Gordion Excavation Project
2008 Site Field Report

Architectural Conservation
Gordion, Turkey

View of Tumuli past Middle Phrygian remains (Wong, 2007)

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Distribution: F.G. Matero (FGM), K. Sams (KS), B. Rose (BR), N. Miller (NM), S. Stokely (SS), E. Erder (EE)

I. OBJECTIVES & SCHEDULE

Kelly Wong was retained by FGM of the University of Pennsylvania to develop a natural soft capping system for the North and South Court structures of the Citadel Gate complex as a pilot program for summer 2008. Her services were also contracted to update the 5-Year Conservation Treatment Plan published in the 2007 Site Field Report, as well as assist in retrieving data from data loggers buried in the slopes of Terrace Building 2 (TB2). A field visit was made from July 1-12, 2008 to install the new soft capping system at the South Court structure, review current site conditions of existing archaeological remains and assist SS in development of TB2 soft cap pilot program. The following schedule of activities was undertaken during the visit:

7/1/08 Depart Ankara for Gordion.

7/2/08 Walk thru at Citadel Mound with NM to review results of TB2 capping. Discussion of proposed plantings used for the Citadel Gate soft capping Pilot Area #1 (South Court building). Take field measurements of Gate Pilot Area #1 at South Court. Visit MM Tumulus and Museum Botanical Garden with NM to survey various types of local plants. Establish schedule and field tasks for summer 2008.

7/3/08 Prepare 80 mud brick units for low wall at Gate Pilot Area #1. Purchase supplies in Ankara for Gate soft cap pilot area.

7/4/08 Document South Court roof plan. Install silicone sealant at gaps between sections of concrete capping. Remove concrete capping at Pilot Area #1. Remove all six data loggers from TB2 cap and slope. Download data from data loggers.

7/5/08 Install steel pipe shoring at Gate wall adjacent to Pilot Area #1 for additional lateral support. Record slope conditions at South Court roof plan to determine drainage patterns. Level rubble fill at Pilot Area #1. Conduct conditions survey of exposed TB2 masonry walls at all three sections to determine performance of reburial material.

7/6/08 Discard concrete capping pieces in pit located south of South Court, as designated by KS. Transport earth from soil heap located outside of fenced area, as designated by KS, for top layer of soft cap. At TB2, fill Section II area with gravel layer (at a slope) and soil mixture on top. Begin mapping existing architectural features on plan (KS).

7/7/08 Install drain pipe at center of Pilot Area #1 and install waterproofing membrane over Pilot Area #1 and over drain pipe. Install protection mat on each side of drain pipe. Fill Pilot Area #1 with gravel to level above the drain pipe. Embed three data loggers total (one north of the pipe and two south) into gravel bed.

7/8/08 Build low mudbrick wall at east and west sides of Pilot Area #1 to act as water run-off barrier. Plaster mudbrick wall.

Meet with Ahmet Turer (AT), structural engineer and professor from the Civil Engineering Department at Middle East Technical University (METU) with FGM to discuss Gate monitoring and its stabilization plan, as well as rubble fill stabilization. The need for an official contract between the University of Pennsylvania and the Civil Engineering Department of METU for AT's involvement was also communicated.

7/9/08 Install two different types of moisture retention mats, cardboard and white geotextile fabric, over gravel bed (a different one on each side of drain pipe). Install black geotextile fabric over moisture retention layer. Fill top layer with soil previously transported from soil heap south of South Court. Divide Pilot Area #1 into three sections to plant poa sods, seeds and mudballs in each section.

Meet with FGM and SS to review the 2007 Conservation Treatment Plan, discuss tasks to be undertaken in summer 2008 and revisions to the schedule. Specific task areas include stabilization of site escarpments and rubble fill in front Gate, development of the visitor circuit, monitoring and stabilization of the Gate, documentation of the Terrace Building Complex (TBC), as well future projects such as documentation and conservation of the megara buildings, Persian Phrygian (PPB) Building and CC Building (CCB) and the reconstruction of mudbrick walls for site interpretation.

7/10/08 Meeting with BR, KS and FGM to discuss overall site stabilization, conservation and interpretation. Discussion of permit process in Turkey for construction, alternatives for rubble fill stabilization, involvement of archaeologists during escarpment stabilization, designs by Gionata Rizzi for visitor circuit viewing stations and site fence, text and graphics for visitor circuit signs and schedule for installing one prototype viewing station and sign by summer 2009. Review of meeting with AT for monitoring and stabilization of the Gate, stabilization of TBC, future Phrygian mudbrick wall reconstruction project, possibility of a Site Conservation Director to manage and implement proposed goals and aim for a five year exit strategy.

7/11/2008 Discussion with EE on future collaboration of site conservation efforts with Middle East Technical University (METU). Day in Polatli.

7/12/2008 Depart Gordion for Ankara.

II. SITE

A. Five-Year Conservation Treatment Plan

A *Five-Year Conservation Treatment Plan* was produced in 2007 as a guideline for the future conservation at Gordion. The plan provides milestones to measure and ensure progress and defines specific tasks to be undertaken each year for areas in need of conservation and development (including Site, Citadel Gate, Terrace Building Complex, Megara, Phrygian-Persian Building, and CC Building). The Five-Year Conservation Treatment Plan has been revised according to BR, KS and FGM review and comments.

Another goal of the plan is to assist in producing a preliminary budget estimate for the work outlined, including costs for labor and materials each season. In addition to the conservation treatment plan, a construction schedule plan was also produced in the 2007 Site Report. The schedule is meant to be dynamic and should be reassessed after each field season and revised accordingly. Table 1 in Appendix A is an updated *Five-Year Conservation Treatment Plan* with conservation recommendations for 2007 to 2011.

Specific tasks undertaken in summer 2008 for the architectural conservation of the Citadel Mound at Gordion include the following:

- Execution of the Gate Cap Pilot Program;
- Development of the Citadel Gate monitoring and stabilization program with structural engineer AT;
- Evaluation of the TB2 Cap Pilot Program; and
- Review of the *Five-Year Conservation Treatment Plan* with KS, BR and FGM to better define future work and schedule.

B. Observations

During a site walk through with FGM in summer 2008, conservation treatments were further discussed for specific locations, including filling base of escarpments with large undercut conditions (Fig. 1). Site escarpments appear to be in worse condition in summer 2008 than the previous year. Many eroded and undercut portions of the escarpment have failed and discharged large masses of fill into the excavation pit, unveiling unexcavated archaeological remains (Figs. 2-5).

III. CITADEL GATE

A. Gate Monitoring & Stabilization

On July 8, 2008, FGM and KW met with structural engineer AT, a professor from the Civil Engineering Department at METU to discuss monitoring and the future stabilization of the Citadel Gate. AT expressed that prior to any work, an official contract between the University of Pennsylvania and the Civil Engineering Department of METU is required for AT's professional involvement in this project.

1. Gate Monitoring

According to AT, gate monitoring should continue for the duration of at least one year (and recommended up to one and a half years). AT mentioned the use of displacement sensors, laser disto and vibrating wire sensors as possible instruments for measuring displacement at the Gate, as well as the possibility of downloading data remotely using GSM technology. Monitoring will determine if displacement occurs, at what degree and if the existing bulge at the north elevation wall of the South Court continues to grow. For details regarding proposed instrumentation, see email correspondence from AT on Wednesday, July 16, 2008 in Appendix D.

2. Gate Stabilization

Different methods of structural stabilization for the gate was discussed during the meeting, including the use of compression struts between the North and South Court buildings, anchoring into soil beyond the masonry walls and partial reconstruction. Although long-term stabilization of the gate will depend on the results of the gate monitoring, temporary shoring can be undertaken by AT as soon as a geotechnical engineer is retained and a soil analysis has been conducted. A soil analysis will to better inform AT about the conditions of the soil on which the Gate sits and allow him to calculate slope stability. AT recommends temporary stabilization by replacing existing pipe scaffolding as soon as possible with diagonal bracing (Fig. 6). For further details, see email correspondence from AT on Wednesday, July 16, 2008 in Appendix D. AT's initial evaluation in 2007 concluded that the current scaffolding provides no structural support to Citadel Gate structures.[1] In summer 2008, the South Court west return wall (adjacent to the bulge on the north elevation) showed an area of major loss at the top of the wall and the widening vertical gaps at masonry joints (Fig. 7).

Additionally, stabilization of the rubble fill located at the entrance (east) of the Citadel Gate was also discussed (Fig. 8). FGM recommended the use of gabion gravity walls (stepped, caged fill used as retaining walls) as a method to stabilize the rubble fill. See Appendix F for product information.

B. Gate Cap Pilot Program

In the summer of 2008, a pilot program for a new Citadel Gate capping system was explored in order to mitigate water infiltration issues caused by the current system, establish a new and sustainable capping system and create a visually cohesive cap that blended with the landscape at Gordion.

Mitigating water infiltration issues associated with the current capping system is the primary objective of the Pilot Program. The current capping system installed in 1988 consists of sections of poured concrete (over wire mesh used as reinforcement) in the area spanning the rubble fill core (Fig.9). Poor bonding between the concrete and masonry, as well as concrete sections have led to the formation of large gaps, allowing water to penetrate the un-reinforced masonry structures. The Pilot Program introduces a new system of "soft capping" using a natural and sustainable approach to protect the masonry from further deterioration and possible failure (collapse by hydrostatic pressure and soil instability) caused by the presence of water.

[1] Wong, Kelly and Sarah Cleary. 2008. Gordion Excavation Project: 2008 Site Field Report. Unpublished Field Report. University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia.

Additionally, a soft capping system is low maintenance once it is established and creates a more visually cohesive appearance against the backdrop of the Citadel Mound.

A lower section of the South Court capping, along the north wall was selected as "Pilot Area #1" for the new pilot program (Fig. 10). Pilot Area #1 measures approximately 7 feet by 9 feet in area. This area was chosen because of its poor concrete cap condition, showing gaps as wide as 2" between concrete sections and between concrete and adjacent masonry units (Fig. 11). Due to its location near the lower end of the structure, a pipe to drain water running off the existing concrete cap had to be incorporated into the soft cap design for Pilot Area #1.

The soft cap design implemented at Pilot Area #1 (South Court) is similar to that of an extensive green (or living) roof, a multi-layered roofing system consisting of water proofing, drainage, growing media and plants. "Extensive" green roofs are also referred to as "low-profile" because of their low growing, horizontally spreading root ground covers (plant heights 16-24" max. and soil substrate 2 1/2" to 6") and are primarily used as ecological roof covers with limited human access.[2] Advantages include their light weight assembly, shallow soils with depths between 20mm and100 mm, their ability to withstand harsh weather conditions (especially in drought conditions) and they are low maintenance. Because of their lightweight construction, they can also be constructed on slopes up to 30° and steeper ones can be installed with the use of raised grids or laths to keep the plant and soil in place.[3] This should be considered for site escarpment stabilization.

1. Soft Cap Layers

Pilot Area #1 consisted of bituminous water proofing membrane, protection mat, gravel drainage layer, moisture retention mat, filter layer, soil and substrate, and seeds and plants on top (Fig.12). See Appendix E for list of materials used and Appendix F for product literature.

a. Water Proofing Layer

A water proofing membrane is used to protect the structure from any water penetration, whether from annual rainfall or water contained by the soft capping system. The membrane is the most important layer in this system because it safeguards the masonry structure below. Correct and meticulous application of the water proofing membrane is thus critical to the viability of any green roof. Although liquid-applied membranes commonly used for green roofs since they are perceived to provide superior water proofing and are easier to maintain, *Bituline prima PP3* manufactured by Onduline Avrasya A.S., a modified bituminous waterproofing sheet membrane was used for its reversibility (Fig. 13).[4] Due to the irregularity of adjacent masonry walls, installation of the 1.2mm thick membrane was difficult. Masonry units on north wall were removed for membrane installation and later reinstalled at their original location. On the south wall, tucking the membrane under the masonry units was sufficient. Use of a self adhering aluminum flashing tape allowed for the membrane to be cut and formed to masonry contours. The flashing tape also kept the membrane secure and from forming gaps between the masonry

[2] Dusty Gedge and Nigel Dunnet, Gary Grant, Richard Jones. "Living Roofs." Natural England. 2007. (Article provided by: www.naturalengland.org.uk)
[3] The Greenroof Industry Resource Portal Website: www.greenroofs.com. Frequently Asked Questions.
[4] Onduline Groupe Avrasya A.S. Website: www.onduline.com.tr. Sistem Bituline.

and Pilot Area #1. It is important that green roofs are tight, to protect it from strong winds that can cause uplift.

b. Protection Layer

A protection layer or root barrier was installed over the water proofing membrane in order to prevent mechanical damage, as well as prevent plant roots from penetrating and ultimately undermining the integrity of the water proofing layer. *Fondaline*, a dimpled, high density polyethylene sheet also manufactured by Onduline Avrasya A.S. was used as the protection layer for Pilot Area #1 since its three-dimensional shape provides a 0.50mm gap between the water proofing membrane and the layers above (Fig. 14).[5] Moreover, since asphaltic bitumen is organic and roots naturally attempt to penetrate the surface while seeking nutrients, it is critical to provide a durable protection layer.[6]

c. Drainage Layer

The primary purpose of the drainage layer is to carry excess water from the living roof via an appropriate system of discharging run off while eliminating surface flow and minimizing seepage flow in the growth-supporting media. An adequate drainage system in return provides a drained condition for maintaining the overlying growth-supporting media and prevents chronic anaerobic conditions. There are two basic classes of drainage, *geocomposiste drains* and *aggregate drains*. Geocomposiste drains are composed of two or more materials, one of which is a geosynthetic. Several types of granular materials may be considered for aggregate type layers including gravel & fines, lava & pumice, expanded clay & slate, and different recycled materials such as crushed roofing tiles or brick.[7] An aggregate drain layer of approximately 4 inches consisting of gravel was installed at Pilot Area #1 (Fig. 15). Additionally, four weeps (approximately 1/4" dia. plastic tubes) were installed along the western edge and base of the sloped pilot area (Fig. 16). Two low mudbrick walls were constructed at the east and west edges of Pilot Area #1 to prevent water run-off (from the current concrete cap) to erode the soft cap (Figs. 17-19).

d. Moisture Retention Layer

According to the International Green Roof Association, a moisture retention layer and water retaining drainage system will help reduce water run off and probably reduce the required number of outlets (weeps).[8] Moisture retention mats absorb and retain water in order to provide enough water for the growth of the plant media. Two different types of moisture retention mats were installed at Pilot Area #1, corrugated cardboard and white thermal geotextile fabric on opposing sides of the central drain pipe (Fig. 20). The white geotextile fabric was used previously for a wall capping/sand bag project in 1999 and TB2 soft capping in 2006. Although the product name is unknown, large rolls were purchased locally from a nursery near Ankara.

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[5] ibid. Sistem Fondaline.
[6] The Greenroof Industry Resource Portal Website: www.greenroofs.com. Waterproofing.
[7] Alan Wingfield, AIA. "The Filter, Drain, and Water Holding Components of Green Roof Design." In the News. March 2005. (Article from www.greenroofs.com)
[8] International Green Roof Association (IGRA). "Practical considerations when specifying rubble/borwn/biodiverse living roofs: Is brown the new green?" Green Roof News. Spring 2008. (Article provided by: www.greenroofs.com)

e. Filter Layer

To prevent fine soil medium particles from clogging or reducing the drainage capacity of the drainage layer, a filter layer is installed parallel with the drainage layer. Filter layers typically used are geosynthetic fabrics (also known as geotextiles), which are available in woven and non-woven materials. Non-woven geotextiles are typically used as aggregate drains and erosion control, whereas woven geotextiles are preferred for their high strength.[9] A good filter layer should be tough enough to withstand abuse during installation while providing adequate water flow into the drainage layer. A common physical property that is tested on a geosynthetic is the apparent opening size (AOS) which determines the size of the majority of the openings in a particular filter fabric. AOS is important for selecting appropriate filter layers. Extensive green roofs where the soil media depths are less, it is desirable that some plant roots are able to pass through the filter in order to form a matrix on which vegetation can grow. For Pilot Area #1, Typar, a non-woven, porous polypropylene, permeable geotextile fabric known for its durability and resistance to rot and mildew was used (Fig. 21).[10] The product was previously used for the 2006 TB2 soft capping pilot program and available on site. Although Typar is a permeable barrier that separates soil from drainage material and minimizes penetration by weeds and roots by its tight fiber structure, its AOS is large enough to permit selected planted medium (see section below) to attach to the geotextile fabric.[11]

f. Soil and Substrate

Soil used as substrate for thee growing medium at Pilot Area #1 consisted of material transported from a nearby soil heap, as designated by the Site Director KS. The dirt is most likely a mix of soil, sand and most likely some clay, although proportions of the mixture are unknown.

g. Seed and plants

Due to the low bearing capacities of extensive green roofs, low growing plants are typically used. Native plants are the best choice since they tend to grow naturally in this climate, require less water and have fewer problems with pest and diseases. Drought tolerant plants such as mosses, sedums, herbs and grasses are also preferred plant communities for their low maintenance.[12] At Pilot Area #1, three different types of plant medium are were planted including poa sods, annual seed mix and mud balls filled with local grass seeds (Figs. 22 & 23). Poa sods were transplanted from a nearby fill. The annual seed mix collected by archaeobotanist NM and archaeologist Mac Marston consisted of local species such as Poa, *Hordeum muinum*, *Scabiosa* sp., *Androsace maxima*, et al. Mud balls with local *Taeniatherum caput-medusae* 'Medusa-head grass' were created by NM, KW and SS with a mixture of soil, sand and clay (2 parts soil and sand : 1 part clay [volume]). See Appendix H for list of plants collected at Gordion.

2. Data Loggers

Three compact, battery-powered data loggers (HOBO® Micro Station) were installed at Pilot Area #1. Probes of two were placed in the drainage layer (in the gravel), one data logger on each

[9] US Fabrics Website: www.usfabricsinc.com. Geotextile Products Overview.
[10] Typar Landscape Fabric Website: www.typarlandscape.com. Typar Premium Landscape Fabric.
[11] Typar Geotextiles Website: www.typargeotextiles.com. Typar Geotextiles Brochure. page 5.
[12] International Green Roof Association (IGRA). "Green Roof Types: Classification and Characteristics." Spring 2007 (Article provided by: www.greenroofs.com)

side of the central drain pipe to record temperature and relative humidity over the duration of one year (Fig. 24). A third data logger was installed as a control unit; its probes placed in the rubble fill to establish a base line. The Micro Station is a mulit-channel data logger designed specifically to monitor site-specific microclimates. Each data logger is equipped with a microprocessor, data storage and sensors with capacity to record temperature, relative humidity and water content.[13]

Data loggers were launched using a personal computer already installed with the Onset HOBOware Pro (Version 2.5.0) software and placed into Pelican cases to protect each from water. A single hole was drilled on one side of each case to allow probe cables to extend outside the case. Holes were sealed with silicone. Data loggers will require downloading onto a computer (already set up with the Onset HOBOware Pro software) in order to view collected data. The advantage of using data loggers is that they operate independently of a computer during data collection.

Information gathered by data loggers is useful in better understanding the microenvironment of the extensive roof. The goal of the extensive roof system is to establish a sustainable environment for vegetation to grow in the harsh climate of Yassihöyük where temperatures according to 2007 data can fluctuate between -10.5°C and 40.3°C and average rainfall a mere 1.08 mm a year.[14] See Appendix G for local meteorological data. If the extensive roof can maintain a consistent environment year round for vegetation to establish their roots, then the Pilot Program can be determined as successful. The goal is low or ideally no maintenance, allowing local fauna and flora to establish itself.

Once data is collected in 2009, we can assess the outcome of the Pilot Program by a combined methodology of visual assessment and data analysis. Visual analysis includes evaluating whether plants are present, indicating their survival through the cold winter and hot summer months, as well as examining whether plant roots have established on the filter paper. Data analysis includes reviewing the data for high or low temperatures, relative humidity and water content during specific times of the year.

South Court and North Court caps were surveyed prior to construction of Pilot Area #1 to investigate existing drainage patterns (Figs. 25-27).

IV. TERRACE BUILDING COMPLEX

See Terrace Building Field Report (Summer 2008) for details (Figs. 28-30).

[13] Onset Computer Corporation Website: www.onsetcomp.com. HOBO® Micro Station.
[14] Evin Erder. "Meteorological Data for Polatlı for 2006 and 2007" from the Republic of Turkey, Ministry of the Environment and Forests, General Directorate of National Meteorological Works Directorate of Electronic Information, Ankara. Station 17728, Polatli, 2007. Email to Kelly Wong. March 28, 2008.

V. CONCLUSION

Megara structures, the Phrygian-Persian Building (PPB) and the CC Building were not discussed in this report since their documentation and conditions survey have been postponed to next year, summer 2009. Additionally, the CC Building also showed further masonry deterioration and should be documented as soon as possible (Fig. 31).

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Onduline Groupe Avrasya A.S. Website: www.onduline.com.tr
Sistem Bituline
Sistem Fondaline

Onset Computer Corporation Website: www.onsetcomp.com
HOBO® Micro Station

The Greenroof Industry Resource Portal Website: www.greenroofs.com

Typar Geotextiles Website: www.typargeotextiles.com
Typar Geotextiles Brochure (page 5)

Typar Landscape Fabric Website: www.typarlandscape.com
Typar Premium Landscape Fabric

US Fabrics Website: www.usfabricsinc.com
Geotextile Products Overview

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Appendix A. Conservation Master Plan 2008

Table 1. 5-Year Conservation Treatment Plan MATRIX

Gordion Excavation Project - Architectural Conservation

			2007	2008	2009	2010	2011
Location	**Area**	**Task Item**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
SITE	**Escarpments**	Stabilization	Review conditions of escarpments		Stabilize Phase 1 and Phase 2 areas	Stabilize Phase 3 areas	Stabilize Phase 4 areas
			Develop a "Schedule Plan" to define areas of work to be undertaken in next 4 years: Phase 1-4 (Upenn)	Determine amount of work that can be undertaken in one season, chart progress of work in season, revise "Schedule Plan" if necessary	Chart progress of work undertaken during season and revise "Schedule Plan" if necessary	Chart progress of work undertaken during season and revise "Schedule Plan" if necessary	Chart progress of work undertaken during season and revise "Schedule Plan" if necessary
			Discussion of appropriate treatment methods for stabilization with Director, archaeologists, etc.	Define quantities of treatments	Assess treatment methods	Assess treatment methods	Assess treatment methods
			Retain geotechnical engineer to design retaining walls (METU)	Design retaining walls w/options; Include cost estimate; Submit for approval	Construction of retaining walls	Monitor retaining walls	Monitor retaining walls
	Visitor Circuit	Fence	Indicate critical areas of fence in need of immediate stabilization	----	----	----	----
			Research fences used at other sites (with local materials)	Develop design for new fence (incl. viewing platforms) with cost estimate and submit for approval	Submit design proposal for approval and cost estimate	Remove existing fence and install new fence	Evaluate new fence
			Retain designer for new fence				
		Shelters & Lookouts	Research shelters/lookouts used at other sites	Determine locations for shelters/lookouts; Establish visitor path around site; Retain designer for shelters/lookouts	Submit design proposal to B. Rose and K. Sams; Develop cost estimate; Obtain approval and Apply for funding	Begin construction of shelters/lookouts	Continue construction of shelters/lookouts; Evaluate new shelters/lookouts
				Retain designer for shelters/lookouts (Upenn, Prof. L. Falck)			
		Brochures & Guidebooks	Determine locations where brochures and guidebooks will be presented at site	Establish logistics for presenting materials (i.e. Museum, site, etc)	Presentation of materials	Evaluate location(s) of materials, re-establish location(s) if necessary	Evaluate location(s) of materials, re-establish location(s) if necessary
			Design brochure (by end of 2007)	Design guidebook (Gareth)	Publish guidebook and review/revise brochure	Review and revise materials; Evaluate effectiveness of	Review and revise materials; Evaluate effectiveness of
		Website	To be completed this year.				

