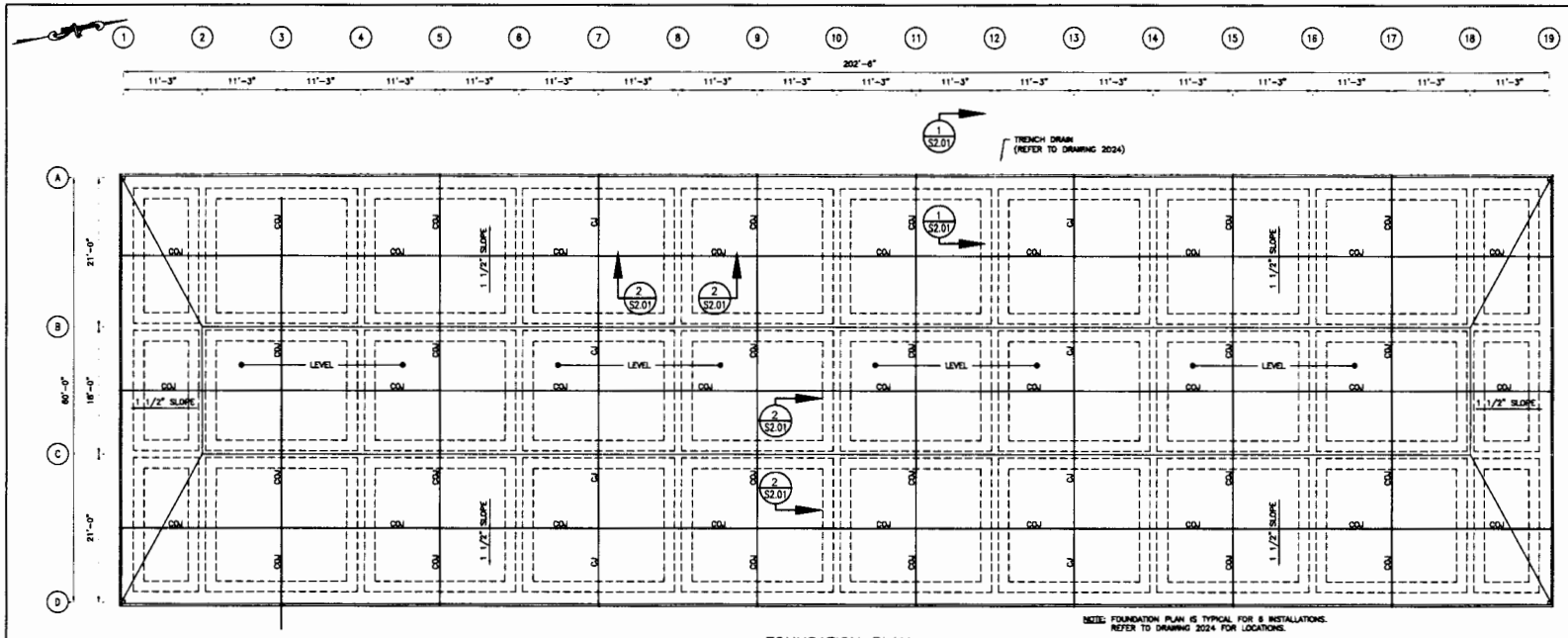


NOTE: FOUNDATION PLAN IS TYPICAL FOR 8 INSTALLATIONS. REFER TO DRAWING 2024 FOR LOCATIONS.

FOUNDATION PLAN

SCALE: 1/8" = 1'-0"

GENERAL NOTES:

1. CONTRACTOR SHALL FIELD VERIFY ALL DIMENSIONS AND ELEVATIONS PRIOR TO COMMENCING WORK. CONTRACTOR SHALL NOTIFY ENGINEER IMMEDIATELY OF ANY DISCREPANCIES.