			2007	2008	2009	2010	2011
Location	**Area**	**Task Item**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
SITE		Presentation & Interpretative Signs	Review signs	Discussion of findings with Brian Rose & Ken Sams	Design of signs - including locations	Submit for approval	Installation of new interpretive signs
			Establish goals and needs of site	Establish program of signs at site	----	----	----
				Include relation of signs from Museum to Citadel Mound	Integrate with Site Interpretation plan	----	----
GATE	**North and South Courts**	Structural Stabilization	Structual analysis by engineer	Retain engineer to test soil & masonry	Develop appropriate stabilization methods	----	----
			Establish monitoring system and evaluate cost	Implement monitoring system to retrieve data for 1 year minimum	If no movement is found, continue monitoring	Continue monitoring	Continue monitoring
					If movement is found, develop structural stabilization program; retain structural engineer, submit for approval	Implement stabilization program and continue monitoring	Continue monitoring
		Documentation		Coordinate laser scanning documentation effort & equipment	Documentation of North and South Court structures by laser scanner	Field verification of documentation	
		Scaffolding / Shoring	Structual analysis by engineer	Establish if scaffolding remains or should be reinforced or removed	Implement shoring plan	Evaluate performance of shoring design	----
		Rubble Fill Stabilization	Structual analysis by engineer	Design proposal for stabilization by geotechnical engineer; Submit for approval; Temporary stabilization	Coordination of design with site interpretation plan; Implement stabilization design for rubble	Evaluation of stabilization design	Evaluation of stabilization design
		Capping	Evaluation of current concrete capping by structural engineer	Design new capping system; Implement capping system at Pilot Area	Implementatin of new capping system	Continue maintenance and evaluation of new capping system	Continue maintenance and evaluation of new capping system
			Establish monitoring system for current capping	Implementation of capping monitoring system	Evaluation of capping monitoring system	Evaluation of capping monitoring system	Evaluation of capping monitoring system
TB	**TB2**	Data Loggers	Review Year 1 (2006)	Review Year 2 (2007); Collect seeds and create mud balls	Collect seeds and create mud balls	----	----
			Evaluate one year performance of cappings and slopes in 2006; Plant mudballs at Section 2	Evaluate two year peformance of cappings and slopes in 2006; Plant mudballs at Section 2 slopes	Establish vegetation plan for all capping and slopes; Implement capping and slope system	Plant mudballs at all cappings and slopes	Evaluate progress of mudballs and slopes
			Soil, sand, and water analysis at UPenn	Document, survey, and rebury TB2 sections	Document, survey, and rebury TB3, 5, 6, 7,8	Evaluate reburial	Continue monitoring reburial
	TB8			Document TB8; discuss stabiliation plan alternatives	Open TB8, survey conditions and begin implementation of stabilization plan	Complete stabilization plan	Evaluate stabilization program

			2007	2008	2009	2010	2011
Location	**Area**	**Task Item**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
MEGARA	**General**	Documentation & Conservation	----	----	Document and survey existing conditions of all Megara; Establish stabilization plan	Implement stabilization program	Implement stabilization plan
PPB	**General**	Documentation & Conservation	----	----	Document and survey existing conditions of all PPB; Establish stabilization plan	Implement stabilization program	Implement stabilization plan
CC BLDG	**General**	Documentation & Conservation	----	----	Document and survey existing conditions of all CC Bldg; Establish stabilization plan	Implement stabilization program	Implement stabilization plan

Appendix B. Site Plan & Escarpment Drawings

The following drawings include data ascertained during the site survey in summers 2006, 2007 and 2008 (with Kenneth Sams, Brian Rose and Frank G. Matero). Details for their proposed stabilization are included, as well as an updated schedule plan for work is to be undertaken. For 2006 site plan proposed by Gionata Rizzi, refer to Summer 2007 Site Field Report.

Drawing List

- Cover Page
- 2008 Site Plan
- 2008 Site Plan Detail
- 2008 Schedule Plan
- Site Escarpment Treatment Details

GORDION EXCAVATION PROJECT

ARCHITECTURAL CONSERVATION SITE STABILIZATION PROJECT

GORDION, TURKEY

SUMMER 2008 PROPOSAL PACKAGE

PROJECT TEAM

CLIENT
BRIAN ROSE, KENNETH SAMS, FRANK G. MATERO
GORDION EXCAVATION PROJECT
011-90-312-638-2219

PREPARED BY
KELLY H. WONG
001-415-554-1403

PROJECT DATA

LOCATION: GORDION EXCAVATION PROJECT
GORDION, TURKEY

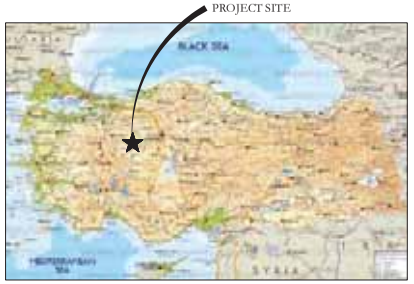
INDEX OF DRAWINGS

T0.0 COVER SHEET

ARCHITECTURAL

A1.0 2008 SITE PLAN
A2.0 2008 SITE PLAN DETAIL
A3.0 2008 SCHEDULE PLAN
A4.0 SITE ESCARPMENT TREATMENT DETAILS

PROJECT LOCATION



VICINITY MAP

UNIVERSITY OF PENNSYLVANIA
Graduate Program in Historic Preservation
Philadelphia, PA 19104

NO.	DESCRIPTION	DATE
	REVISIONS	

GORDION EXCAVATION PROJECT
ARCHITECTURAL CONSERVATION SITE STABILIZATION PROJECT

GORDION, TURKEY

SHEET TITLE
COVER SHEET

ISSUANCE
2008 FIELD SEASON

DATE
DECEMBER 18, 2008

PROJ. NO.	NA
DRAWN	KHW
CHECKED	NA

DRAWING NO.
T0.0
1 OF 5

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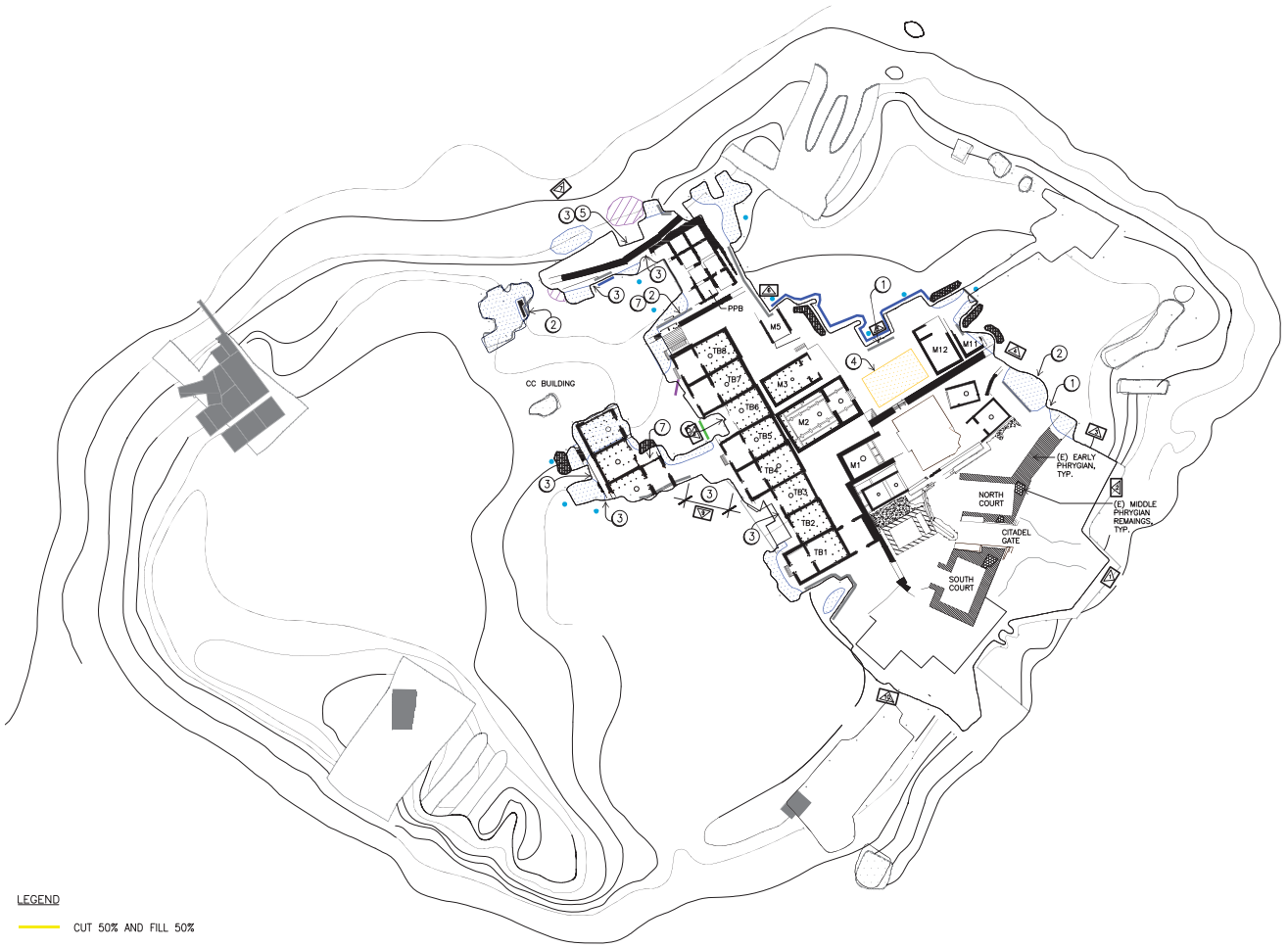
24"x36" OR 22"x34" SHEET SIZE. IF SHEET SIZE IS SMALLER, THEN DRAWING HAS BEEN REDUCED.



2007 NOTES:

1. CRITICAL AREAS TO BE STABILIZED IMMEDIATELY.
2. STEEP SLOPE.
3. LEAVE AREA AS IS AND ALLOW SLOPE TO NATURALLY DETERIORATE.
4. BACKFILL ARCHAEOLOGICAL REMAINS.
5. STRATIGRAPHY VISIBLE.
6. SHAVE TO CONTOUR OF SLOPE BELOW.
7. ALLOW ENOUGH SPACE FOR A WALKWAY.

LEGEND

- CUT 50% AND FILL 50%
- FILL 100%
- CUT 100%
- FILL
- REMOVE
- PULL FENCE BACK
- FLATTEN AREA TO MOUND LEVEL
- RETAINING WALL

1 2008 SITE PLAN
SCALE: NTS

N

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Philadelphia, PA 19104

NO.	DESCRIPTION	DATE
REVISIONS		

GORDION EXCAVATION PROJECT

ARCHITECTURAL CONSERVATION SITE STABILIZATION PROJECT

GORDION, TURKEY

SHEET TITLE

2008 SITE PLAN

ISSUANCE
2008 FIELD SEASON

DATE
DECEMBER 18, 2008

PROJ. NO.	NA
DRAWN	KHW
CHECKED	NA

DRAWING NO.
A1.0

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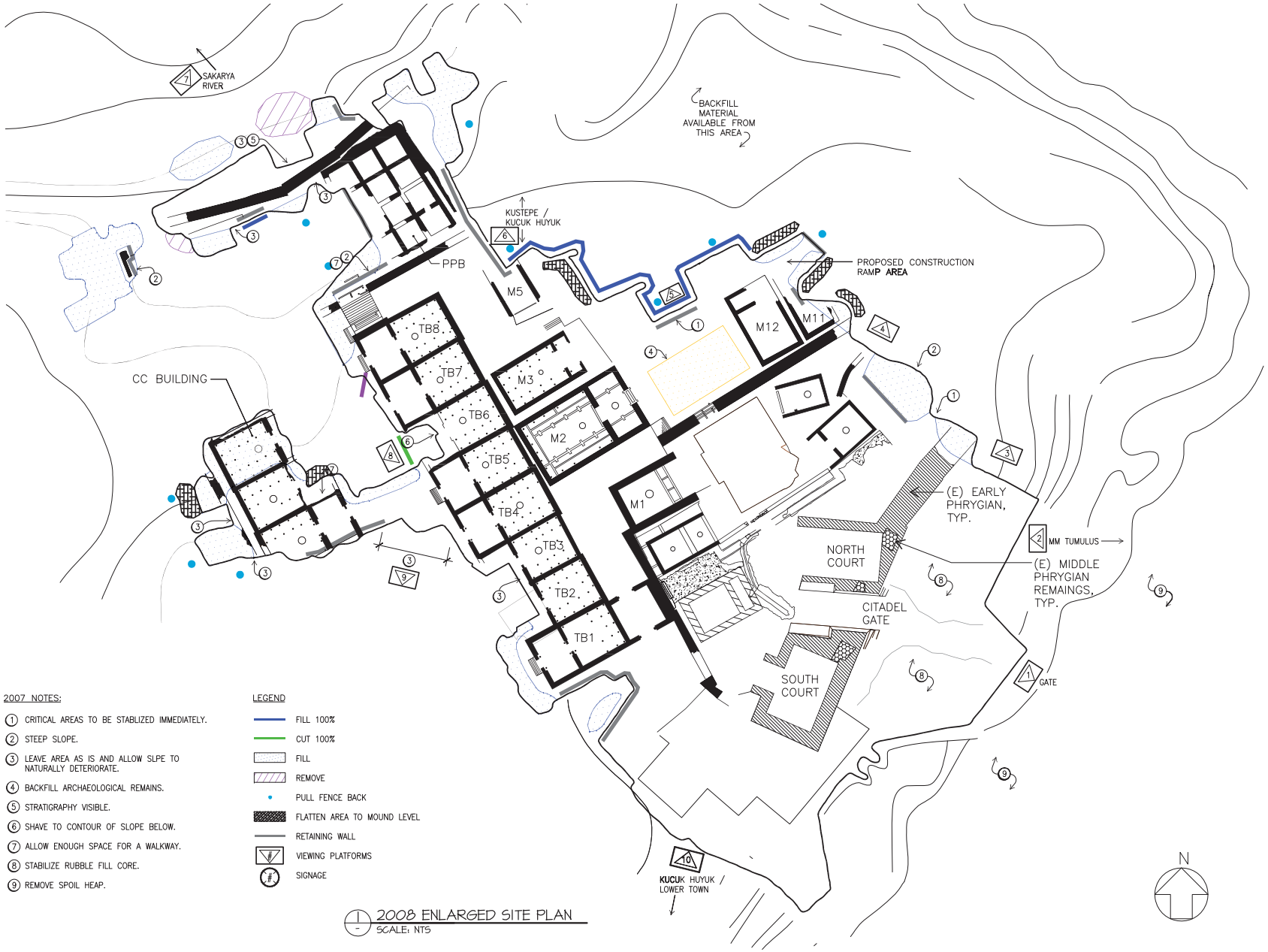

2007 NOTES:

1. CRITICAL AREAS TO BE STABLIZED IMMEDIATELY.
2. STEEP SLOPE.
3. LEAVE AREA AS IS AND ALLOW SLPE TO NATURALLY DETERIORATE.
4. BACKFILL ARCHAEOLOGICAL REMAINS.
5. STRATIGRAPHY VISIBLE.
6. SHAVE TO CONTOUR OF SLOPE BELOW.
7. ALLOW ENOUGH SPACE FOR A WALKWAY.
8. STABILIZE RUBBLE FILL CORE.
9. REMOVE SPOIL HEAP.

LEGEND

- FILL 100%
- CUT 100%
- FILL
- REMOVE
- PULL FENCE BACK
- FLATTEN AREA TO MOUND LEVEL
- RETAINING WALL
- VIEWING PLATFORMS
- SIGNAGE

1 / - 2008 ENLARGED SITE PLAN
SCALE: NTS

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NO.	DESCRIPTION	DATE
REVISIONS		

GORDION EXCAVATION PROJECT

ARCHITECTURAL CONSERVATION SITE STABILIZATION PROJECT

GORDION, TURKEY

SHEET TITLE

2008 SITE PLAN DETAIL

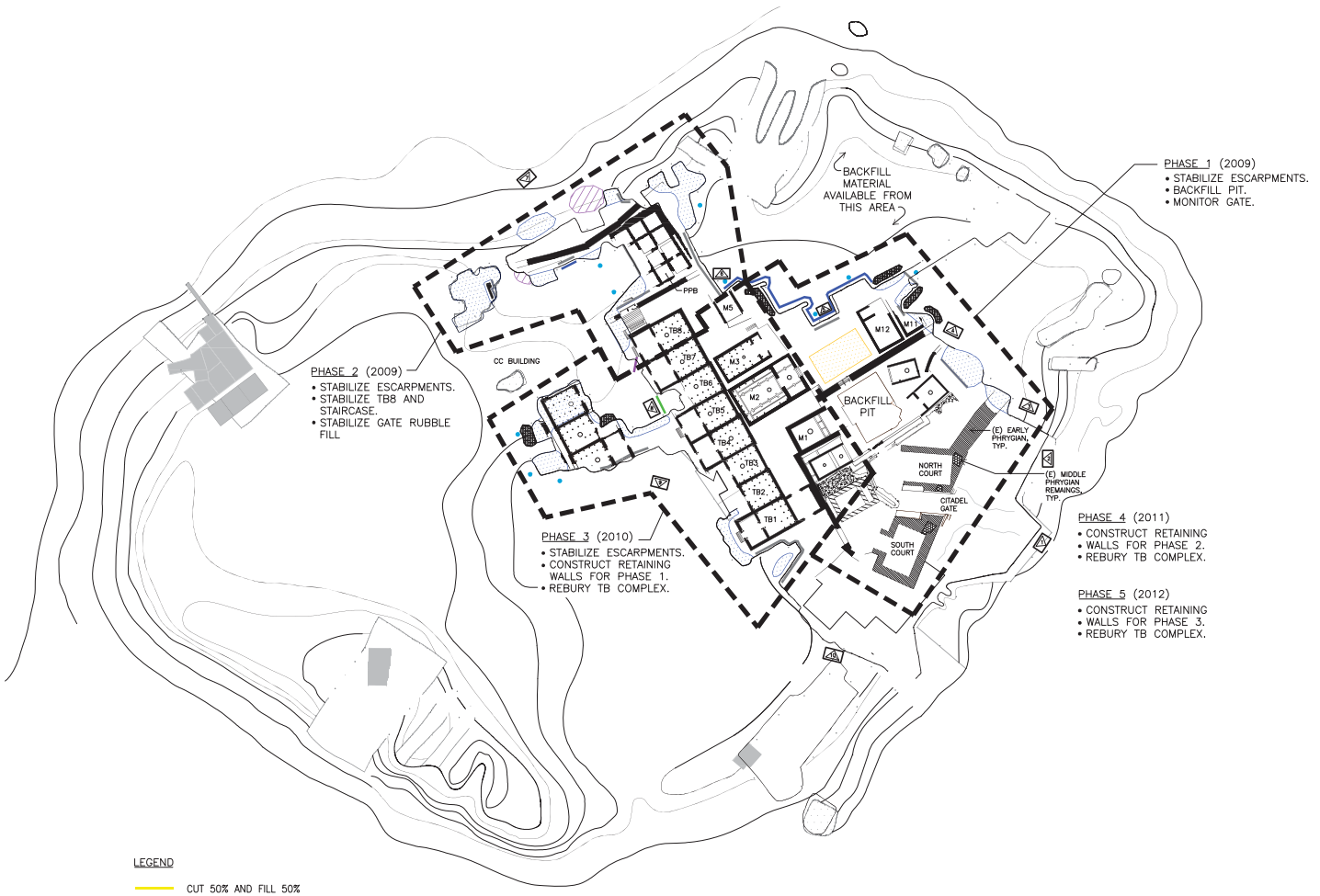
ISSUANCE
2008 FIELD SEASON

DATE
DECEMBER 18, 2008

PROJ. NO.	NA
DRAWN	KHW
CHECKED	NA

DRAWING NO.

A2.0



1 2008 SCHEDULE PLAN
SCALE: NTS

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Graduate Program in Historic Preservation
Philadelphia, PA 19104

NO.	DESCRIPTION	DATE
	REVISIONS	

GORDION EXCAVATION PROJECT

ARCHITECTURAL CONSERVATION SITE STABILIZATION PROJECT

GORDION, TURKEY

SHEET TITLE

2008 SCHEDULE PLAN

ISSUANCE
2008 FIELD SEASON

DATE
DECEMBER 18, 2008

PROJ. NO.	NA
DRAWN	KHW
CHECKED	NA

DRAWING NO.
A3.0
4 OF 5

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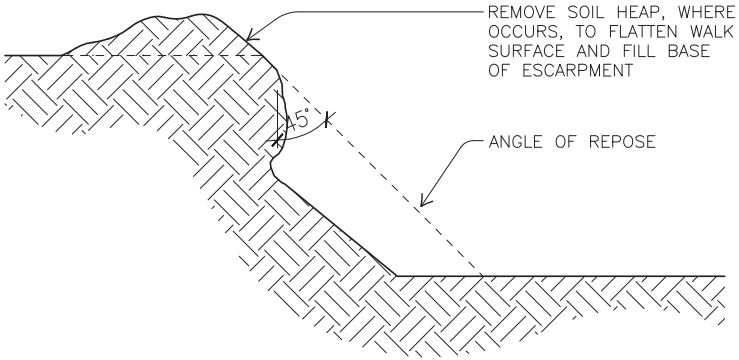
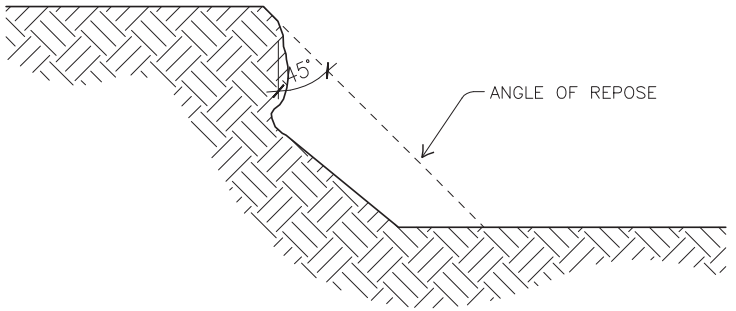


CONDITION C

REMOVE SOIL HEAP TO LEVEL OFF TO WALKWAY AND USE SOIL TO FILL BELOW

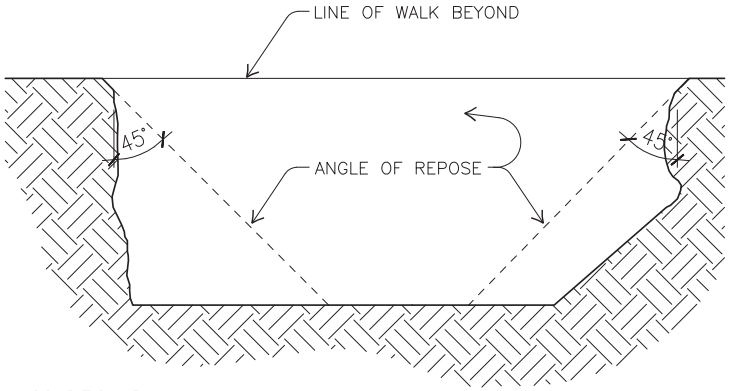
3 ESCARPMENT DETAIL C - FLATTEN WALK AND FILL SLOPE
SCALE: NTS



CONDITION A

FILL UNDERCUT ESCARPMENT TO ANGLE OF REPOSE

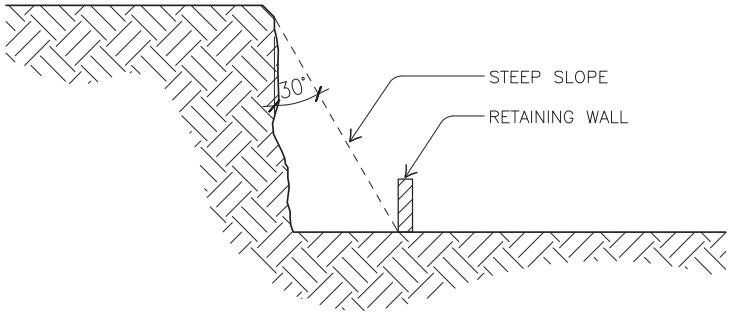
1 ESCARPMENT DETAIL A - ANGLE OF REPOSE
SCALE: NTS



CONDITION D

AT ADJACENT AND FACING ESCARPMENTS, FILL TO ANGLE OF REPOSE

4 ESCARPMENT DETAIL D - ADJACENT ESCARPMENTS
SCALE: NTS



CONDITION B

FILL TO STEEP ANGLE AND PROVIDE RETAINING WALL AT BASE

2 ESCARPMENT DETAIL B - STEEP ANGLE W/RETAINING WALL
SCALE: NTS

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NO.	DESCRIPTION	DATE
REVISIONS		

GORDION EXCAVATION PROJECT

ARCHITECTURAL CONSERVATION SITE STABILIZATION PROJECT

GORDION, TURKEY

SHEET TITLE

SITE ESCARPMENT TREATMENT DETAILS

ISSUANCE	2008 FIELD SEASON
DATE	DECEMBER 18, 2008
PROJ. NO.	NA
DRAWN	KHW
CHECKED	NA

DRAWING NO.

A4.0

Appendix C. Figures

The following figures include photographs of the Pilot Area #1 and the Citadel Mound site taken during a field visit in July 2008, as well as field notes of the Citadel Gate caps.

Figure 1. Undercutting at site escarpment revealing exposed archaeological remains.

Figure 2. Archaeological remains found at base of undercut site escarpment.

Figure 3. Free standing site escarpment detached from excavation pit.

Figure 4. Undercut condition at base of site escarpment to be treated with fill at base.

Figure 5. Typical pits found throughout site to be filled and leveled to provide safe conditions.

Figure 6. View from east of existing scaffolding at the Citadel Gate between South Court (left) and North Court (right) structures. Rubble fill at foreground.

Figure 7. Major masonry loss at top portion of South Court west return wall and large, open masonry joints.

Figure 8. Unstable rubble fill east of Citadel Gate.

Figure 9. Current concrete capping at South Court building.

Figure 10. Lower section of South Court selected for Pilot Area #1 showing rubble fill between masonry walls after removal of concrete capping.

Figure 11. Typical gaps between concrete and adjacent masonry at South Court capping.

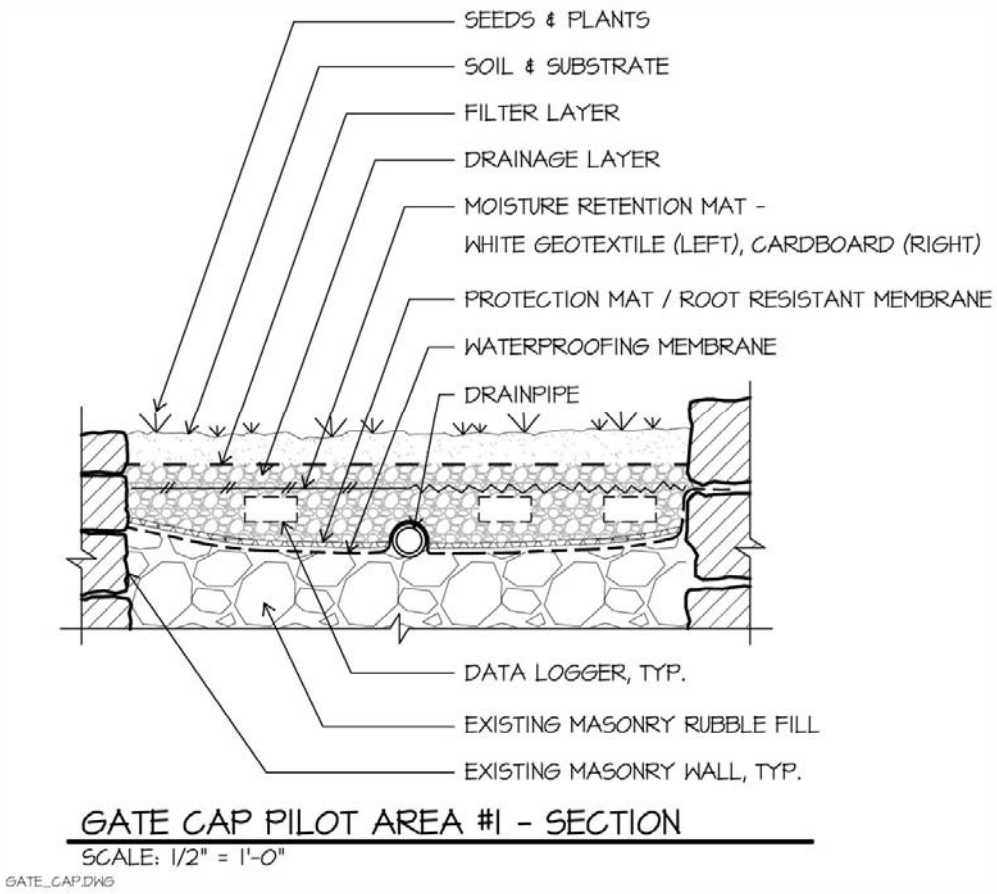

Figure 12. Section (from west) drawing through Pilot Area #1 showing layers of tested capping system.

Figure 13. Complete installation of water proofing membrane.

Figure 14. Dimpled polyethylene sheet installed to protect water proofing membrane.

Figure 15. Drainage layer consisting of gravel installed at Pilot Area #1 (contained within mudbrick walls).

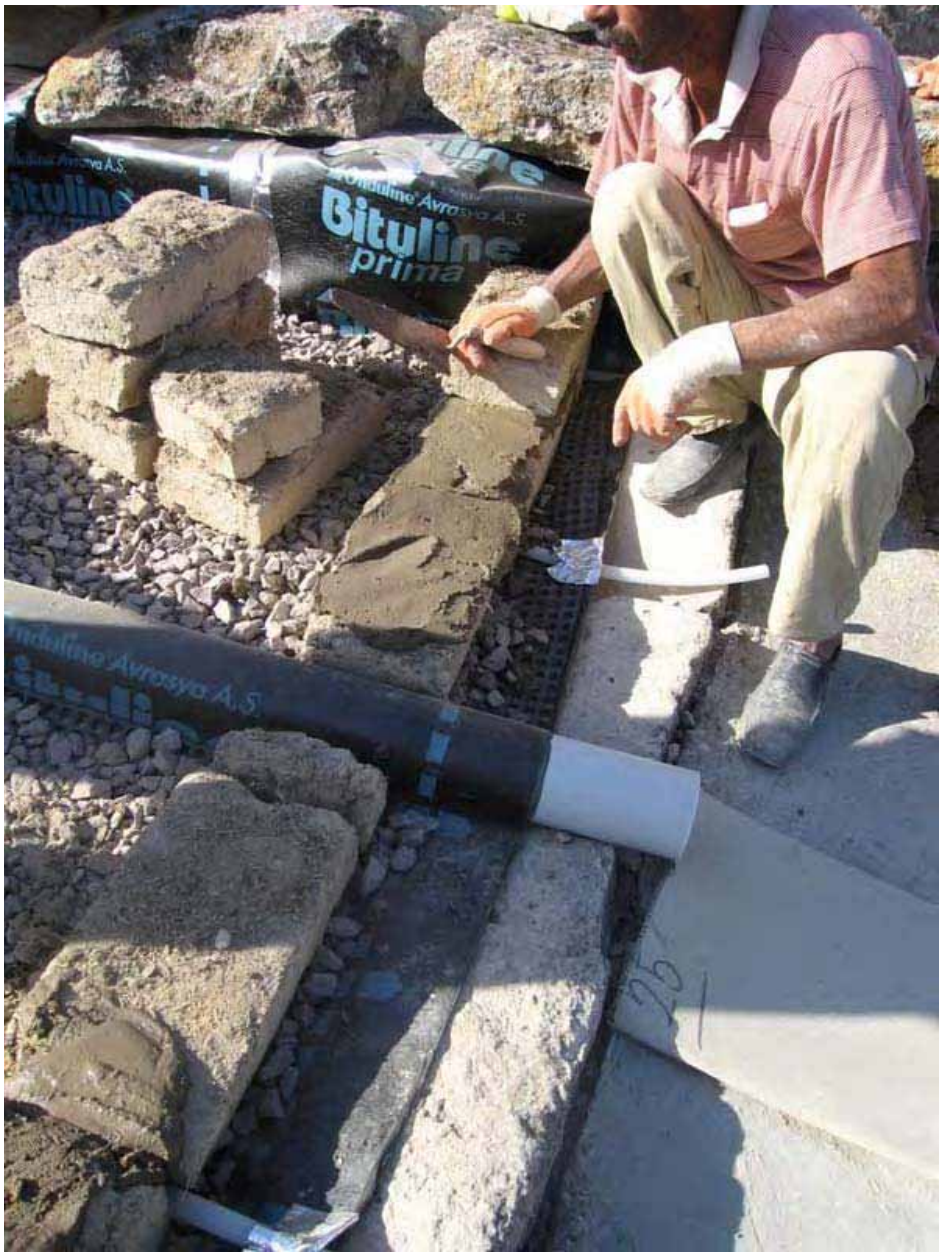

Figure 16. Weeps installed at base of sloped pilot area (west end).

Figure 17. Flipping mudbricks during drying process.

Figure 18. Detail of mudbrick units showing use of straw as filler.

Figure 19. Formwork used to make mudbricks (typical size 20cmx40cmx10cm).

Figure 20. Moisture retention mats: (left) cardboard and (right) white geotextile fabric.

Figure 21. Non-woven geotextile fabric installed as filter layer.

Figure 22. Three different types of seeds and vegetation planted: (top) mud balls with local 'Medusa-head grass,' (middle) annual seed mix, and (bottom) poa sods.

Figure 23. ‘Medusa-head grass.’

Figure 24. Data loggers installed at Pilot Area #1.

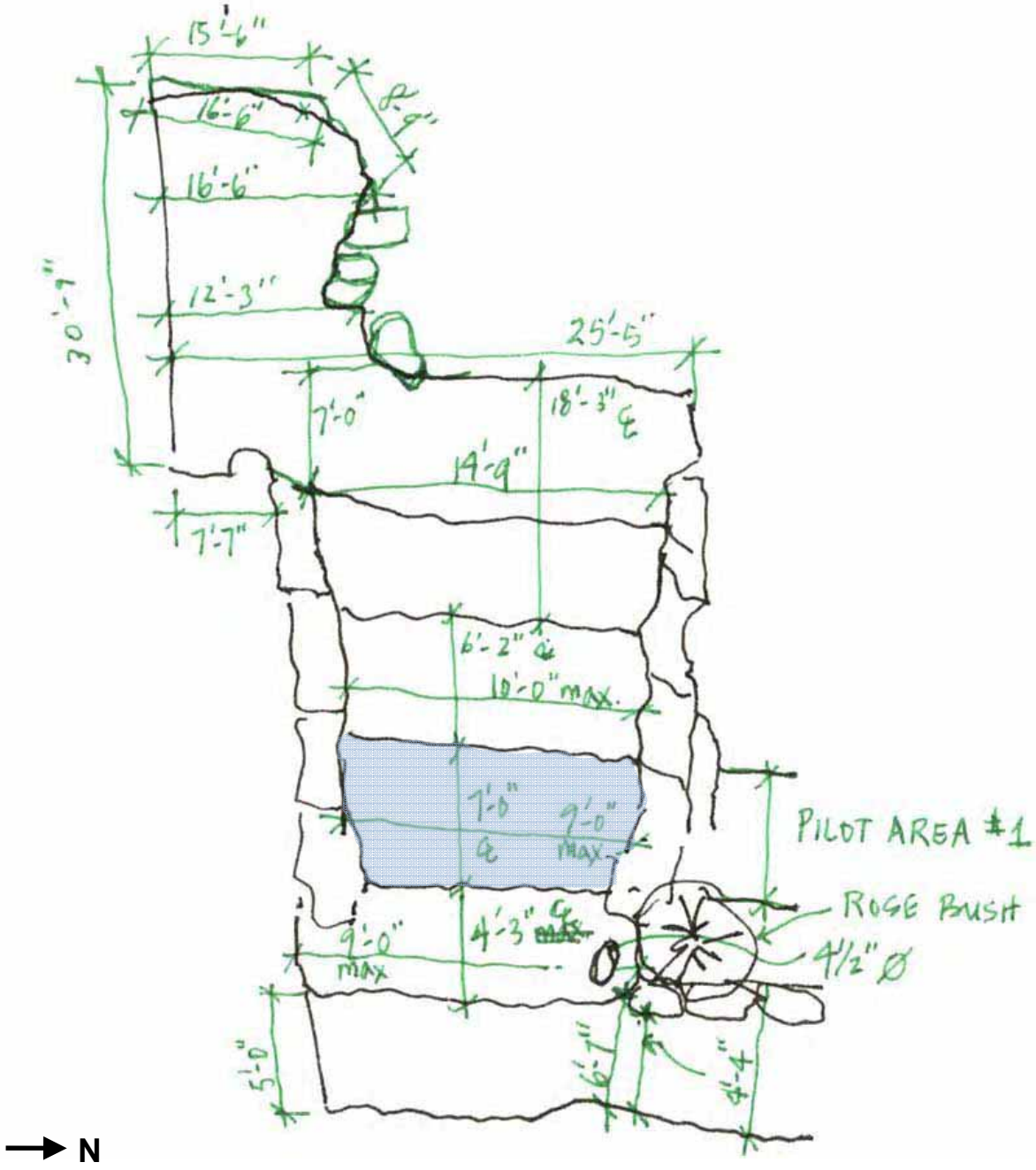

Figure 25. Field dimensions of South Court cap.

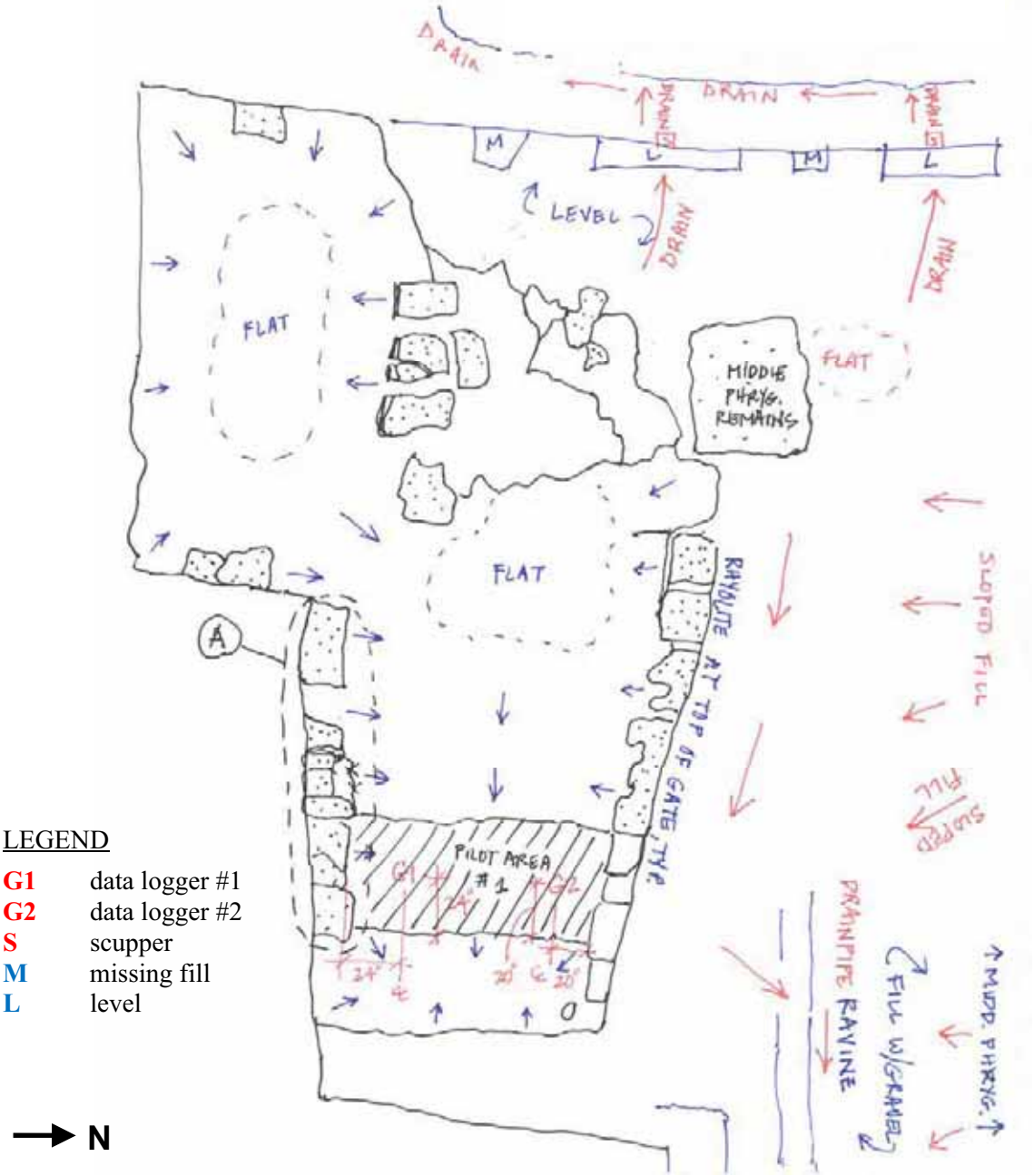

Figure 26. Drainage patterns at South Court cap and surroundings.

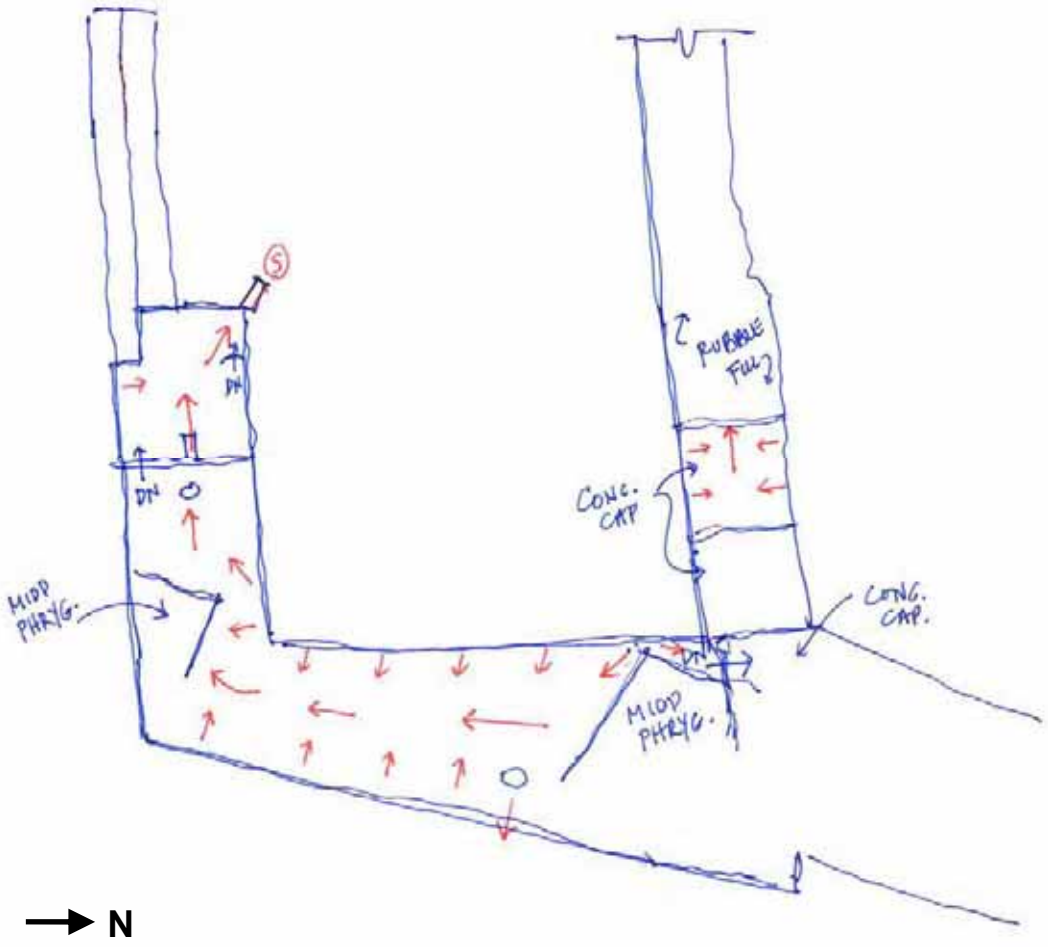

Figure 27. Drainage pattern at North Court cap.

Figure 28. TB2 showing vegetation at slopes of Pilot Program Area.

Figure 29. Review of existing masonry wall at TB2.

Figure 30. Watering slope of TB2 Pilot Program area after planting mudballs.

Figure 31. CC Building showing deteriorated masonry. Condition at base is especially poor.

Appendix D. Structural Engineer Correspondences

Structural Engineer Correspondences

Structural Engineer: Dr. Ahmet Türer, Structural Engineer and Assistant Professor, Civil Engineering Faculty, Middle East Technical University

From: Frank Matero <fgmatero@design.upenn.edu>
To: Ahmet Turer <aturer@metu.edu.tr>
Cc: "Evin H. Erder" <evin@metu.edu.tr>, "ciao.kelly@gmail.com" <ciao.kelly@gmail.com>,
"gksams@imap.unc.edu" <gksams@imap.unc.edu>, Brian Rose <roseb@sas.upenn.edu>
Date: Sun, Jul 13, 2008 at 8:51 AM
Subject: Gate Monitoring
Attachment: Turer_memo.docx (16K) **[see next section]**

Dear Ahmet bey,

It was a pleasure to finally meet you. Thank you for your time and interest in this project. We are very pleased you have joined the research team for Gordion and in so doing now add the Engineering Department's contribution to the new Cooperative Agreement forged between METU and UPENN. If you have any questions or concerns please do not hesitate to contact me via email. As per your 2007 site report and our meeting I have asked Evin to bring you some representative samples of the two major rock types from the gate: local limestone and rhyolite for general tests such as strength and density. If you would like us to do them instead perhaps Evin can send them to us. Also please send me some idea of your consultancy fees for the shoring design once you have a better idea so that we may prepare the budget for 2009.

With best regards,
Frank

MEMO

To: Dr. Ahmet Turer
Middle Eastern Technical University
From: Frank Matero, University of Pennsylvania
Date: July 10, 2008
Cc: Evin Erder, Kelly Wong, Ken Sams, Brian Rose

Dear Ahmet:

Again many thanks for taking the time to meet with us on Wednesday to discuss the Gordion project. As promised I am sending a synopsis of the meeting to clarify our conversation and your kind offer to assist. If anything below is unclear or misrepresented please do not hesitate to contact me.