2. CONTRACTOR SHALL COMPLY WITH ALL FEDERAL, STATE AND LOCAL RULES AND REGULATIONS GOVERNING PERFORMANCE OF WORK.

3. DIMENSIONS ARE BASED UPON PRELIMINARY METAL BUILDING VENDOR PRINTS. CONTRACTOR TO COORDINATE WITH METAL BUILDING VENDOR TO OBTAIN FINAL CERTIFIED VENDOR PRINTS. NOTIFY ENGINEER OF ANY CHANGES FROM DESIGN DRAWING.

CONCRETE

1. ALL CONCRETE WORK SHALL BE IN ACCORDANCE WITH ACI 301 AND 318 LATEST EDITION.

2. ALL CONCRETE SHALL HAVE A MINIMUM COMPRESSIVE STRENGTH OF 4000 PSI AT 28 DAYS.

3. ALL CONCRETE TO CONTAIN 3% ENTRAINED AIR.

4. CONCRETE TO BE PLACED WITH MAXIMUM SLUMP OF 4 INCHES.

5. ALL REINFORCING BARS SHALL MEET THE REQUIREMENTS OF ASTM A-615, GRADE 60. DETAILING SHALL CONFORM TO ACI 315, LATEST EDITION.

6. ALL REINFORCING SPLICES SHALL BE IN ACCORDANCE WITH ACI 318. PLACE BARS AT CONSTRUCTION JOINTS AS DETAILED OR SPECIFICALLY APPROVED BY ENGINEER.

7. ALL EXPOSED CONCRETE PAD SURFACES SHALL BE CURED USING A "NON-RESIDUAL" LIQUID MEMBRANE CURING COMPOUND (L&M CURE MANUFACTURED BY L&M CONSTRUCTION CHEMICALS OR APPROVED EQUAL). AFTER CURING, APPLY CHEMICAL SEALER/HARDENER (SEALHARD MANUFACTURED BY L&M CONSTRUCTION CHEMICALS OR APPROVED EQUAL) TO PAD SURFACE. DO NOT APPLY TO AREAS WHICH RECEIVE COLUMN BASE PLATES.

8. PROVIDE 3/4" INCH CHAMFER ON ALL EXPOSED EDGES.

9. CONTRACTOR SHALL SUBMIT REINFORCING STEEL SHOP DRAWINGS FOR REVIEW AT LEAST 10 WORKING DAYS PRIOR TO FABRICATION.

10. BAR CHAIRS, HIGH CHAIRS, SUPPORT BARS AND ALL OTHER ACCESSORIES SHALL BE PROVIDED IN ACCORDANCE WITH ACI AND CRSI STANDARDS.

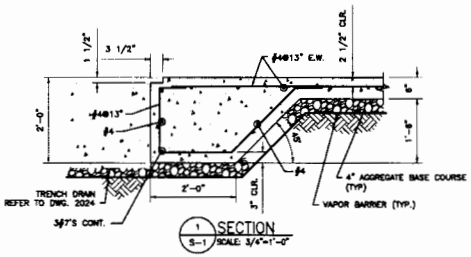
11. ALL CONCRETE SHALL RECEIVE A STEEL TROWEL FINISH.

12. ANCHOR BOLTS SHALL BE IN ACCORDANCE WITH ASTM A-307.

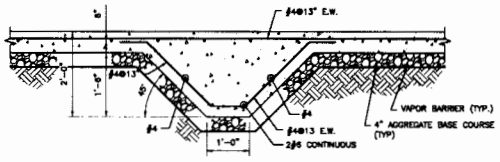
13. NONSHRINK GROUT SHALL HAVE A MINIMUM COMPRESSIVE STRENGTH OF 7000 PSI.

14. AGGREGATE BASE COURSE SHALL CONFORM TO NMDOT SPECIFICATIONS SECTION 304.21 FOR CLASS I BASE COURSE.

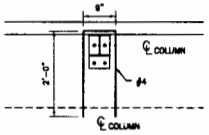
15. VAPOR BARRIER SHALL BE 6 MIL POLYETHYLENE SHEET COVERED WITH 10 OZ. (MIN.) NONWOVEN GEOTEXTILE. EXTEND VAPOR BARRIER 2 FEET (MIN.) BEYOND EDGE OF CONCRETE.