AT-Ahmet Turer
FM-Frank Matero
EE-Evin Erder
KW-Kelly Wong

1. **Gate monitoring**
   - 1.1. AT will prepare specifications for wireless 8 channel monitoring equipment and suppliers for purchase in the U.S. FM will purchase and give to EE in Sept/Oct to hand carry to METU.
   - 1.2. KW will send AT documents on the Phrygian Gate to assist in preliminary structural assessment and selection of monitoring locations by AT. Battery power source to be concealed on gate tops under piled rubble stones to prevent theft. See drawing/photograph to be provided.
   - 1.3. Current scaffolding will remain in place to aid in sensor installation on the wall.
   - 1.4. Monitoring will occur for a minimum of 1 year with transmitted radio download of data to AT directly. Movement, inner wall temperature and moisture will be monitored in at least two locations.
   - 1.5. AT will collect and analyze data at the end of monitoring period and prepare report to team pro bono.

2. **Gate shoring**
   - 2.1. AT will design a shoring system to support the bulging north gate inner wall after the field visit in the fall to install monitors.
   - 2.2. Shoring will be installed by the beginning of summer 2009 as a temporary precaution against collapse and for safety during the 2009 field season.
   - 2.3. AT to provide specifications and budget and arrange with Turkish contractor to construct.

AT to provide UPENN with cost estimate for professional services for this component.

From : **Ahmet Turer <aturer@metu.edu.tr>**
To: Frank Matero <fgmatero@design.upenn.edu>
Cc: Kelly H. Wong <ciao.kelly@gmail.com>,"Evin H. Erder" <evin@metu.edu.tr>, Ken Sams <gksams@imap.unc.edu>, Brian Rose <roseb@sas.upenn.edu>
Date: **Wed, Jul 16, 2008 at 2:51 AM**
Subject: **Gate Monitoring**

Dear Frank bey and Kelly,

Thank you very much for your kind email message and nice meeting we had in my office. I share your concerns regarding Gordion gate and would like to cooperate with in the best possible way.

I have reviewed the copy of cooperative agreement signed between the two universities. Prof. Dr. Haluk Palamir has signed the agreement on METU side as the dean of the Faculty of Architecture. Civil Engineering Department is not connected to the Faculty of Architecture but to the Faculty of Engineering. I will check if a separate (but probably simpler) agreement needs to be signed under Faculty of Engineering also.

As we have discussed in our meeting, I would be happy to cooperate with the instrumentation and monitoring studies on a voluntary basis without any fees, provided that the instrumentation would be supplied by the US team. I would conduct the instrumentation, programming of the datalogger, and post-processing of the collected data as a part of my TUBITAK structural health monitoring project. I would report the results and related suggestions to you on a semi-annual basis. I would recommend the sensors would remain in operation at least for 1.5 years or more. If any urgencies rise during that interval, I would report that immediately as well and we would discuss and decide on emergency actions. Otherwise, if the wall is stable, we may make different decisions including keeping the wall in its current state.

I would be happy to make additional suggestions and design for the cross sectional and geometric properties to place temporary shoring. It might be necessary to ask the opinions of a geotechnical engineer for slope stability since my major is on structural engineering. I need to receive the dimensions of the wall and backfill as well together with plan drawings. (for example why the front wall is not bulging?). We should make decisions on whether or not putting the props (shoring) before or after the instrumentation. If shoring stops or slows down the movement, that may be detected by monitoring if the monitoring starts a few months before shoring. On the other hand, if we won't prop the wall now, the wall might get further damaged during the fall and through winter. This is a critical decision which is not too much technical. I would recommend shoring placement as soon as possible, (although you have stated the shoring in 2009).

Finding a contractor for shoring, preparing drawings, and ruling application on the field (as you have also stated during our meeting) are time consuming and not very academically appealing. I understand that you need a local contact and team member and this work has to be done. I would be happy to receive some consultancy for these efforts. I don't know the total project budget and other expense items related to the overall project. Therefore, it is not easy and would not be

correct for me to define and ask a consultancy fee from you. Please imagine yourself in my position and based on your budget allocation and the scope of work that I need to be done, optimize the fee that can be paid from the project. The payment to the manufacturing, transportation and installation on site should be paid directly to the contractor from you since about 70% of the money goes to overhead if payment is channeled through the university.

For the instrumentation systems and available TR prices:

- 1x CR800 1879 USD + 18%TAX (Campbell http://www.campbellsci.com/)

- 1x AM16/32 mux 1250 USD + 18%TAX (Campbell http://www.campbellsci.com/)

- 1x GSM modem 300 USD + 18%TAX (Sony Ericsson GT47 or equivalent http://www.alibaba.com/catalog/10971014/GT47_GM29_GSM_Terminal.html)

- 4x Distance measurement sensor (LVDT), I could not find a specific brand in US. But linear resistance type displacement transducers are commonly available in any country. Please ask Campbell and request suggestions on distance measurement sensor with direct voltage output. It should have a spring which pulls the tip of the sensor inwards as we will be attaching a thin wire between the two walls. The cable should be in tension all the time. The sensor can have 4 inch range; we will set it in the middle position and it will be recording plus or minus 2" in either direction. The temperature change during winter and summer will cause the thin wire to shrink or elongate. We will correct our distance measurements as the thermal expansion coefficient of steel is known and the ambient temperature on site will be measured at each distance measurement. If you can find reasonably priced laser based LVDTs in US, that would also be acceptable. However, the sensor should be low energy consumption since the data logger will operate on batteries and/or solar panel. Let's discuss before you purchase the LVDT sensors.

- If necessary, we may purchase the solar panel from Turkey (with your funds) since Evin would not be able to bring the solar panel from USA.

- 1x Air temperature and air relative humidity sensor (http://www.campbellsci.com/relative-humidity Turkey price is not available but easily more than 1000 USD)

- 3x Air, soil or water temperature (http://www.campbellsci.com/109-temperature -50 to +70 C degree - price is not available but expected to be less than 200 USD; some models are very cheap about 10USD)

- 2x soil water content probe (http://www.campbellsci.com/cs616-l I have not used this sensor before but looks like it measures the water content in soil from 0% to saturation). There are additional sensors at http://www.campbellsci.com/soil-water-content but please consult campbell representative explaining our application.

The sensor numbers may change as a function of allocated budget. Please feel free to change the numbers as you like. Using the AM16/32 multiplexer, we will have about 16 channels of input…

Best regards,
Ahmet Turer.

Additional information:

Campbell Scientific, Inc.
815 West 1800 North
Logan, Utah 84321-1784
USA

Phone:
435.753.2342 (Info)
435.750.9681 (Orders)
Fax:
435.750.9540

Email: info@campbellsci.com
Web: www.campbellsci.com

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Asst. Prof. Dr. Ahmet Turer, PhD Tel:+90 (312) 210-5419
Civil Engineering Department Fax:+90 (312) 210-7991
Structural Mechanics Lab.

Middle East Technical University email: aturer@metu.edu.tr
06531 ANKARA – TURKEY http://www.ce.metu.edu.tr/~aturer/

~~~~~~

From: **Frank Matero <fgmatero@design.upenn.edu>**
To: Ahmet Turer <aturer@metu.edu.tr>
Cc: Kelly H. Wong <ciao.kelly@gmail.com>, "Evin H. Erder" <evin@metu.edu.tr>
Date: **Wed, Jul 23, 2008 at 6:21 AM**
Subject: **Gate Monitoring**

Dear Ahmet bey,

Thank you for your very detailed reply. I will begin to assemble the materials as specified in time for Evin to take back to Turkey in the fall. I have asked Kelly to send you what documents we have on the conditions of the gate masonry that were recorded two years ago. They should give you some idea as to the general condition. The two areas of cracking and bulging we have suggested are the most obvious and will probably be all we can mange with the budget this year.

As for the shoring, I had wanted to install some protection by summer 2009 since that is when the team will reassemble at the site and safety issues will become important. Could we not shore the wall but leave an unrestrained area in the vicinity of the bulge and the monitors? I assume they are measuring localized movement across a number of critical stones. The general design and supervision of the shoring should involve you since it is also part of the gate masonry. Normally on conservation grants for non-profits, such as for the Getty Conservation Institute, professionals are budgeted at a reduced hourly rate. For international projects this is usually about $50/hr with a not to exceed figure. If we get a good contractor who is familiar with such construction, I would imagine your input would be limited to general schematic design and calculations of the shoring and supervision of its installation so as not to damage or upset the monitoring. Remember we will need to gain access through the gate during the 2009 summer season. Having said that, it would be helpful if you estimated how much time might be required on your part for this but we understand it is unknown until a contractor is found. So if the hourly is ok with you, we can proceed until a contractor is found and he develops the cost for the shoring installation, You should tell me though if this consultancy is to come to you directly or if it is to go through METU. If the latter then I understand there may be a 70% overhead which we would prefer to avoid.

In the meantime I will contact some colleagues at Ove Arup in Istanbul to see if they can make a recommendation on a contractor for the stabilization of the scarps and rubble fill.

I look forward to hearing from you soon,

All the best,
Frank

Frank Matero
Professor of Architecture and Chair
Graduate Program in Historic Preservation
School of Design
University of Pennsylvania
Philadelphia, PA 19104-6311
215.898.3169

From: **Kelly H. Wong <ciao.kelly@gmail.com>**
To: Ahmet Turer <aturer@metu.edu.tr>
Date: **Thu,Jul 24, 2008 at :36 PM**
Subject: **Gordion: Gate Documents**

Dear Ahmet bey,

I apologize for the delay in sending these Gate documents to you. Once back in the US, it was really busy in the office after a 2 week leave!

Anyway, I am sending you the following electronic documents:

1. Field Report 2007 - Site (Master Preservation Plan)
2. Photo Comparisons 2006 - historic vs. present
3. Site Plan - indicating the North & South Courts of the Citadel Gate

I also have the Field Report from 2006 (work on the Gate including grout injection and conditios survey). Unfortunately, it is too large of a PDF to send, so I will send tomorrow (after I break it into 2 parts). Please let me know if you need anything else that may help in your work. **Additionally, I know that the North Court is not within your current scope of work, but there is a bulge at the interior east wall (below the Middle Phrygian remains). I thought I would point it out, so you can take a look when you are out there installing the monitors.**

Ok, please stay in touch and let me know if I need to help facilitate or bug Frank for you! Great to see you again this summer. We're so lucky to have you on our team!!

Cheers,
Kelly

From: **Ahmet Turer <aturer@metu.edu.tr>**
To: Kelly H. Wong <ciao.kelly@gmail.com>
Date: **Wed, Jul 30, 2008 at 11:04 AM**
Subject: **Gordion: Access to Documents**

Dear Kelly,

I have received the attachment files by logging on the google email system and was able to read your recent message which was a lot of fun.

I have looked over the three documents, and all are very informative.

I think that it is quite normal to have another bulging at the north court interior east wall since it has a quite similar shape as the current wall that we are dealing with. I wouldn't be surprised either if the north side of the same wall would start to bulge in a few years if the height and soil conditions are similar.

Having similar movement in both walls is, I am afraid, an indication of general instability with the walls and soil conditions behind them. I expect that the bulging will continue and lead to partial collapse if unattended. As I remember, Evin will be visiting US this fall when she will be bringing back the monitoring equipment. I should install them before the winter and we should be planning for a proper buttress – prop system (and removing current scaffolding) by summer of 2009. Monitoring for another year until 2010 would reveal if the prop system is effective or not. Otherwise, we should be planning for a permanent anchorage system that will pass the wall across until the south court. As I understand, the south court is currently filled with debris. The court might be partially excavated and anchorage would be tied from both ends which would permit excavation of south court in the future as well. Otherwise, south court wall is also expected to bulge.

As the current agreement between our universities is signed by the architecture dean, I may need to sign a parallel agreement with engineering dean's office. I will explore that further and may prepare a draft project agreement.

Thank you for your kind words in your recent email message. I am happy to be a team member together with you all in Gordion project.

Kind regards,
Ahmet

From: **Ahmet Turer <aturer@metu.edu.tr>**
To: Frank Matero <fgmatero@design.upenn.edu>
Cc: Kelly H. Wong <ciao.kelly@gmail.com>, "Evin H. Erder" <evin@metu.edu.tr>
Date: **Wed, Jul 30, 2008 at 11:21 AM**
Subject: **Gate Monitoring**

Dear Frank,

Thank you for your message below. I think $50/hr is fine; however, it should go through METU since otherwise it would not be legal. It is ok to have deductions, just a fact of life. Out of 50, there is a 18% tax deduction, then University takes 45% of the remaining. The remaining portion is again taxed by about 25% and the remaining is about 35% of the original. So I will be receiving about $17.5/hour (better rate than flipping burgers ;). After all, I am not in this for making big money, but motivation counts. I should prepare a second (parallel) agreement that would be signed between engineering faculty dean and UPenn. Now I remember that international projects might have a reduced deduction rate, so I may end up with about -18% tax and 15% overhead. I will check that.

Is it ok to prepare a second agreement for you? If affirmative, I will proceed in preparing a draft copy. Evin will be bringing transducers this fall which we should immediately install. I have dropped a few lines to Kelly as well. I think the bulging in the North court is an indication that the walls are unstable and will progress. We would monitor until summer of 2009 when we should be placing the steel shoring. Until 2010 we would monitor to see if there are any additional movement or if the characteristic has changed. If the shoring is not adequate, we may proceed with installing an anchorage system that will pass through the wall and anchored at the other side of the wall in south court with minor – regional excavation.

Please let me know..

Best regards,
Ahmet.

From: **Frank Matero <fgmatero@design.upenn.edu>**
To: Ahmet Turer <aturer@metu.edu.tr>
Cc: Kelly H. Wong <ciao.kelly@gmail.com>, "Evin H. Erder" evin@metu.edu.tr
Date: **Thu, Aug 14, 2008 at 5:34 PM**
Subject: **Gate Monitoring**

Dear Ahmet,

I hope this finds you well. A gentle reminder to send me the draft agreement you would like to use for official cooperation and payment. I am assembling the equipment prices and info now and will confirm before I purchase. I also understand from kelly that she sent you the information we have on the gate for your review. Be assured we are confirmed with or without the agreement.

With kind regards,
Frank

From: **Ahmet Turer <aturer@metu.edu.tr>**
To: Frank Matero <fgmatero@design.upenn.edu>
Cc: Kelly H. Wong <ciao.kelly@gmail.com>, "Evin H. Erder" <evin@metu.edu.tr>
Date: **Mon, Aug 25, 2008 at 10:54 PM**
Subject: **Gate Monitoring**

Dear Frank,

Sorry for not getting back at you on time. I have been out in the field testing a bridge in Adana and just recently recovering from 47 C degree (117 Fahrenheit) hot and humid air working conditions.

Do you mind sending me an electronic copy of the agreement that was initially signed between University of Pennsylvania and METU – Dean of Architecture? I would be happy to make a first round of modifications to obtain a similar version for the Dean of Engineering or Rector. I am currently investigating if this international project can be accepted and processed as an European Project (FP7), which has a smaller university overhead in the order of 10%.

Kind regards,
Ahmet

Appendix E. Materials List

The following table includes materials used for the Citadel Gate Pilot Program in summer 2008. See Appendix F for product literature.

Table 1. Materials used for the Citadel Gate Capping Pilot Program.

	Layer	Material	Description
BOTTOM LAYERS	Water Proofing Layer	*Bituline prima PP3* manufactured by Onduline Avrasya A.S.	Modified bituminous waterproofing sheet membrane
	Protection Layer	*Fondaline* manufactured by Onduline Avrasya A.S.	Dimpled, high density polyethylene sheet
	Drainage Layer	Gravel	Obtained from site
	Moisture Retention Layer	Two types installed: 1. Corrugated cardboard 2. White geotextile fabric	 1. Purchased in Ankara 2. Obtained from site
----	Filter Layer	*Premium Landscape fabric* manufactured by Typar	Non-woven, porous polypropylene, permeable geotextile fabric
TOP LAYERS	Soil and Substrate	Mix of soil, sand and (most likely) some clay	Obtained from site
	Seed and plants	Three types: 1. Poa sods 2. Annual seed mix (Poa, *Hordeum muinum*, *Scabiosa* sp., *Androsace maxima*, et al.) 3. Mud balls (filled with local *Taeniatherum caput-medusae* 'Medusa-head grass')	 1. Transplanted from nearby 2. Seeds collected locally 3. Seeds collected locally

Appendix F. Product Literature

TS EN 13707
TS EN 13969

Onduline
groupe

Onduline AVRASYA A.Ş.

Değirmen Sokak Nida Kule
No 12 Kat 8 34742
Kozyatağı / Kadıköy/ İstanbul
Phone : +90 216 384 16 00 pbx.
Fax : +90 216 384 16 10

www.onduline.com.tr
avrasya@onduline.com.tr

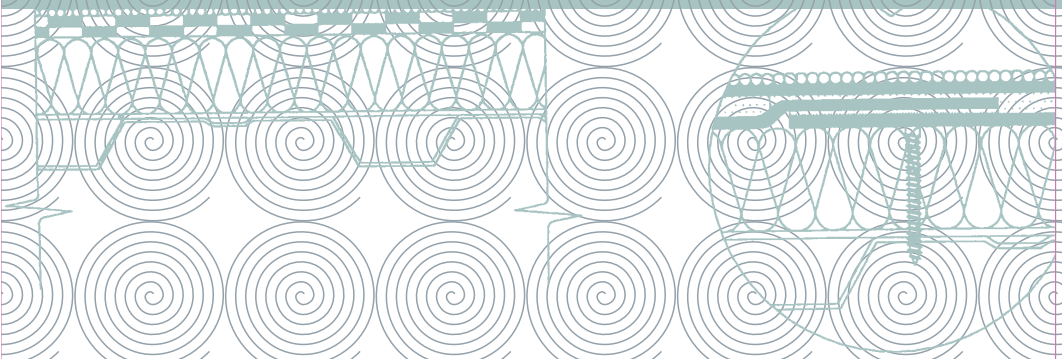
SİSTEM BITULINE 10/2007/5000/003

System Bituline®

Onduline
groupe

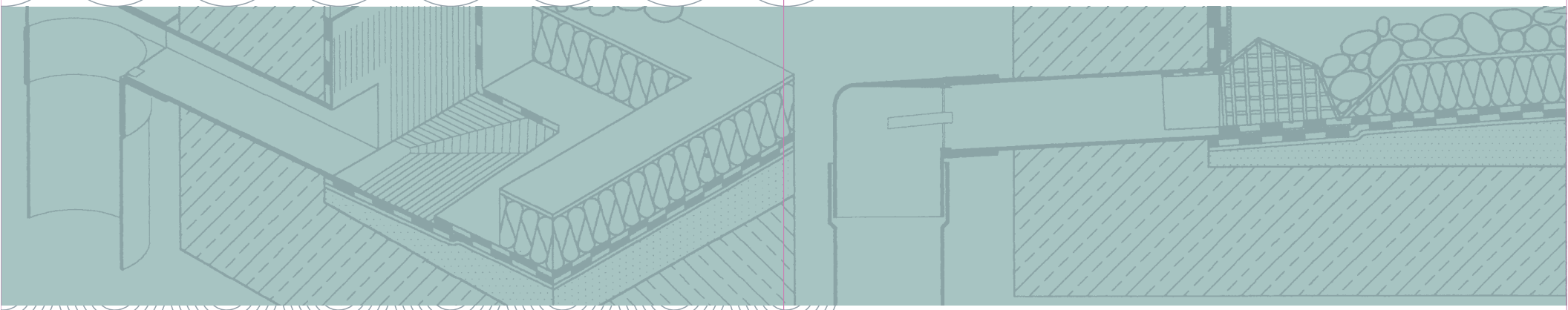
SYSTEM BITULINE

The System Bituline's scope is the use of torch applied modified bituminous waterproofing membranes Bituline and its accessories in various waterproofing needs.
Bituline membranes are used for waterproofing of flat and low sloped roofs, terraces, wet surface floorings, underground surfaces such foundations, basements and pools, roof gardens or of particular engineering structures such as multistorey parkings, highway or railway bridges.

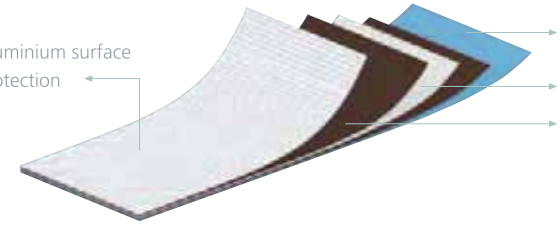


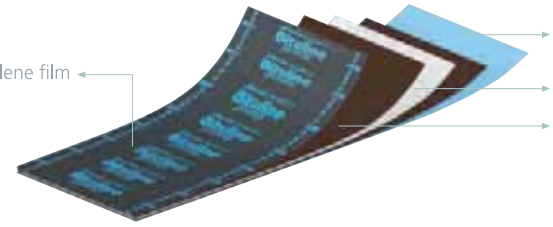
ADVANTAGES

- Bituline membranes, the fundamental element of waterproofing, are manufactured of high quality bitumen modified with polymers and reinforced with polyester or fiberglass of different ticknesses and whenever required with various coatings on the surface and therefore have a broad product range enabling the selection of the most ideal material that fits best to a particular application need.
- Thanks to the modified bitumen, insulation retains its flexibility even under very low temperatures, free of any cracks, while loosening rather late and thus maintaining its form under high temperatures. This is why Bituline System may be used safely under any climatic conditions.
- The fact that Bituline membranes are manufactured using a state-of-the art technology equipment at a factory environment ensures homogeneous waterproofing as well as integrity of materials in terms of quality which eliminates any insulation risks due to difference in performance, as common with the traditional systems implemented throught application by laying of product mixes prepared in site.
- The membranes are combined together by fusion welding and then simply bonded onto the desired surface. This welding technique makes waterproofing permanent. The waterproofing of the Bituline system is also complete at joints.
- The reinforcement set into the membranes increases the tensile streght and pressure resistance of the waterproofing. System Bituline is thus available for use safely at such locations where levels of exposure to mechanical stresses are considered high, such as motorways, bridges, road pavements, etc.
- Available with granulated mineral or aluminium coated with a wide range of colors, Bituline membranes are especially ideal for use as a final coat waterproofing material as they are not affected from airborne particles of chemical and biological nature and are resistant to UV beams Bituline membranes provides aesthetically attractive surfaces at all times.



Granulated
mineral surface
protection
Polyethylene film
Fiberglass or polyester
reinforcement
Plastomeric (APP) modified
bitumen of elastomeric
(SBS) modified bitumen.


Aluminium surface
protection
Polyethylene film
Fiberglass or polyester
reinforcement
Plastomeric (APP) modified
bitumen of elastomeric
(SBS) modified bitumen.


Polyethylene film
Polyethylene film
Fiberglass or polyester
reinforcement
Plastomeric (APP) modified
bitumen of elastomeric
(SBS) modified bitumen.

HIGH QUALITY PRODUCTION

ITC

Certificate of Factory Production Control

FLEXIBLE SHEETS FOR WATERPROOFING

CE

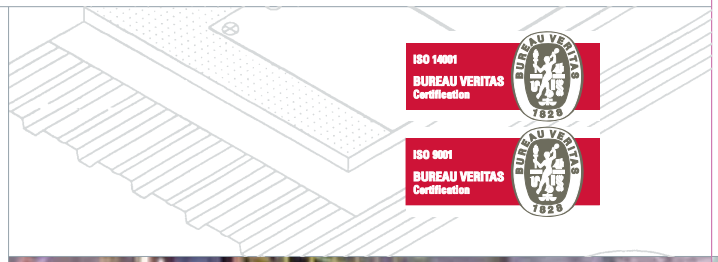
ITC

Certificate of Factory Production Control

FLEXIBLE SHEETS FOR WATERPROOFING

CE

Bituline membranes are produced in modern plants under the guarantee of Onduline Avrasya member of french ONDULINE GROUPE. In obtaining the indispensible characteristics of a high quality waterproofing membrane, which are "durability", "flexibility" and "longevity"; the high grade bitumen, polymers and reinforcement felt play an important role together with the special computerised formulation, developped by "Onduline Groupe" and Onduline Avrasya. The environmentally friendly technologies used have enabled Onduline Avrasya to receive various environmental awards and to be granted the ISO 9002 and ISO 14001 certificates.


ISO 14001
BUREAU VERITAS
Certification

ISO 9001
BUREAU VERITAS
Certification

All Bituline waterproofing membranes are produced in conformity with EN 13707 "Flexible sheets for waterproofing- Reinforced bitumen sheets for roof waterproofing" and EN 13969 "Flexible sheets for waterproofing- Bitumen damp proof sheets including bitumen basement tanking sheets" harmonized standarts in compliance with the directive 89/106/EEC of the European Economic Community and are marked CE

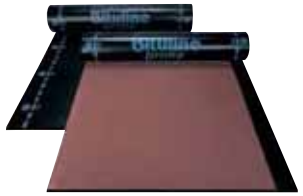
TS EN 13707
TS EN 13969

CE

TSE

BITULINE PRIMA

The "Prima" series consist of plastomeric membranes modified with "Atactic Polypropylene" (APP). Bituline Prima membranes are in compliance with the cold and warm weather conditions of mild climate zones (minimum -5°C) offering economic and reliable waterproofing systems with a wide spectrum for different types of buildings. Minimum 150 gr/m2 of polyester reinforcement are used in "Prima" PP series and minimum of 60 gr/m2 of fiberlass reinforcement are used in "Prima" PG series.



BITULINE EXTRA

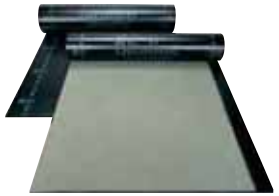
The "Extra" series consist of plastomeric membranes modified with "Atactic Polypropylene" (APP). Bituline Extra EP membranes series having increased their tensile strenght with minimum of 180 gr/m2 of polyester reinforcement perform better at high and low temperatures in regions with extreme climatic conditions (minimum -10°C) with its flexibility and durability. Minimum of 60 gr/m2 of fiberlass reinforcement are used in "Extra" EG series.

The Bituline EP410 is an especially formulated "Heavy Duty" membrane for use in the waterproofing of highways pavements, road bridges, viaducs etc. And a minimum of 250 gr/m2 of polyester reinforcement is used to perform maximum tensile strenght in extreme mechanical conditions.

The Bituline EP410 has been also tested by LCPC (Laboratoires Central des Ponts et Chaussées-French Public Works Research Laboratory) in France and General Directorate of Highways - Technical Research Laboratories in Turkey for use in several road pavements and bridges projects.

BITULINE MAXIMA

The "Maxima" group contains elastomeric membranes modified with "Styrene Butadiene Styrene" (SBS). Having the highest possible flexibility even at lowest temperatures (minimum -20°C)and increased their tensile strenght with minimum of 180 gr/m2 of polyester reinforcement, Bituline Maxima MP series membranes are especially suitable for cold climates and are also ideal for "bundle" type foundation waterproofing against underground water subject to pressure as well as for roofs subject to high vibrations or dilatation. Minimum of 60 gr/m2 of fiberlass reinforcement are used in "Maxima" MG series.



BITULINE ALUMINIUM

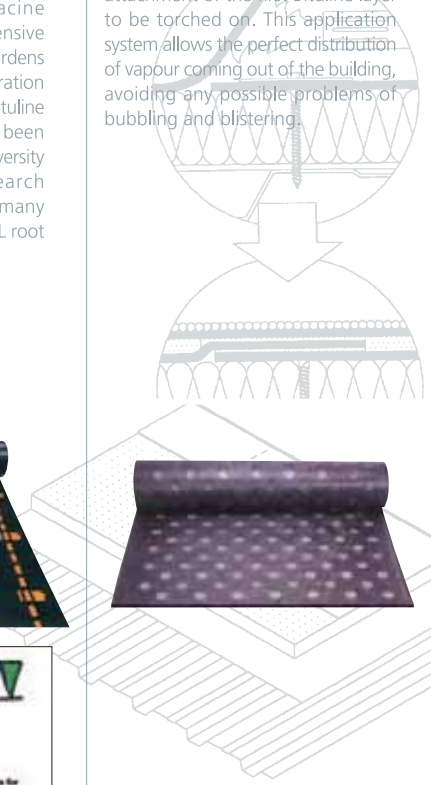
Aluminium foil finish membranes of the Bituline Extra group EG30A and EP30A are used as the final layer material like the granulated finish types. Their technical specifications are identical to Extra group. This type is also used for flashing details of the roof like valleys, hiden gutters, etc.

BITULINE ANTIRACINE

The Bituline Anti-root EP300 Anti-racine and EP400 Anti-racine membranes are used for intensive or extensive roof planting of gardens and are resistant to root perforation or penetration damages. The Bituline Anti-racine membranes have been tested during two years by University of Applied Sciences Research Institute of Horticulture-Germany by FLL method and granted FLL root resistance Certificate.

BITULINE PERFOR

The Bituline Perfor, loose laid on the substrate provides the partial attachment of the first Bituline layer to be torched on. This application system allows the perfect distribution of vapour coming out of the building, avoiding any possible problems of bubbling and blistering.



Specifications	Standart	Unit	Valor
Thickness	EN 1849-1	mm	1.2
Lenght	EN 1848-1	m	20
Width	EN 1848-1	m	1
Number of gaps		Pieces/m^2	119
Gap ratio		%	15

BITULINE SPECIFICATIONS ACCORDING TO "TS EN 13707" STANDART

				Bituline® maxima							Bituline® extra											Bituline® prima						