1 SECTION
S-1 SCALE: 3/4"=1'-0"

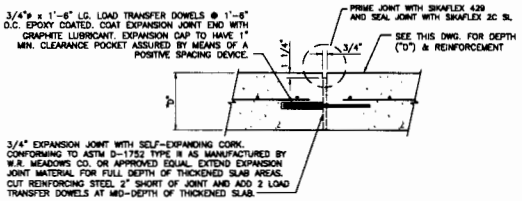


2 SECTION
S-1 SCALE: 3/4"=1'-0"



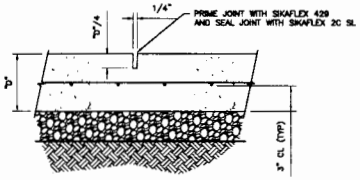
TYPICAL ENLARGED PLAN AT EXTERIOR COLUMN

SCALE: 3/4" = 1'-0"



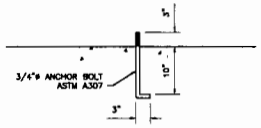
SLAB CONSTRUCTION/EXPANSION JOINT DETAIL (CJ)

SCALE: NONE



SLAB CONTROL JOINT DETAIL (COJ)

SCALE: NONE



NOTE: SEE METAL BUILDING VENDOR DRAWING FOR LOCATIONS.

ANCHOR BOLT DETAIL

SCALE: 1" = 1'-0"

ERECT-A-TUBE 8 UNIT N60-45 HANGAR COLUMN REACTIONS

COLUMN	Vdown	Vup	±Hx	±Hy	DESCRIPTION
B.1, B.19, C.1, C.19	4.28	1.84	2.84	1.00	ENDWALL COLUMNS
B.2, B.18, C.2, C.18	12.63	6.32	4.37	3.05	FIRST INTERIOR COLUMNS
B.4, B.6, B.8, B.10, B.12, B.14, B.16 C.4, C.6, C.8, C.10, C.12, C.14, C.16	17.11	7.49	4.37	3.05	INTERIOR COLUMNS
A.1, D.19	5.76	1.94	1.42	1.52	CORNER COLUMNS
A.3, D.17	13.79	3.48	1.00	3.05	SINGLE DOOR COLUMNS
A.7, A.11, A.15, D.5, D.9, D.13	20.68	5.06	1.00	3.05	DOUBLE DOOR COLUMNS
A.19, D.1	10.68	2.98	1.42	1.52	CORNER/DOOR COLUMNS
FS	N/A	N/A	N/A	3.05	FLOOR SOCKETS

NOTES:

1. THE FOUNDATION HAS BEEN DESIGNED USING THE COLUMN REACTIONS INDICATED. IF THE FINAL COLUMN REACTIONS ARE DIFFERENT, THE ENGINEER SHALL BE NOTIFIED.

2. ALL REACTIONS ARE IN KIPS.

3. Vup, Hx AND Hy ARE DUE TO WIND LOAD.

4. ALL HORIZONTAL REACTIONS CAN ACT IN POSITIVE OR NEGATIVE DIRECTION.

5. ALL COLUMN BASE PLATES ARE DESIGNED FOR FOUR 3/4" DIA. ANCHOR BOLTS, TO COMPLY WITH THE OSHA REGULATIONS OF MARCH 2003 FOR STEEL ERECTION.

NO.	DATE	APPR.	REVISION
A	11/9/06	BK	ISSUED FOR CONSTRUCTION, MODIFIED DWG. 2024, ADDED DWG. 3003

LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

North Wind | WESTON TEAM

		DATE	CLIENT APPROVALS	DATE
CHECKED	FWS	4/19/06		
DSN. ENG.	TB	4/19/06		
PRIM. ENG.	AH	4/19/06		
PRIM. MEC.	BK	4/19/06		
APPROVED	BK	4/19/06		
APPROVED				

BERG KESHAN JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER 11/9/06

HANGAR FOUNDATION

DRAWN A. SPANIER	DATE 4/11/06	DWG. NO. 3003	REV. A
SCALE AS SHOWN	W.O. NO. 13104.002.001	SHT. 1 OF 1	

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