				MG200	MG300	MP300	MP400	MG40M	MP40M	MP50M	EG200	EG300	EP300	EP400	EP300 Antiracine	EP400 Antiracine	EP410	EG40M	EP40M	EP50M	EG30A	EP30A	PG200	PG300	PP300	PP400	PG40M	PP40M	PP50M
APPLICATION	(X)= Yes (-) = No	UNDERLAY AND INTERMEDIATE LAYER		X	X	X	X	-	-	-	X	X	X	X	ROOF GARDEN		X	-	-	-	-	-	X	X	X	X	-	-	-
		TOP LAYER AND SINGLE LAYER		-	-	-	-	X	X	X	-	-	-	-	-	-	-	X	X	X	X	X	-	-	-	-	X	X	X
TEST METHOD	METHOD	UNIT	TOLERANCE																										
REINFORCEMENT	G: GLASSFIBER P: POLYESTER	-	-	G	G	P	P	G	P	P	G	G	P	P	P	P	P	G	P	P	G	P	G	G	P	P	G	P	P
UPPER SURFACE COATING	-	-	-	PE FILM				MINERAL			PE FILM								MINERAL		ALUMINIUM		PE FILM				MINERAL		
LOWER SURFACE COATING	-	-	-	PE FILM				PE FILM			PE FILM								PE FILM		PE FILM		PE FILM				PE FILM		
VISIBLE DEFECTS	TS EN 1850-1	-	-	NONE							NONE												NONE						
LENGTH	TS EN 1848-1	m.	min (-0,03)	15	10	10	10	10	10	10	15	10	10	10	10	10	10	10	10	10	10	10	15	10	10	10	10	10	10
WIDTH	TS EN 1848-1	m.	min (-0,02)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
STRAIGHTNESS	TS EN 1848-1	-	-	PASS							PASS												PASS						
THICKNESS	TS EN 1849-1	mm.	± 0,2	2	3	3	4	3,5	3,5	4,5	2	3	3	4	3	4	4	3,5	3,5	4,5	3	3	2	3	3	4	3,5	3,5	4,5
WATERTIGHTNESS	TS EN 1928 (methodB 10kPa)	-	-	PASS							PASS												PASS						
REACTION TO FIRE	TS EN 13501-1	-	-	E							E												E						
JOINT STRENGTH	TS EN 12317-1	N/50mm.	± %30	-	-	-	-	400	800	800	-	-	-	-	700	850	-	300	700	700	650	800	-	-	-	-	300	600	600
WATER VAPOUR TRANSMISSION	TS EN 1931	-	min	20000							20000												20000						
TENSILE STRENGTH (longitudinal)	TS EN 12311-1	N/50mm.	-%0;+%30	400	400	800	800	400	800	800	400	400	800	800	800	800	1000	400	800	800	400	800	300	300	600	600	300	600	600
ELONGATION AT BREAK (longitudinal)	TS EN 12311-1	%	G: (-0;+1) P: (-0;+10)	2	2	35	35	2	35	35	2	2	35	35	35	35	40	2	35	35	2	35	2	2	30	30	2	30	30
TENSILE STRENGTH (transversal)	TS EN 12311-1	N/50mm.	-%0;+%30	300	300	600	600	300	600	600	300	300	600	600	600	600	800	300	600	600	300	600	200	200	400	400	200	400	400
ELONGATION AT BREAK (transversal)	TS EN 12311-1	%	G: (-0;+1) P: (-0;+10)	2	2	35	35	2	35	35	2	2	35	35	35	35	40	2	35	35	2	35	2	2	30	30	2	30	30
RESISTANCE TO IMPACT	TS EN 12691 (method A)	mm.	min	-	-	-	-	750	1000	1000	-	-	-	-	550	550	-	750	1000	1000	1250	1250	-	-	-	-	750	1000	1000
RESISTANCE TO STATIC LOADING	TS EN 12730 (method A)	kg.	min	-	-	-	-	5	10	10	-	-	-	-	5	5	-	5	10	10	15	15	-	-	-	-	5	10	10
RESISTANCE TO TEARING	TS EN 12310-1	N	± %30	150	150	200	250	150	200	270	100	100	150	200	150	200	200	100	150	150	150	200	75	75	100	150	100	125	125
RESISTANCE TO ROOT PENETRATION	pr EN 13948	-	-	-	-	-	-	-	-	-	-	-	-	-	PASS	PASS	-	-	-	-	-	-	-	-	-	-	-	-	-
DIMENSIONAL STABILITY	TS EN 1107-1	%	max	-	-	-	-	-	0,6	0,6	-	-	-	-	0,6	0,6	-	-	0,6	0,6	-	0,6	-	-	-	-	-	0,6	0,6
FLEXIBILITY AT LOW TEMPERATURE	TS EN 1109	°C	min	-20	-20	-20	-20	-20	-20	-20	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-5	-5	-5	-5	-5	-5	-5
FLOW RESISTANCE AT ELEVATED TEMPERATURE	TS EN 1110	°C	min	100	100	100	100	100	100	100	120	120	120	120	120	120	120	120	120	120	120	120	110	110	110	110	110	110	110
ARTIFICIAL AGEING BEHAVIOUR	TS EN 1296 / TS EN 1109	°C	-0;+10	-	-	-	-	5	5	5	-	-	-	-	-	-	-	10	10	10	10	10	-	-	-	-	15	15	15
	TS EN 1296 / TS EN 1110	°C	-0;+10	-	-	-	-	5	5	5	-	-	-	-	-	-	-	10	10	10	10	10	-	-	-	-	15	15	15
ADHESION OF GRANULES	TS EN 12039	%	0-30	-	-	-	-	20	20	25	-	-	-	-	-	-	-	20	20	25	-	-	-	-	-	-	20	20	25
DANGEROUS SUBSTANCES	-	-	-	NONE							NONE												NONE						

TS EN 13707 " Flexible sheets for waterproofing- Reinforced bitumen sheets for roof waterproofing"

*Bituline EP300 Antiracine and EP400 Antiracine are certified root resistant sheets according to FLL method delivered by the University of Applied Sciences- Institute of Horticulture

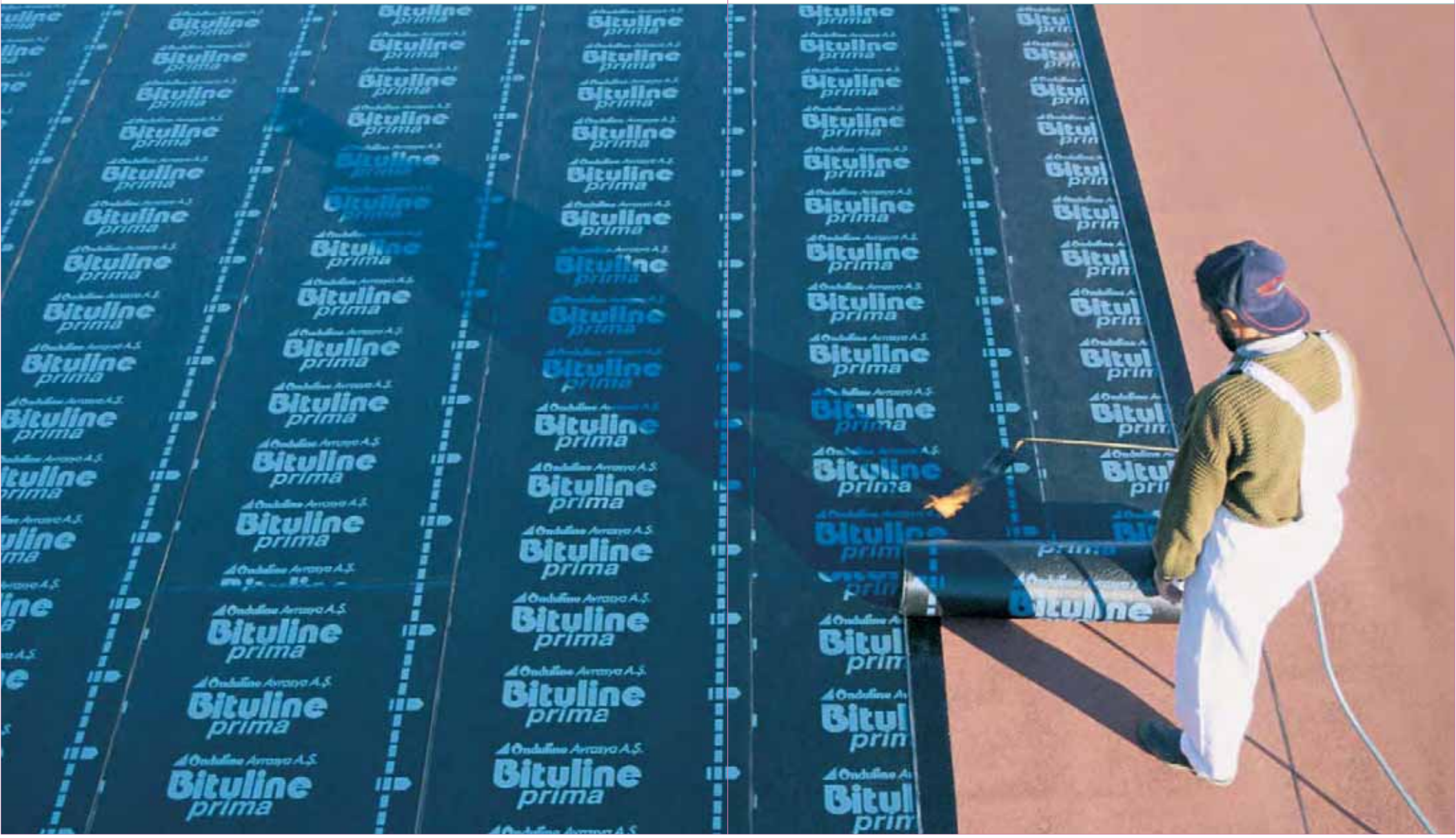
*The Harmonization Standart prEN 14695 "Flexible sheets for waterproofing - Reinforced bitumen sheets for waterproofing of concrete bridge decks and other concrete surfaces trafficable by vehicles "for Bituline EP410 "Heavy Duty" waterproofing membrane for use in the waterproofing of highways pavements, road bridges, viaducs etc.did not become valid yet.

BITULINE SPECIFICATIONS ACCORDING TO "TS EN 13969" STANDART

				Bituline® maxima							Bituline® extra											Bituline® prima						
				MG200	MG300	MP300	MP400	MG40M	MP40M	MP50M	EG200	EG300	EP300	EP400	EP300 Antiracine	EP400 Antiracine	EP410	EG40M	EP40M	EP50M	EG30A	EP30A	PG200	PG300	PP300	PP400	PG40M	PP40M	PP50M
APPLICATION	(X)= Yes (-) = No	TYPE A		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		TYPE T		X	X	X	X	-	-	-	X	X	X	X	X	X	X	-	-	-	-	-	X	X	X	X	-	-	-
TEST METHOD	METHOD	UNITS	TOLERANCE																										
REINFORCEMENT	G:Glassfiber P:Polyester	-	-	G	G	P	P	G	P	P	G	G	P	P	P	P	P	G	P	P	G	P	G	G	P	P	G	P	P
UPPER SURFACE COATING	-	-	-	PE FILM				MINERAL			PE FILM								MINERAL		ALUMINIUM		PE FILM				MINERAL		
LOWER SURFACE COATING	-	-	-	PE FILM				PE FILM			PE FILM								PE FILM		PE FILM		PE FILM				PE FILM		
VISIBLE DEFECTS	TS EN 1850-1	-	-	NONE							NONE												NONE						
LENGTH	TS EN 1848-1	m.	min (-0,03)	15	10	10	10	10	10	10	15	10	10	10	10	10	10	10	10	10	10	10	15	10	10	10	10	10	10
WIDTH	TS EN 1848-1	m.	min (-0,02)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
STRAIGHTNESS	TS EN 1848-1	-	-	PASS							PASS												PASS						
THICKNESS	TS EN 1849-1	mm.	± 0,2	2	3	3	4	3,5	3,5	4,5	2	3	3	4	3	4	4	3,5	3,5	4,5	3	3	2	3	3	4	3,5	3,5	4,5
WATERTIGHTNESS	TS EN 1928 (method B 60kPa)	-	-	PASS							PASS												PASS						
REACTION TO FIRE	TS EN 13501-1	EURO CLASS	-	E							E												E						
JOINT STRENGTH	TS EN 12317-1	N/50mm.	± %30	350	350	800	1000	400	800	800	300	600	700	850	700	850	1000	300	700	700	650	800	450	450	500	550	300	600	600
WATER VAPOUR TRANSMISSION	TS EN 1931		min	20000							20000												20000						
TENSILE STRENGTH (longitudinal)	TS EN 12311-1	N/50mm.	-%0;+%30	400	400	800	800	400	800	800	400	400	800	800	800	800	1000	400	800	800	400	800	300	300	600	600	300	600	600
ELONGATION AT BREAK (longitudinal)	TS EN 12311-1	%	G: (-0;+1) P: (-0;+10)	2	2	35	35	2	35	35	2	2	35	35	35	35	40	2	35	35	2	35	2	2	30	30	2	30	30
TENSILE STRENGTH (transversal)	TS EN 12311-1	N/50mm.	-%0;+%30	300	300	600	600	300	600	600	300	300	600	600	600	600	800	300	600	600	300	600	200	200	400	400	200	400	400
ELONGATION AT BREAK (transversal)	TS EN 12311-1	%	G: (-0;+1) P: (-0;+10)	2	2	35	35	2	35	35	2	2	35	35	35	35	40	2	35	35	2	35	2	2	30	30	2	30	30
RESISTANCE TO IMPACT	TS EN 12691 (method A)	mm.	min	150	250	500	750	750	1000	1000	200	300	550	550	550	550	1500	750	1000	1000	1250	1250	250	350	600	600	750	1000	1000
RESISTANCE TO STATIC LOADING	TS EN 12730 (method B)	kg.	min	5	5	15	15	15	20	20	5	5	15	15	15	15	15	15	20	20	25	25	5	5	15	15	15	20	20
RESISTANCE TO TEARING	TS EN 12310-1	N	± %30	150	150	200	250	150	200	270	100	100	150	200	150	200	200	100	150	150	150	200	75	75	100	150	100	125	125
FLEXIBILITY AT LOW TEMPERATURE	TS EN 1109	°C	min	-20	-20	-20	-20	-20	-20	-20	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-5	-5	-5	-5	-5	-5	-5
ARTIFICIAL AGEING BEHAVIOUR	TS EN 1296 / TS EN 1928 (method B 60kPa)	-		PASS							PASS												PASS						
DURABILITY AGAINST CHEMICAL	TS EN 1847 / TS EN 1928 (method B 60kPa)	-		PASS							PASS												PASS						
DANGEROUS SUBSTANCES	-	-		NONE							NONE												NONE						

TS EN 13969 "Flexible sheets for waterproofing - Bitumen damp proof sheets including bitumen basement tanking sheets."

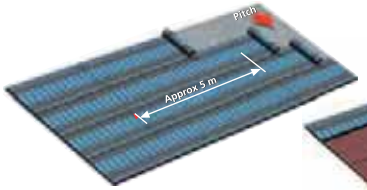
*The Harmonization Standart prEN 14695 "Flexible sheets for waterproofing - Reinforced bitumen sheets for waterproofing of concrete bridge decks and other concrete surfaces trafficable by vehicles "for Bituline EP410 "Heavy Duty" waterproofing membrane for use in the waterproofing of highways pavements, road bridges, viaducs etc.did not become valid yet.


Bituline
prima
Onduline Arroyo A.Ş.

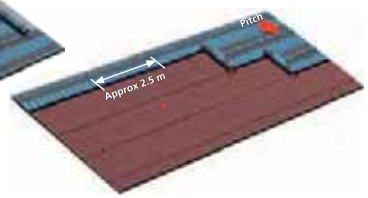
APPLICATION GUIDELINES

The rolls should be stored in upright position. Do not store under direct sunlight. If the use of materials in cold weather is desired they should be stored at standart room temperature for 24 hours before application in order to render workmanship easy and sound. No applications should be made under cold weather conditions where the temperature tends to fall below +5°C. Bituline waterproofing membranes have No specific hazards for human and enviromental under normal use conditions and they do not contain any dangerous substances.

The application of Bituline in two layers, the sublayer being reinforced with fiberglass and the second layer with polyester is considered to be a good practice when waterproofing is to be made on flat roofs with inclinations up to 5%. The selection of the type and thickness of the membrane to be applied depend on the caracteristic of the type or mode of utilization of the building and to the climatic conditions prevailing in the area. Excessive care should be taken to ensure that application surface on which the membrane is to adhere is clean and dry at time of application and a single layer of undercoat Bituline Primar should be applied to the surface to ensure a good retention. In full adhesion technique all the surfaces along which the upper membrane layer contacts with the ground or with the sublayer membrane are treated with fusion welding technique using a welding torch.



Application of the 1st layer



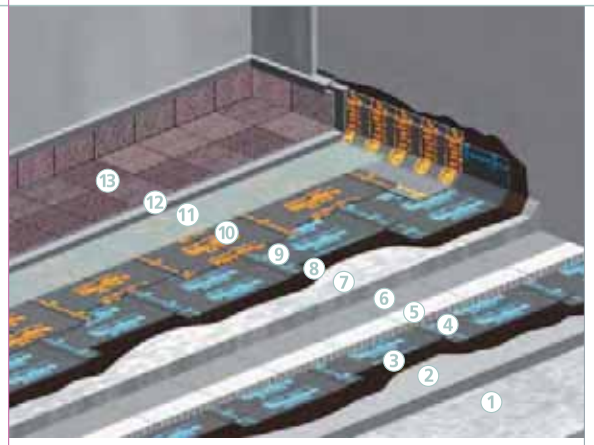
Application of the 2nd layer

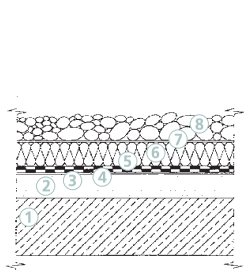
When Bituline Perfor is used the membrane shall facilitate an ideal vapor distribution as it will adhere onto the ground on a pointwise basis. However, Bituline Perfor should be laid avoiding any material overlaps and should never be adhered to the application surface at a prior time. The fusion weld should be applied to the first membrane layer coming over and appropriate measures should be taken to ensure that the bitumen melt due to fusion adheres to the surface perfectly after passing throught the holes of Bituline Perfor.

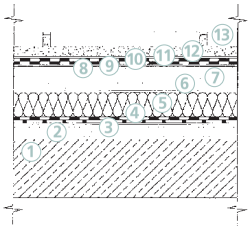
d- Bituline rolls should be aligned so that they overlap one another by 10 cm both at lenght and width. While overlapping mineral coated membranes at lenght the granules must be scrapped off completely followed by their heating using the welding torch and embedding them into the membrane to produce an

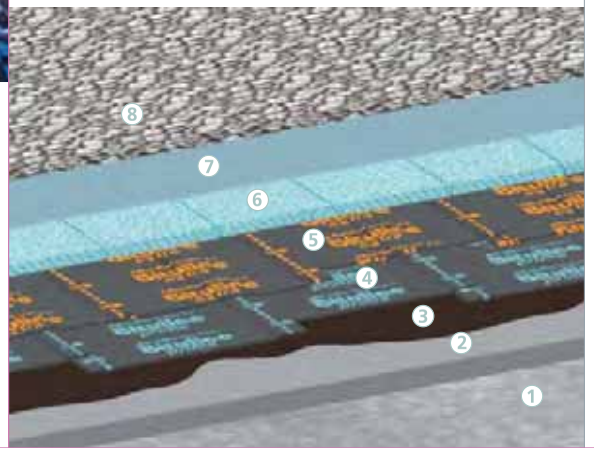
overlapping lenght of 15 cm.

Rows of membrane should be performed perpendicular to the direction of slope in all layers while care is taken to avoid intersection or overlapping of joints to the extent possible, employing the deviation technique.









Passable roofs

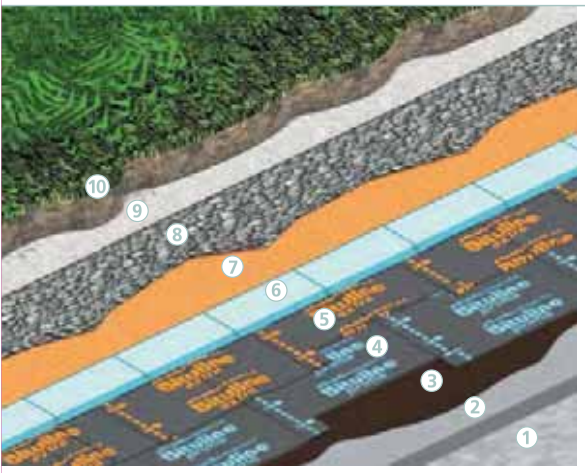
At terrace type open roofs insulated with the conventional system the heat insulation layer is placed under the waterproofing layer where there is a wide variety of options to use for this purpose. Including glasswool or rockwool with a minimum density of 150 kg/cbm and XPS extruded or EPS expanded polystrene foams with a minimum density of 30 kg/cbm.

1- Concrete pavement
2- Leveling screed (if needed)
3- Primer
4- Vapor barrier (linear and pointwise adhesion)
5- Heat insulation material
6- Polyethylene folio
7- Sloping concrete
8- Primer
9- 1st layer of Bituline with polyester reinforcement
10- 2nd layer of Bituline with polyester reinforcement
11- Geotextile as separating layer
12- Mortar
13- Tiles

Non-passable roofs

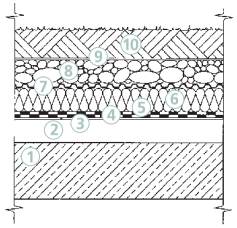
In inverted roofing systems there is no need for using of a vapor barrier as the heat insulation layer standts above the waterproofing. On the other hand, heat insulation should be absolutely provided by employing a waterproof material (i.e.XPS) and consideration should be given to the fact that a certain amount of heat loss would occur due to the passage of rain water discharged underneath the heat insulation layer.

1- Concrete pavement
2- Sloping concrete
3- Primer
4- 1st layer of Bituline with fiberglass reinforcement
5- 2nd layer of Bituline with polyester reinforcement
6- XPS Extruded polystrene heat insulation board
7- Geotextile as separating layer
8- Gravel

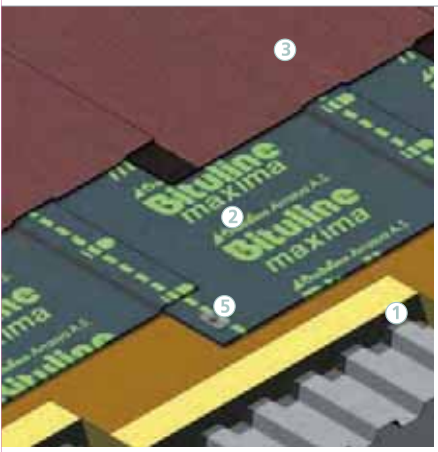


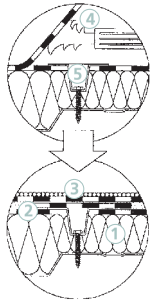
Roof gardens

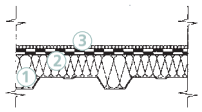
Both the classical and inverted waterproofing systems may be applied to passable or non-passable roofs or roof gardens.



1- Reinforced concrete flooring
2- Sloping concrete
3- Primer
4- 1st layer of Bituline with fiberglass reinforcement
5- 2nd layer of Bituline with polyester reinforcement
6- XPS Extruded polystrene heat insulation board
7- Fondaline HDPE membrane
8- Gravel
9- Geotextile as separating layer
10- Soil



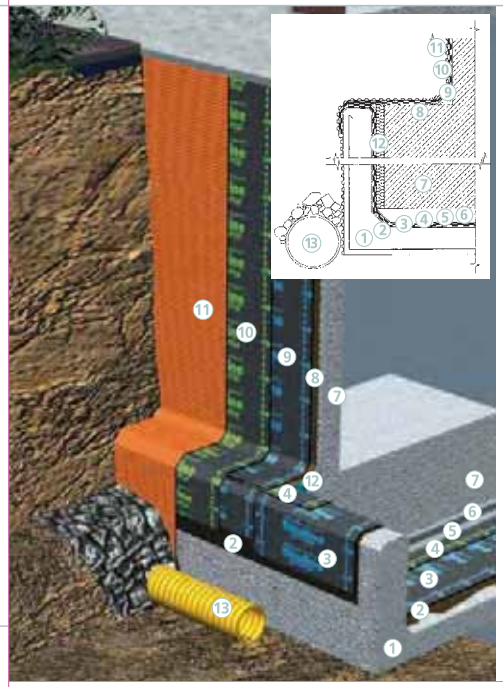




Oversheeting of light metallic roofs.

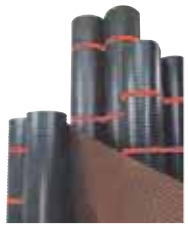
For waterproofing of light metallic roofing systems commonly used for covering concrete, heavy prefabricated or steel systems, the sublayer membrane is fixed onto the roof panel applying mechanical means. A membrane layer coated with granulated mineral is employed as the second layer. Here a s a widely flexible moving roof system is concern it is essential that membranes with high elastomeric characteristics should be preferred.

1- Kraft paper covered heat insulated light metallic roof panel
2- 1st layer of Bituline with polyester reinforcement
3- 2nd layer of Bituline with mineral surface protection and polyester reinforcement
4- Adhesion using torch
5- Mechanicak fixing



Protection of the Foundations and basements

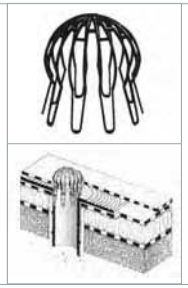
Fondaline, made of HDPE "high density polyethylene" is used for the draining of ground water and the protection of the underground waterproofing systems against damages caused by ground pressure. Its strong and flexible naps resist against the mechanical impacts caused by the back filling of the ground avoiding any kind of damage on the surface of the waterproofing layer. The air gap created by the naps of Fondaline between the ground and building parts like basement walls or floors is ideal for all kinds of drainage.
The underground parts of buildings must be protected against damp and ground water. This is not only necessary for a comfortable use of the building but also for safety reasons. Humidity leads to the corrosion of the steel. When rust affects the reinforcement of the concrete the structure system is also damaged and this can be dangerous for the stability of the building especially in critical situations like earthquakes. Therefore, foundations and basements have to be waterproofed. Moreover, the waterproofing materials are very sensitive. If not properly protected, they are under the risk of being damaged during the back-filling of the building site. Fondaline's tough but flexible body absorbs mechanical impacts of ground parts like stones and gravel and prevents any such damage on the waterproofing layer even if they might hit the wall. Furthermore the air gap created by Fondaline's naps links the ground water to the drainage tube on the bottom. In places where there is no risk of ground water, Fondaline is also efficient if it is used as a single layer for damp proofing. During the life-time of the building Fondaline continues to protect the underground walls also against the attacks of roots and most chemicals which might be harmful for underground building parts. Fondaline has to be placed so that the black side touches the wall, the brown side the soil. Rolls can be applied horizontally or vertically depending on the depth of the building. Overlaps of 10 cm are necessary. Until the back-filling the position of Fondaline has to be fixed so that no damage occurs on the waterproofing by any kind of fixing element . For this purpose the system consisting of self adhesive nails and washers can be used. If needed, the system can also be combined with hard-board insulation panels like XPS or EPS. Fondaline can be nailed directly to concrete only on levels where there is no risk of infiltration of damp or ground water.



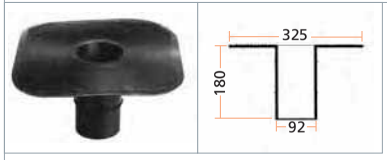
1- Precats concrete
2- Primer
3- 1st layer of Bituline with polyester reinforcement
4- 2nd layer of Bituline with polyester reinforcement
5- Geotextile separation layer
6- Protective concrete
7- Reinforced concrete system
8- Primer
9- 1st layer of Bituline with polyester reinforcement
10- 2nd layer of Bituline with polyester reinforcement
11- Fondaline HDPE membrane
12- EPS or XPS Heat Insulation protector
13- Drainage pipe

TECHNICAL SPECIFICATIONS	Fondaline 500	Fondaline 600
MATERIAL	High density polyethylene	
COLOR	Brown (to the ground)	Black (to the building)
WEIGHT	500 gr/m²	600 gr/m²
THICKNESS	0,5 mm	0,6 mm
LENGTH	20 m	
WIDTH	2,0 m	
HEIGHT OF NAPS	8 mm	
QUANTITY OF NAPS	1800 pcs/m²	
WIDTH OF PLAIN SIDE	70 mm	
COMPRESSION STRENGTH	≥150 kN/m²	≥250 kN/m²
ELONGATION	45,4 %	43,6 %
TENSILE STRENGTH	8,0 kN/m	8,44 kN/m
TEAR RESISTANCE	200 N	375 N
REACTION TO FIRE	B2	
TEMPERATURE STABILITY	-30°C ÷ +80°C	
DRAINAGE GAP	5,5 l / m²	

Bituline Primer
High quality non-ionic bitumen emulsion produced in accordance with TS113.
Packaging: 17 kg Net metal canister.

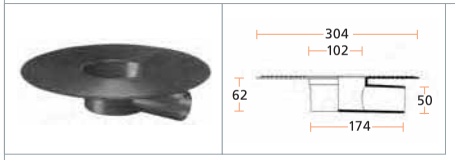


Round leaf trap
For vertical and horizontal rainwater outlets

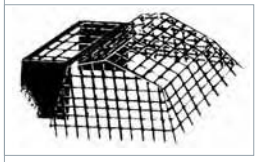


Rainwater hopper with vertical outlet
Thermoplastic rubber
Outside diameter: 92 mm
(Fits to Ø 100 PVC pipe)
Depth: 180 mm

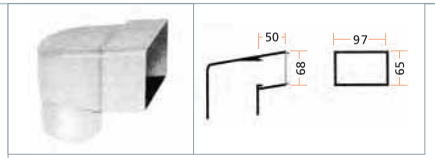
Wall base rainwater hopper
Thermoplastic rubber
Outlet dimensions: 65 mm X 97 mm
(fits to 70 X 100 square pipe)
Depth: 425 mm



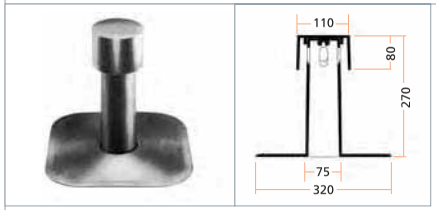
Rainwater hopper with horizontal outlet
Thermoplastic rubber
Outside diameter: 50 mm
(Fits to Ø 50 PVC pipe)



Prismatical leaf trap
For wallbase rainwater outlets

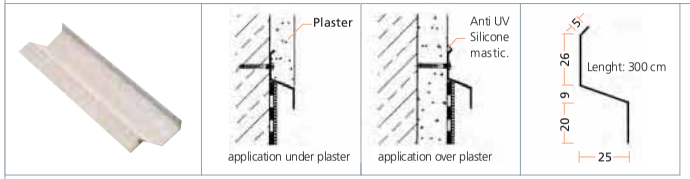


Round pipe adaptor
For wall base Rainwater outlet
Outside diameter: 92 mm
(Fits to Ø 100 PVC pipe)



Air shaft
Thermoplastic rubber
Inside diameter: 75 mm
Heigh: 270 mm

Inside and Outside corner piece
for sealing at membrane joints



Aluminium Z-profile
for finishing details
lenght: 300 cm

Fondaline fixing device
for fixing Fondaline to the waterproofing membrane
Self sticking base
Lenght: 6 cm

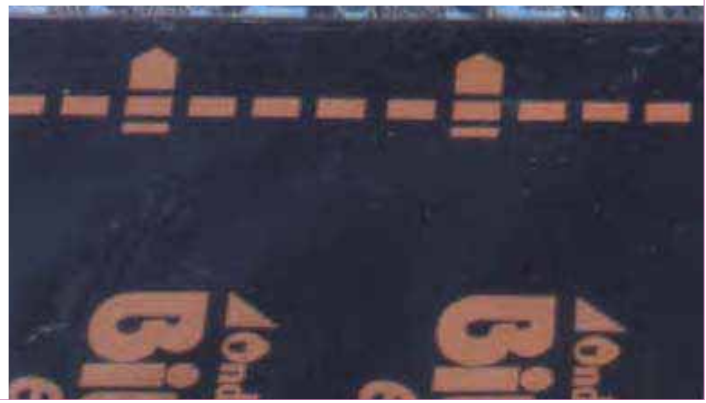
Onduline Roofing Torch
Made of durable materials for professionnal use Onduline roofing torch includes all parts necessary to torch down modified bitumen sheets in all climates. The kit includes: Piezo ignitor, Quick connect fittings, LP Gas Hose, Regulator, Squeeze Valve and Adjusting Valve. Lenght: 30 cm. and 40 cm.

REFERENCES

Bituline
maxima

Bituline

Onduline Arrasya A.Ş.
Bituline
extra



Bituline
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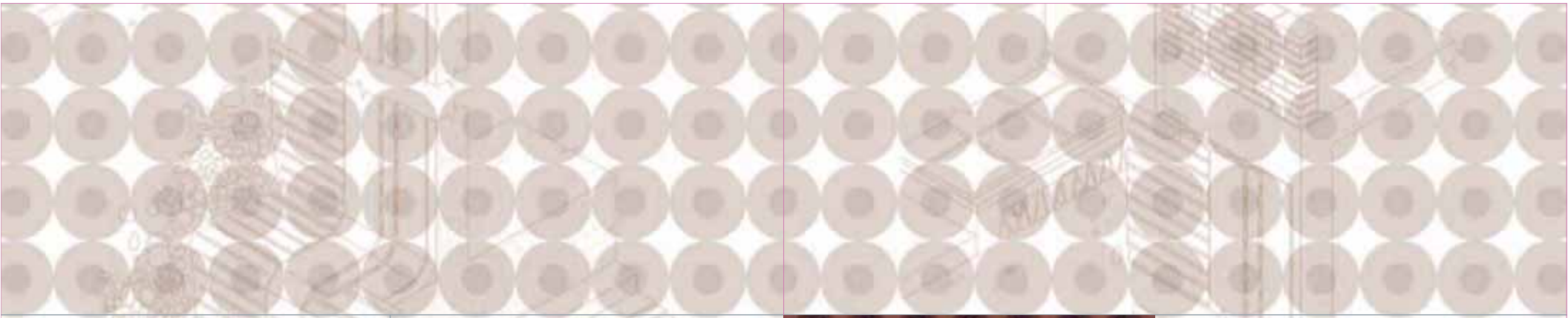

TS EN 13967

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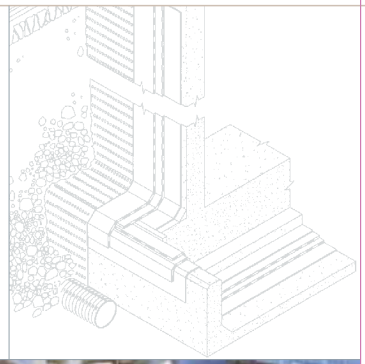
FONDALINE İNG-06/2008/1000/002

System Fondaline®

Damp-Proofing and Drainage Membrane for the Protection of Foundations and Basements

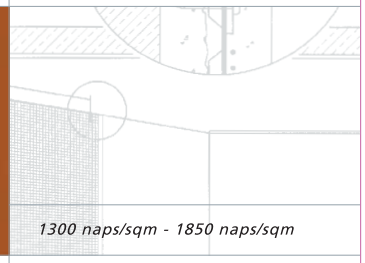
NEW PRODUCTION - HIGH QUALITY

Fondaline, made of high density polyethylene is used for the draining of ground water and the protection of the underground waterproofing systems against damages caused by ground pressure. Its strong and flexible naps resist against the mechanical impacts caused by the back filling of the ground avoiding any kind of damage on the surface of the waterproofing layer. The air gap created by the naps of Fondaline between the ground and building parts like basement walls or floors is ideal for all kinds of drainage.
The modern line of Onduline Italia plant in Altopascio has been equipped with the newest technologies and enables the production of high density polyethylene membranes of high performance and long life time.



The naps of Fondaline resist against compressions even higher than 250 kN/m² keeping continuously an air gap of 5,5 l/sqm between the walls or floors of the building and itself. This space is big enough for the drainage of the rain or ground water, as well as for the evaporation of humidity if supported with a suitable system of ventilation.

In the underground parts of the building there is also the problem of the compression caused by the soil leaning to the basement walls. Fondaline's 1850 naps by sqm provide a homogenous distribution of the ground pressure and do not allow any mechanical damage on the surface of the waterproofing materials.

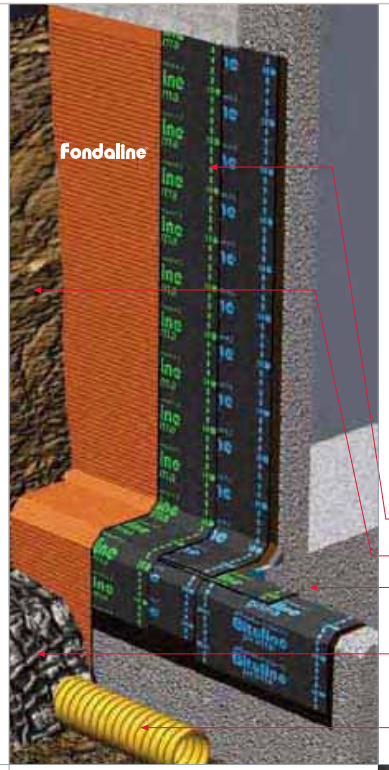


1300 naps/sqm - 1850 naps/sqm

PROTECTION OF BASEMENT WALLS AND FOUNDATIONS

DESCRIPTION:

The underground parts of buildings must be protected against damp and ground water. This is not only necessary for a comfortable use of the building but also for safety reasons. Humidity leads to the corrosion of the steel. When rust affects the reinforcement of the concrete the structure system is also damaged and this can be dangerous for the stability of the building especially in critical situations like earthquakes. Therefore, foundations and basements have to be waterproofed.
Moreover, the waterproofing materials are very sensitive. If not properly protected, they are under the risk of being damaged during the back-filling of the building site. Fondaline's tough but flexible body absorbs mechanical impacts of ground parts like stones and gravel and prevents any such damage on the waterproofing layer even if they might hit the wall.



Furthermore the air gap created by Fondaline's naps links the ground water to the drainage tube on the bottom.
In places where there is no risk of ground water, Fondaline is also efficient if it is used as a single layer for damp proofing.
During the life-time of the building Fondaline continues to protect the underground walls also against the attacks of roots and most chemicals which might be harmful for underground building parts.

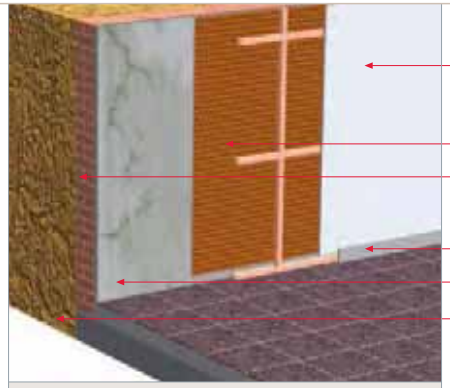
APPLICATION:

Fondaline has to be placed so that the black side touches the wall, the brown side the soil. Rolls can be applied horizontally or vertically depending on the depth of the building. Overlaps of 10 cm are necessary.

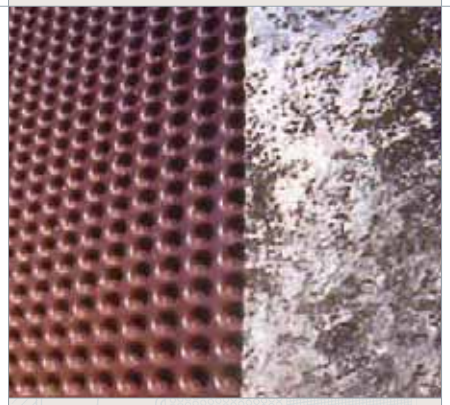
Until the back-filling the position of Fondaline has to be fixed so that no damage occurs on the waterproofing by any kind of fixing element . For this purpose the system consisting of self adhesive nails and washers can be used. If needed, the system can also be combined with hard-board insulation panels like XPS or EPS. Fondaline can be nailed directly to concrete only on levels where there is no risk of infiltration of damp or ground water.

INTERNAL REPAIR OF WALL DAMAGES CAUSED BY DAMP AND HUMIDITY

DESCRIPTION:
If basements are not correctly waterproofed from outside, the walls get mouldy and the damage of the humidity cannot be repaired by repainting or plastering from inside.
If Fondaline is applied together with a new layer of plaster or gypsum board, the final surface of the wall remains clean and smooth. Combined with openings for ventilation on the floor- and ceiling level the air gap created by Fondaline between the new finishing and the existing wall helps also to the evaporation of the damp.



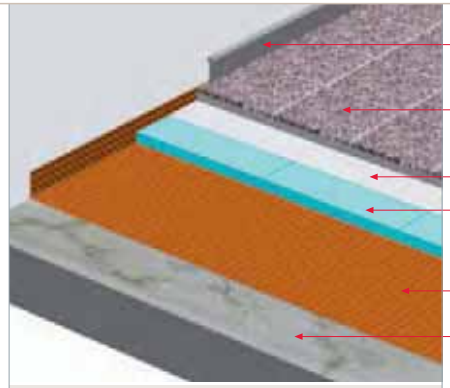
APPLICATION:
In case of roughness the existing plaster has to be repaired with cement based compounds. Fondaline has to be placed with the black side against the wall. It has to be fixed every 30cm by nails or dowels and screws. Overlaps must be of 10cm. If plaster is used for the final finishing, a reinforcement mesh, to be fixed to the wall together with Fondaline is necessary.



INTERNAL REPAIR OF FLOOR DAMAGES CAUSED BY DAMP AND HUMIDITY

DESCRIPTION:
Mould is a problem also for ground slabs. If no waterproofing is made during the construction period, damages and deformations appear on finishing layers of ground slabs caused by humidity. The problem can be solved by an additional damp-proofing layer.

Fondaline is the ideal material for the internal damp–proofing of floors, because it can resist not only against humidity, but also against vertical loads, as Fondaline's 8mm high naps do not squash down. So, a continuous air gap is provided between the existing- and the new floor, which can also be ventilated at wall flashings.

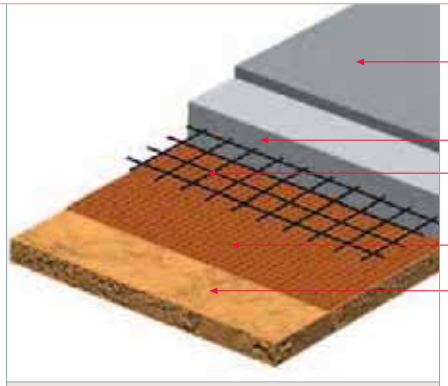


APPLICATION:
In case of roughness the existing floor has to be repaired with cement based compounds. Fondaline has to be laid with the naps (black side) to the ground. It has to be fixed every 30cm. Overlaps must be of 10cm. At wall flashings 10cm of Fondaline has to be turned upwards in order to provide a good air circulation. If necessary an insulation layer of XPS or EPS can be laid over Fondaline, which is to be covered with reinforced screed and flooring materials.

PROTECTION OF GROUND SLABS AGAINST HUMIDITY COMING FROM THE GROUND

DESCRIPTION:

Even if concrete slabs for open areas are coated with materials like asphalt, they have to be protected against the humidity coming from the ground. The damp-proofing layer must be also resistant against impacts, compression and tearing otherwise it can easily be damaged during the construction works for the application of the ground slab. The concrete is well protected if Fondaline is laid loosely on the compressed ground. The system is also safe against mechanical damages, as the loading capacity of Fondaline is over 25 tons / sqm.



APPLICATION:

Fondaline is laid loosely on the ground with the black side downwards. The overlaps have to be 20cm.

TECHNICAL SPECIFICATIONS	Fondaline 400	Fondaline 500	Fondaline 600
MATERIAL	High density polyethylene		
COLOR	Brown (to the ground) Black (to the building)		
WEIGHT	400 gr/sqm	500 gr/sqm	600 gr/sqm
THICKNESS	0,4 mm + - %10	0,5 mm + - %10	0,6 mm + - %10
LENGTH	20 m		
WIDTH	0,5 - 1,0 - 1,5 - 2,0 - 2,5 - 3,0 - 3,5 - 4,0 m		
HEIGHT OF NAPS	8 mm		
QUANTITY OF NAPS	1850 pcs/sqm		
WIDTH OF PLAIN SIDE	70 mm		
COMPRESSION STRENGTH	>100 kN/sqm	>150 kN/sqm	>250 kN/sqm
ELONGATION	% 37	% 45,4	% 43,6
TENSILE STRENGTH	5,3 kN/m	6,0 kN/m	8,64 kN/m
TEAR RESISTANCE		200 N	325 N
TEMPERATURE STABILITY		-30°C - + 80°C	
DRAINAGE GAP		5,5 L / sqm	

TYPAR® GEOTEXTILES

UNPAVED ROADS
LESS AGGREGATE, LESS RUTTING

PAVED ROADS AND PARKING LOTS
LONGER LIFE, LESS MAINTENANCE

INDUSTRIAL YARDS
LESS AGGREGATE, LONGER LASTING

SUBSURFACE DRAINS
PRESERVES DRAINS

EROSION CONTROL
PREVENTS PIPING

LANDFILLS
TOUGH, DURABLE AND STOPS CLAY

RECREATION FACILITIES
EASY INSTALLATION,
MINIMAL MAINTENANCE

WASTE HANDLING SYSTEMS
PREVENTS SOIL INTERMIXING
FOR LONG LASTING SEPTIC SYSTEMS

LANDSCAPING
EFFECTIVE WEED CONTROL

Typar is the tough, long lasting and versatile geotextile fabric to cut your construction and maintenance costs.

TYPAR® GEOTEXTILES

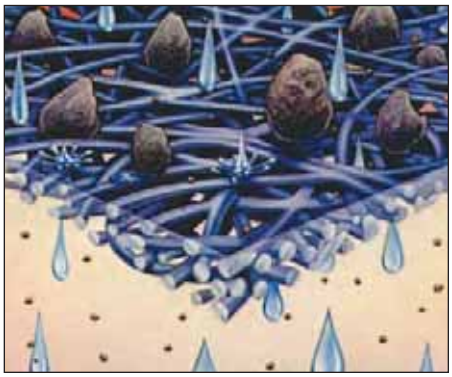
TYPAR – The ideal geotextile

Typar is a long lasting, durable nonwoven geotextile fabric for paved and unpaved roads and surfaces, drainage, waste handling systems, erosion control and landfills. Manufactured from high quality polypropylene, Typar is a continuous filament, heat bonded fabric with superior uniformity that separates, reinforces and filters soil particles while letting water pass freely through.

No matter what your needs, Typar geotextiles offer an easy to install, economical and proven alternative to more expensive and less effective construction materials and methods.

Typar is a high quality geotextile that offers a number of benefits including:

- Lower construction cost from reduced aggregate base thickness
- Reduction in construction time from reliable product quality and ease of installation
- Reduction in ongoing maintenance costs through Typar's proven performance, toughness and durability over time



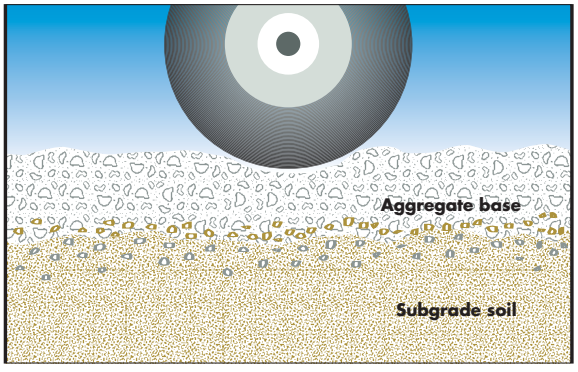
Typar is available in a variety of widths and lengths and weights ranging from 1.5 oz/yd^2 to 8 oz/yd^2. The requirements of AASHTO M288 are met by the following styles:

Class 3 – Typar 3401
Class 2 – Typar 3501
Class 1 – Typar 3631

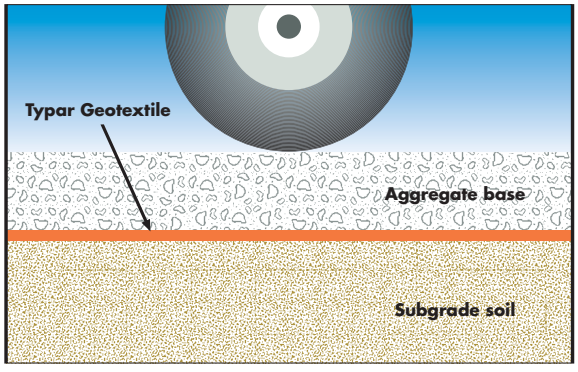
Unpaved Roads and Industrial Yards

Unpaved roads and yards built without an asphalt or concrete surface course derive all structural support from the aggregate base and are generally used by heavy trucks and equipment that are prone to cause severe damage. Greater thicknesses of aggregate base are needed to support the loads. Typar is vital to prevent intermixing of the aggregate into the subgrade soil which results in ruts and pot holes.

- Prevents intermixing of aggregate with underlying soils
- Reduces the thickness of aggregate required
- Eliminates the need for frequent re-application of aggregate



Without Typar, soil contaminates and weakens aggregate base resulting in failure of the road.



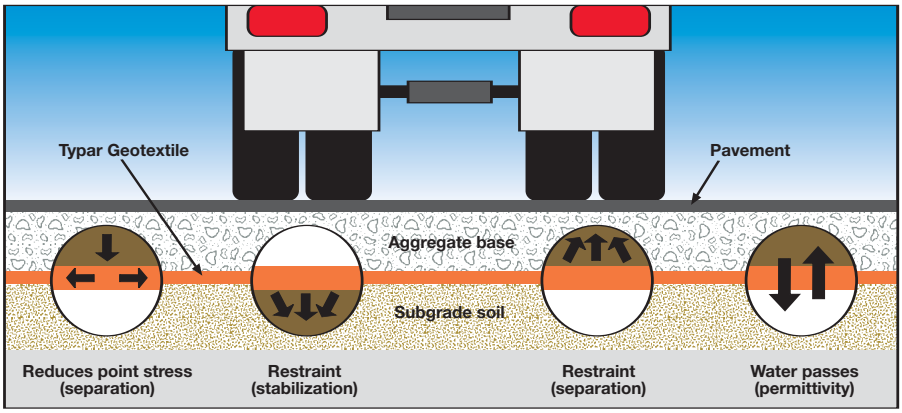
With Typar, aggregate won't sink into poor soil but stays in tact to support loads.

Paved Roads and Parking Lots

Typar provides a rugged separation and stabilization layer between the road structure and the subgrade soils. The use of Typar in this application goes back over 30 years, and is proven to be an exceptionally durable geotextile.

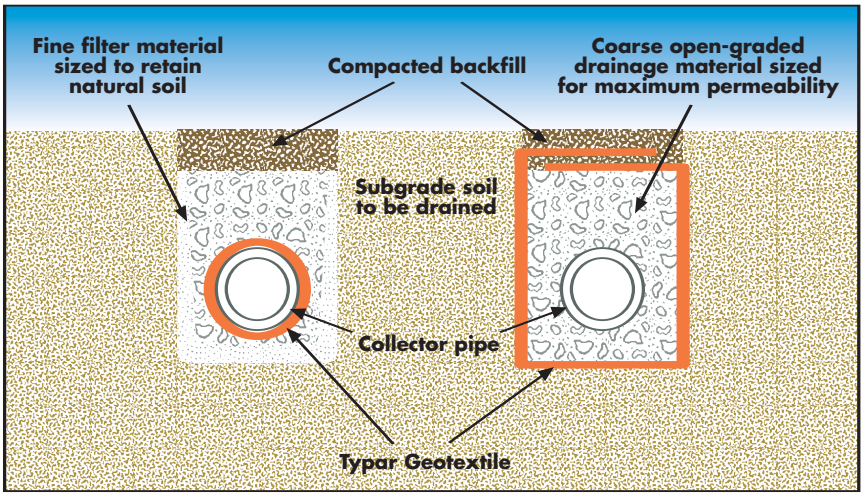
- Prevents mixing of the valuable road base aggregate with the underlying subgrade soils
- Enhances drainage of the subgrade soils while preventing pumping of fine soil particles into the base aggregate
- Reduces the required amount of road base aggregate by preventing intermixing
- Assures long term prevention of road base deterioration

Typar stabilizes and preserves paved roads by providing a separation layer between the aggregate base and subgrade.



Subsurface Drains

Subsurface drains require a properly designed protective layer that prevents the movement of soil into a drain that would cause clogging of the drainage system. Typar geotextiles provide a uniform filter layer around subsurface drains, allowing water to pass freely into and through to the drain. Typar Geotextiles also function similarly behind retaining walls and next to pools.



Interceptor drain systems.

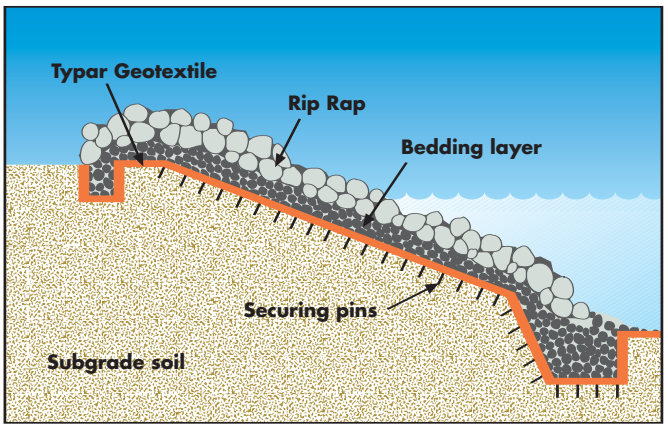
- Prevents migration of subgrade soil particles into the drain
- Enhances the natural long-term development of a graded particle filter
- Reduces construction time and cost
- Eliminates the cost and difficulty of constructing an alternative graded aggregate filter
- Easy to handle and install
- Typar is available in a range of opening sizes to deal with most any soil

Erosion Control

Erosion control structures dissipate the mechanical and hydraulic forces that cause erosion of the soil behind them. Typar geotextiles provide a dependable filter and protection layer for stream banks, shorelines, slopes, submerged foundations, retaining walls, bulkheads and revetments. Typar is installed with a layer of bedding stone under armor stone (rip rap), gabions or pre-cast block systems.

Bedding stones are needed to provide intimate contact (prevent piping), UV protection, protection from armor stones and vandalism.

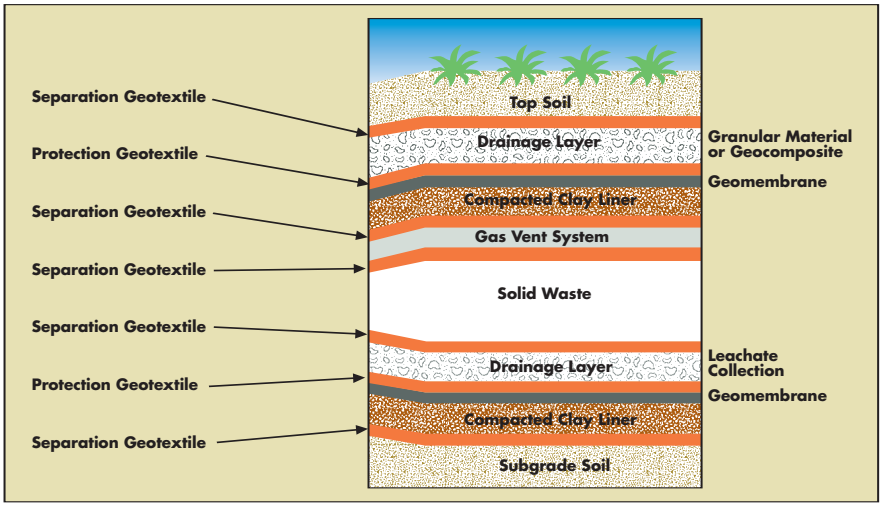
- Prevents undermining of the armor layer by soil movement
- Enhances drainage of the slope soils without associated pumping or piping of fine soil particles
- Eliminates the difficulty and uncertainty associated with graded aggregate systems
- Simplifies construction and reduces construction time and cost



Stream bank erosion control.

Landfills

Typar geotextiles serve a number of important functions in all types of landfill and waste management applications. It is used as a protective layer to prevent geomembrane liner damage, as a permeable separation layer to preserve drainage integrity and prevent clay intrusion into a geonet, and in landfill cover systems as well as for temporary daily covers. Because Typar resists a wide range of chemicals, it is frequently used in hazardous waste landfills which must meet stringent EPA regulations and FHWA drainage criteria. Typar has particularly high strength and tear resistance properties when compared to other geotextiles of the same weight making it the economical choice.



Typical hazardous waste landfill lining and cover system to meet EPA regulations.

- Typar is a very effective and durable daily cover, easy to use and store
- Prevents damage to or abrading of the geomembrane during its deployment and the placement of overlying materials
- High modulus protects drainage layers from soil intrusion
- Small opening size prevents clay from passing into leachate collection and leak detection layers
- Resists chemical attack
- Assures long term tear resistance

Recreational Facilities

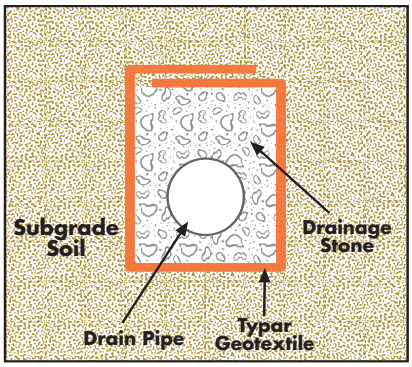
From football fields, baseball parks and race tracks to golf courses, Typar geotextiles are needed to keep layers of the structure separate and prevent contamination of customized surfaces by underlying soils. Blanket and trench drain systems for recreational facilities often use Typar for economical reasons and for ease of installation permitting fast, simple construction.

- Preserves the integrity of specialized surface materials
- Enhances the natural long-term development of a graded particle filter
- Eliminates the need for sacrificial layers and allowances in the structure
- Simplifies construction and reduces construction time and cost

Waste Handling Systems

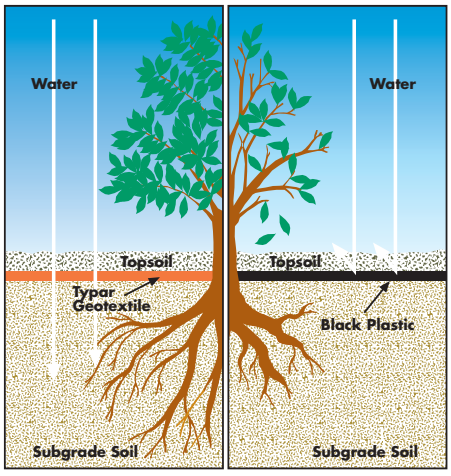
On site waste water disposal or septic systems serve approximately one-third of the households in the United States. Septic systems are designed to disperse large volumes of liquid by percolation into the ground through large subsurface drainage systems. Typar extends the system life significantly.

- Prevents soil particles from clogging large drainage systems
- Enhances the passing of liquid through the system
- Unaffected by most chemicals
- Simplifies construction of large drainage fields
- Proven alternative to graded aggregate or sand filters which are more expensive and difficult to install



Typar is a permeable barrier that separates soil from drainage material.

Landscaping



Compared to the plastic film on the right, Typar's porous structure allows water, nutrients and air to pass through to plant roots

Typar is ideally suited for landscaping applications. Its permeability allows for fast drainage and the passage of air and fertilizers. Its tight fiber structure minimizes penetration by weeds and roots and prevents unwanted growth beneath the fabric. Its small opening size prevents piping or erosion of subgrade soils. Typar is generally placed over natural soil and covered with a layer of decorative stone, bark or mulch. Weed growth is inhibited in landscaped beds and under decks. Gravel and stone paths retain their structure longer by separating cover materials from subgrade soils. When roots are a problem particularly in sidewalks, curbs and drainage systems, Typar Biobarrier® root control system should be used which involves the controlled release of a herbicide from the Biobarrier® fabric system.

- Allows moisture, fertilizers and air to reach soil for healthy plants
- Reduces weed germination
- Prohibits weed growth beneath fabric
- Prevents uneven settling of patios
- Durable, tear resistant, won't rot or mildew
- Lightweight and easy to install
- Assures long term minimal maintenance of the landscape

TYPAR English Properties

AASHTO Class M288			-	-	-	-	3	2	2	1	1
			Typar 3151	**Typar 3201**	**Typar 3301**	**Typar 3341**	**Typar 3401**	**Typar 3501**	**Typar 3601**	**Typar 3631**	**Typar 3801**
MECHANICAL (MARV)[1]											
Grab tensile strength	ASTM D4632	lbs	35	60	120	120	130	160	240	250	300
Grab elongation	ASTM D4632	%	60	60	60	60	60	60	60	60	60
Trapezoidal tear strength	ASTM D4533	lbs	15	25	35	40	60	60	90	90	95
Puncture strength	ASTM D4833	lbs	10	18	25	34	41	56	67	81	93
CBR Puncture	ASTM D6241	lbs	-	-	-	-	225	310	370	435	510
ENDURANCE (MARV)[1]											
UV resistance @ 500 hrs	ASTM D4355	%	-	-	-	70	70	70	70	70	70
HYDRAULIC (MARV)[1]											
Apparent opening size[2]	ASTM D4751	US Sieve	20/30	30	50	60	70	70	140	140	170
Permittivity	ASTM D4491	sec^{-1}	1.5	1.0	0.8	0.7	0.7	0.5	0.1	0.2	0.1
Water flow rate	ASTM D4491	$gal/min/ft^2$	235	190	95	85	60	50	15	20	8
PHYSICAL (Typical)											
Unit weight		oz/yd^2	1.6	1.9	3.0	3.4	4.0	5.0	6.0	6.3	8.0
Roll diameter		in	7	7	8	8	9	10	10	10	12
Length		yd	100	100	100	100	100	100	100	100	100
Width		in	151	151	151	151	151	151	151	151	151
Roll area		yd^2	419	419	419	419	419	419	419	419	419
Roll weight gross		lbs	50	58	87	97	113	138	165	173	218
Width		In	-	-	-	-	187	187	187	187	187
Roll area		yd^2	-	-	-	-	519	519	519	519	519
Roll weight gross		lbs	-	-	-	-	142	175	209	219	275

NOTES:
1 Minimum average roll values (MARV) in the weaker principal direction
2 O_{95} Max. ARV

Product Selection Guide

	3151	3201	3301	3341	3401	3501	3601	3631	3801
Paved roads & parking lots				●	●	●	●	●	
Unpaved roads				●	●	●	●	●	
Industrial yards				●	●	●	●	●	
Subsurface drains		●	●	●	●	●	●	●	
Erosion control				●	●	●	●	●	●
Landfills				●	●	●	●	●	●
Recreational facilities		●	●	●	●	●	●	●	
Waste handling systems	●	●	●	●	●	●	●	●	●
Landscaping		●	●	●	●				

Typar also has many other unique related applications.

TYPAR Metric Properties

AASHTO Class M288			-	-	-	-	3	2	2	1	1
			Typar 3151	**Typar 3201**	**Typar 3301**	**Typar 3341**	**Typar 3401**	**Typar 3501**	**Typar 3601**	**Typar 3631**	**Typar 3801**
MECHANICAL (MARV)[1]											
Grab tensile strength	ASTM D4632	N	156	267	533	533	578	710	1067	1110	1445
Grab elongation	ASTM D4632	%	60	60	60	60	60	60	60	60	60
Trapezoidal tear strength	ASTM D4533	N	70	110	155	180	270	270	400	400	425
Puncture strength	ASTM D4833	N	45	80	110	150	180	250	300	360	415
CBR Puncture	ASTM D6241	N	-	-	-	-	990	1375	1650	1925	2285
ENDURANCE (MARV)[1]											
UV resistance @ 500 hrs	ASTM D4355	%	-	-	-	70	70	70	70	70	70
HYDRAULIC (MARV)[1]											
Apparent opening size[2]	ASTM D4751	mm	0.840	0.590	0.300	0.250	0.212	0.200	0.100	0.100	0.090
Permittivity	ASTM D4491	sec^{-1}	1.5	1.0	0.8	0.7	0.7	0.5	0.1	0.2	0.1
Water flow rate	ASTM D4491	$l/min/m^2$	9635	7790	3895	3485	2460	2050	615	820	328
PHYSICAL (Typical)											
Unit weight		g/m^2	54	65	104	116	136	170	204	214	272
Roll diameter		mm	180	180	200	200	230	250	250	250	300
Length		m	91.4	91.4	91.4	91.4	91.4	91.4	91.4	91.4	91.4
Width		m	3.83	3.83	3.83	3.83	3.83	3.83	3.83	3.83	3.83
Roll area		m^2	350	350	350	350	350	350	350	350	350
Roll weight gross		kg	23	26	40	44	51	63	75	79	100
Width		m	-	-	-	-	4.75	4.75	4.75	4.75	4.75
Roll area		m^2	-	-	-	-	434	434	434	434	434
Roll weight gross		kg	-	-	-	-	63	78	93	98	124

NOTES:
1 Minimum average roll values (MARV) in the weaker principal direction
2 O_{95} Max. ARV

Product Width Guide

Width (inches)*	**3151**	**3201**	**3301**	**3341**	**3401**	**3501**	**3601**	**3631**	**3801**
36		●	●						
48		●	●		●				
60	●				●				
75		●	●						
108			●						
151	●	●	●	●	●	●	●	●	●
187					●	●	●	●	●

**Available in other put-ups*

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Old Hickory, TN 37138-3651
Toll Free: 800-321-6271
Tel: 615-847-7000
Fax: 615-847-7068
www.typargeotextiles.com

Distributed by:

Fiberweb™

TYPAR® GEOTEXTILES

Bio barrier®

Note: Typar is manufactured from the highest quality polypropylene. During the manufacturing process a surface tension is formed on the product which, prior to contact with soil, will cause water to run off the fabric giving the appearance of water resistance. This is a temporary phenomenon which disappears when the fabric comes into contact with soil, and normal hydraulic properties will take effect.

The information contained herein is offered free of charge and is, to the best of our knowledge, accurate. However, since the circumstances and conditions under which such information and the products discussed therein can be used may vary and are beyond our control, we make no warranty, expressed or implied, of merchantability, fitness or otherwise, or against patent infringement, and we accept no liability, with respect to or arising from use of such information or any such product.

GEO-2007-1

NQA ISO9002 REGISTERED COMPANY ANSI-RAB QMS ACCREDITED

GEOPRODUCTS, INC. 2007 PRODUCT CATALOG

Geoproducts, Inc. specializes in top quality marketing and distribution of erosion control, stabilization, restoration and storm water management products. As experienced professionals, we pride ourselves on the efficient deployment of geotextile products to the greater Midwestern region, utilizing technically advanced distribution facilities in central locales.

Our warehouses consistently contain large inventories, and orders are always processed in a timely and efficient manner. The Geoproducts staff is on hand to accept product orders via phone, fax or e-mail daily. In addition, product may be picked up or shipped directly to job sites, warehouses or holding areas. Our distribution centers have extensive experience in product movement, and have access to a fleet of over 40 vehicles. From small shipments to full semis, Geoproducts has your jobsite needs covered.

Our goal is to harness the power of technology, factor it in with the specific needs of our customers, to provide a custom fit product solution. Our sales and support staffs are committed to delivering timely products, meeting specifications, and fulfilling budget requirements. Everyone at Geoproducts stands behind our products and services. We will continue to work toward our goals of being the #1 resource to the engineering community, as well as being the premier provider of geotextile products to the Midwest's construction industry.

Non Woven Geotextiles

Trench was wrapped with Mirafi 140NC, fitted with 6" ADS pipe and backfilled with stone

Nonwoven needle punched geotextiles get their name from a unique manufacturing process. Polypropylene fibers are laid into a web, then passed through thousands of needles that penetrate and orient the fibers, interlocking them together. With superior filtration and hydraulic conductivity characteristics, nonwoven needle punched Geotextiles are among the most versatile types of Geotextiles. They are available in many weights, with heavier fabrics possessing superior strength. High elongation characteristics ensure survivability in demanding installations.

PRODUCT SIZES

Product	Size	Sq. Yds.	Uses
Propex 4546	12.6' x 432'	600 syds	Drainage, joints, pipe, wrapping culverts & concrete
Propex 4553	15'x 300'	500 syds	Rip rap fabric, separation
Propex 4512	15' x 180'	300 syds	Heavy rip rap fabric, separation
Mirafi 140NC	12.6' x 360'	500 syds	Drainage, joints, pipe, wrapping culverts & concrete
	3' x 300'	100 syds	Drainage, joints, pipe, wrapping culverts & concrete
Mirafi 180N	15' x 300'	500 syds	Rip rap fabric, separation
Mirafi 1100N	15' x 300'	500 syds	Heavy rip rap fabric, separation

Spunbonded Nonwoven Geotextiles

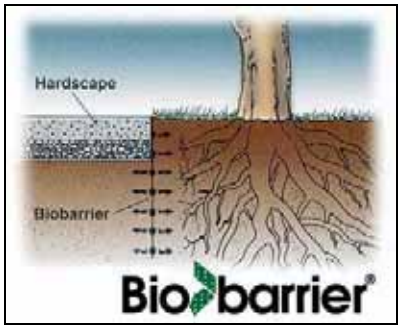
Typar®, a versatile nonwoven spunbonded geotextile with a unique combination of high tensile strength and high permeability, is ideal for a variety of applications including; separation, stabilization, subsurface drainage and erosion control. Continuous monofilaments of extruded polypropylene are randomly spun, then rolled and heat set to create this premium nonwoven geotextile. Typar® nonwoven spunbonded Geotextiles are used in applications requiring high survivability.

PRODUCT SIZES

Product	Size	Uses
Typar 3201	3' x 300'	Landscape fabric, Drainage & Filtration
Typar 3201	4' x 300'	Landscape fabric, Drainage & Filtration
Typar 3201	6.25' x 300'	Landscape fabric, Drainage & Filtration
Typar 3201	12.5' x 300'	Landscape fabric, Drainage & Filtration
Typar 3401	12.5' x 300'	Meets AHSHTO specifications for separation
Typar 3601	12.5' x 300'	Stabilization, MDOT separation

Root and Weed Control

Biobarrier

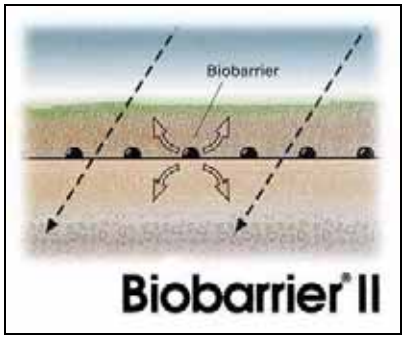


- Root control system
- Made of durable, nonwoven, polypropylene geotextile fabric with permanently attached nodules containing trifluralin
- Is porous to allow air, nutrients and water through it so that soil hydrology can continue to be healthy

PRODUCT SIZES

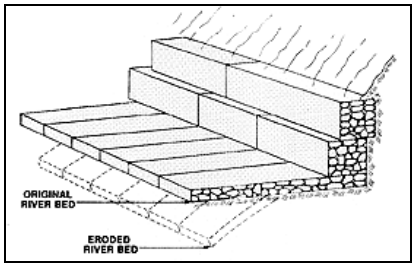
- Biobarrier (12" x 100')
- Biobarrier (19.5" x 100')
- Biobarrier (29" x 100')
- Biobarrier (39" x 100')
- Biobarrier (58.5" x 100')
- Biobarrier (58.5" x 100')

Biobarrier II



Biobarrier II Preemergence Weed Control System eliminates weed growth in a variety of situations. Used like a landscape fabric and covered with two inches of mulch, gravel or soil, Biobarrier II inhibits root growth both above and below it. It is frequently placed in areas where mechanical trimming or spraying herbicides is expensive and/or dangerous, such as landscaped beds (where ornamental shrubs have roots more than two inches below the surface), under fences, brick or gravel walkways and driveways, around the base of cellular phone towers, and under guardrails and signs on highways.

Gabions



Gabion aprons are commonly used to protect the toe of a gabion retaining wall structure from scour that could cause undermining in channel works applications. It is recommended that the gabion apron be a minimum of 9"-12" in depth. The length of the gabion apron shall extend beyond the toe of the structure a minimum of 2 times the anticipated depth of scour. This will ensure that the gabion apron reaches just beyond the outer limit of the anticipated scour hole that may form.

Gabions or reno mattresses may also be connected together filled and then placed into the water with a sling arrangement. This method is frequently used for building scour-resisting mats around bridge piers etc.

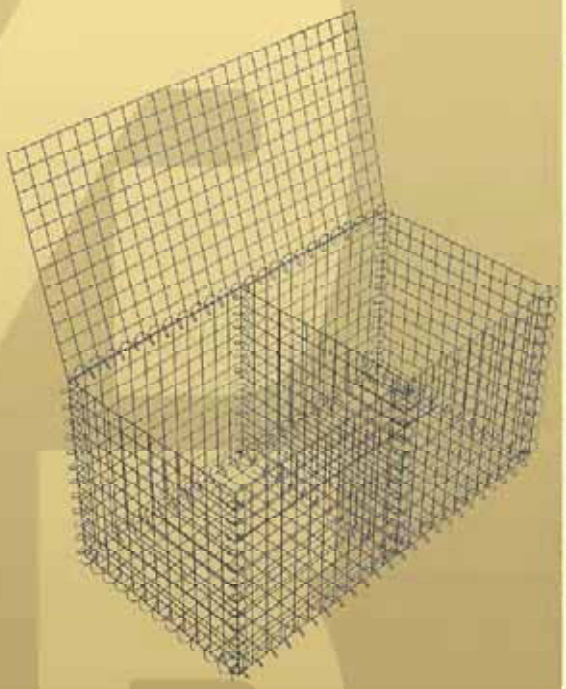
Gabions

Code-WT.	Color	Size	Galvanized Y/N	PVC Coated Y/ N
A – 41	Blue	6’ x 3’ x 3’	Y	Y
B – 58	White	9’ x 3’ x 3’	Y	Y
C – 74	Black	12’ 3’ x 3’	Y	Y
D – 29	Red	6’ x 3’ x 1.5’	Y	Y
E – 41	Green	9’ x 3’ x 1.5’	Y	Y
F – 50	Yellow	12’ x 3’ x 1.5’	Y	Y
G – 25	Blue / Red	6’ x 3’ x 1’	Y	Y
H – 35	Blue / Yellow	9’ x 3’ x 1’	Y	Y
I – 44	Blue / Green	12’ x 3’ 1’	Y	Y

Reno Mattresses

Code	Size	Galvanized Y/N	PVC Coated Y/N	Weight
Q (W/Y)	9’ x 6’ x 6”	Y	Y	48 lbs
R (W/G)	12’ x 6’ x 6”	Y	Y	49 lbs
T (R/Y)	9’ x 6’ x 9”	Y	Y	50 lbs
U (R/G)	12’ x 6’ x 9”	Y	N	52 lbs

GABION WALLS DESIGN



Gabion Gravity Wall

Mechanically Stabilized Earth (MSE)
Gabion Wall
[Reinforced Soil Wall]

Gabion Walls Installation Guide

Foundation

Foundation Requirements, which must be established by the engineer, will vary with site conditions, height of gabion structure, etc. Generally, the top layer of soil is stripped until a layer of the required bearing soil strength is reached. In some cases, the foundation may consist of suitable fill material compacted to a minimum of 95 percent of Proctor density.

Assembly

To assemble each gabion, fold out the four sides and the ends; fold adjacent sides up and join edges with spiral binders; insert diaphragms at 3-foot centers and fasten them to the base panel with spiral binders. Place the empty gabions in the designed pattern on the foundation. When the entire first course is in position, permanently secure adjacent gabions by installing vertical spiral binders running full height at all corners. Similarly secure both edges of all diaphragms with spiral binders. Crimp ends of all spiral binders. Corner stiffeners are then installed diagonally across the corners on 1-foot centers (not used for gabions less than 3-feet high). The stiffeners must be hooked over crossing wires and crimped closed at both ends. Final gabion alignment must be checked before filling begins.

Filling

Fill material must be as specified by the engineer. It must have suitable compressive strength and durability to resist the loading, as well as the effects of water and weathering. Usually, 3 to 8-inch clean, hard stone is specified. A well graded stone-fill increases density. Place the stone in 12-inch lifts with power equipment, but distribute evenly by hand to minimize voids and ensure a pleasing appearance along the exposed faces. Keep baskets square and diaphragms straight. The fill in adjoining cells should not vary in height by more than 1-foot. Level the final stone layer allowing the diaphragms' tops to be visible. Lower lids and bind along all gabions' edges and at diaphragms' tops with spiral binders. Alternatively, tie or lacing wire can be utilized for this operation.

Successive Courses

Place the next course of assembled empty gabions on top of the filled course. Stagger the joints so that the vertical connections are offset from one another. Bind the empty baskets to the filled ones below the spirals or tie wire at all external bottom edges. Bind vertical edges together with spiral binders and continue with the same steps as for the first layer. Successive courses are placed in like manner until the structure is complete.

Gabion Walls Design Guide

Gravity Wall Design

Gabion Walls are generally analyzed as gravity retaining walls, that is, walls which use their own weight to resist the lateral earth pressures. The use of horizontal layers of welded wire mesh (Anchor Mesh) as horizontal tie-backs for soil reinforcement (MSE Walls) is discussed separately. This material is presented for the use of a qualified engineer familiar with traditional procedures for retaining wall design.

Gabion walls may be stepped on either the front or the back (soil side) face as illustrated in Figure 1. The design of both types is based on the same principles.

Design begins with the selection of trail dimensions for a typical vertical cross section through the wall. Four main steps must then be followed:

1. Determine the forces acting on the wall.
2. Check that resisting moment exceeds the overturning moment by a suitable safety factor.
3. Check that sliding resistance exceeds the active horizontal force by a suitable safety factor.
4. Check that the resultant force falls within the middle third of the wall's base, and that the maximum bearing pressure is within the allowable limit.

These steps are repeated iteratively until a suitable design that meets all criteria is achieved. The wall stability must be checked at the base and at each course. Pertinent equations are given below, and an application is illustrated in Example 1.

Mechanically Stabilized Earth (MSE) Walls Soil Reinforcement

When required, flat layers of welded wire mesh (Anchor Mesh) are specified as soil reinforcement to secure the gabion wall into the backfill. In such cases, the Anchor Mesh must be joined securely to the gabion wall facing with spirals or tie wire at the specified elevations as layers of backfill are placed and compacted.

Forces Acting on the Wall

As shown in Figure 1, the main forces acting on gabion walls are the vertical forces from the weight of the gabions and the lateral earth pressure acting on the back face. These forces are used herein to illustrate the main design principles. If other forces are encountered, such as vehicular loads or seismic loads, they must also be included in the analysis.

The weight of a unit length (one foot) of wall is simply the product of the wall cross section and the density of the gabion fill. The latter value may be conservatively taken as 100 lb/ft for typical material (W_g).

The lateral earth pressure is usually calculated by the Coulomb equation. Although based on granular material, it is conservative for cohesive material. According to Coulomb theory, the total active force of the triangular pressure distribution acting on the wall is:

$$P_a = K_a w_s H^2 / 2$$

Equation 1

Where w_s is the soil density, H is the wall height, and K_a is the coefficient of active soil pressure. The soil density is often taken as 120 lb/ft^3 where a specific value is not available.

If a uniformly distributed surcharge pressure (q) is present on top of the backfill surface, it may be treated as an equivalent layer of soil that creates a uniform pressure over the entire height of the wall. Equation 1 is modified to:

$$P_a = K_a(w_s H^2 / 2 + qH)$$

Equation 1A

The pressure coefficient is K_a is given by:

$$K_a = \frac{\cos^2(\quad -\beta)}{\cos^2 \quad \cos(\quad + \quad)\left[1+\sqrt{\frac{\sin(\quad + \quad)\sin(\quad - \quad)}{\cos(\quad + \quad)\cos(\quad - \quad)}}\right]^2}$$

Equation 2

Where:

- = slope angle of backfill surface
- = acute angle of back face slope with vertical (-value where as in Fig. 1A; + value when as in Fig. 1B)
- = angle of wall friction
- = angle of internal friction of soil

P_a is inclined to a line normal to the slope of the back face by the angle . However, because the effect of wall friction is small, δ is usually taken as zero. Typical values of for various soils are given in Table I. Values of K_a for various combinations of ß, , and are given in Table II.

The horizontal component of P_a is:

$$P_h = P_a \cos$$

Equation 3

The vertical component of P_a is usually neglected in design because it reduces the overturning moment and increases the sliding resistance.

Overturning Moment Check

The active soil pressure forces tend to overturn the wall, and this must be properly balanced by the resisting moment developed from the weight of the wall and other forces. Using basic principles of statics, moments are taken about the toe of the wall to check overturning.

This check may be expressed as

$$M_r \geq SF_o M_o$$

Equation 4

Where M_r is the resisting moment, M_o is the overturning moment, and SF_o is the safety factor against overturning (typically 2.0). Each moment is obtained by summing the products of each appropriate force times its perpendicular distance the toe of the wall.

Neglecting wall friction, the active earth force acts normal to the slope of the back face at a distance H/3 above the base. When a surcharge is present, the distance of the total active force above the toe becomes

$$d_a = \frac{H(H + 3q / w_s)}{3(H + 2q / w_s)} + B\sin$$

Equation 5

The overturning moment is

$$M_o = d_a P_h$$

Equation 6

The weight of the gabion wall (W_g) acts vertically through the centroid of its cross section area. The horizontal distance to this point from the toe of the wall (d_g) may be obtained from the statical moment of wall areas. That is, moments of areas about the toe are taken, then divided by the total area, as shown in Example 1.

The resisting moment is the sum of the products of vertical forces or weights per unit length (W) and their distance (d) from the toe of the wall:

$$M_r = \sum dW$$

Equation 7

For the simple gravity wall, the resisting moment is provided entirely by the weight of the wall and

$$M_r = d_g W_g$$

Equation 7A

Sliding Resistance Check

The tendency of the active earth pressure to cause the wall to slide horizontally must be opposed by the frictional resistance at the base of the wall. This may be expressed as

$$W_V \geq SF_S P_h$$

Equation 8

Where μ is the coefficient of the sliding friction (tan of angle of friction of soil), W_V is the sum of the vertical forces (W_g in this case), and SF_S is the safety factor against sliding (typically 1.5).

Check Bearing Pressure

First check to determine if the resultant vertical force lies within the middle third of the base. If B denotes the width of the base, the eccentricity, e, of the vertical force from the midwidth of the base is

$$e = B/2 - (M_r - M_o)/W_V$$

Equation 9

For the resultant force to lie in the middle third:

$$-B/6 \leq e \leq B/6$$

Equation 10

The maximum pressure under the base, P, is then

$$P = (W_v/B)(1 + 6e/B)$$

Equation 11

The maximum pressure must not exceed the allowable soil bearing pressure, P_b:

$$P \leq P_b$$

Equation 12

The safety factor must be included in P_b.

Example 1:

Given Data (Refer to Cross Section, page 5)

Wall Height……	H	=	9 ft
Surcharge…….	q	=	300 psf
Backfill slope angle…….		=	0 deg
Back Face slope angle…….		=	-6 deg
Soil friction angle……		=	35 deg
Soil density……..	w_s	=	120 pcf
Gabion fill density……..	w_g	=	100 pcf
Soil bearing pressure……..	P_b	=	4000 psf

Determine if safety factors are within limits:

Pressure coefficient from Equation 2 is K_a=0.23

Active earth force, P_a, from Equation 1A is

$$P_a = 0.23(120x9^2 + 300x9)$$
$$= 1{,}739\,lb/ft$$

Horizontal component from Equation 3 is

$$P_h = 1739\cos 6$$
$$= 1{,}730\,lb/ft$$

Vertical distance to P_h from Equation 5 is

$$d_a = \frac{9(9 + 3\times 300/120)}{3(9 + 2\times 300/120)} + 6\sin(-6)$$
$$= 2.91\,ft$$

Overturning moment from Equation 6 is

$$M_o = 2.91 \times 1730$$
$$= 5034\,ft - lb/ft$$

Weight of gabions for a 1-ft unit length is

$$W_g = (18 + 13.5 + 9)100$$
$$= 40.5 \times 100$$
$$= 4050\,lb/ft$$

Horizontal distance to W_g is

$$dg = \Sigma Ax/\Sigma A$$
$$= \begin{bmatrix} 18(3\cos 6 + 1.5\sin 6) + 13.5(3.75\cos 6 \\ + 4.5\sin 6) + 9(4.5\cos 6 + 7.5\sin 6) \end{bmatrix} / 40.5$$
$$= 3.96\,ft$$

Resisting moment from Equation 7 is

$$M_r = 3.96x4050$$
$$= 16{,}038\ ft - lb / ft$$

Safety factor against overturning from Equation 4 is

$$SF_O = M_r / M_O$$
$$= 16.038 / 5034$$
$$= 3.19 > 2.00$$

OK

Safety factor against sliding from Equation 8 is

$$SF_S = W_g / P_h$$
$$= \tan 35x4050 / 1730$$
$$= 1.64 > 1.50$$

OK

Reaction eccentricity from Equation 9 is

$$e = 6/2 - (16038 - 5034)/4050$$
$$= 0.283\ ft$$

Limit of eccentricity from Equation 10 is

$$-1 \le e \le 1 ft$$

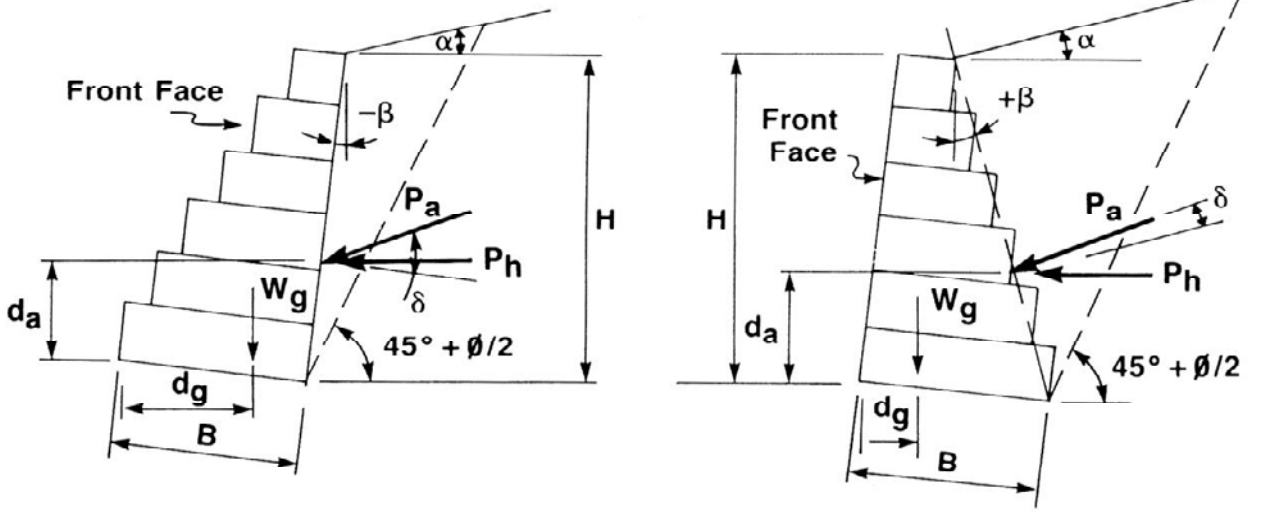
OK

Maximum base pressure from Equation 11 is

$$p = (4050/6)(1 + 6x.283/6)$$
$$= 866\ psf < 4000\ psf$$

OK

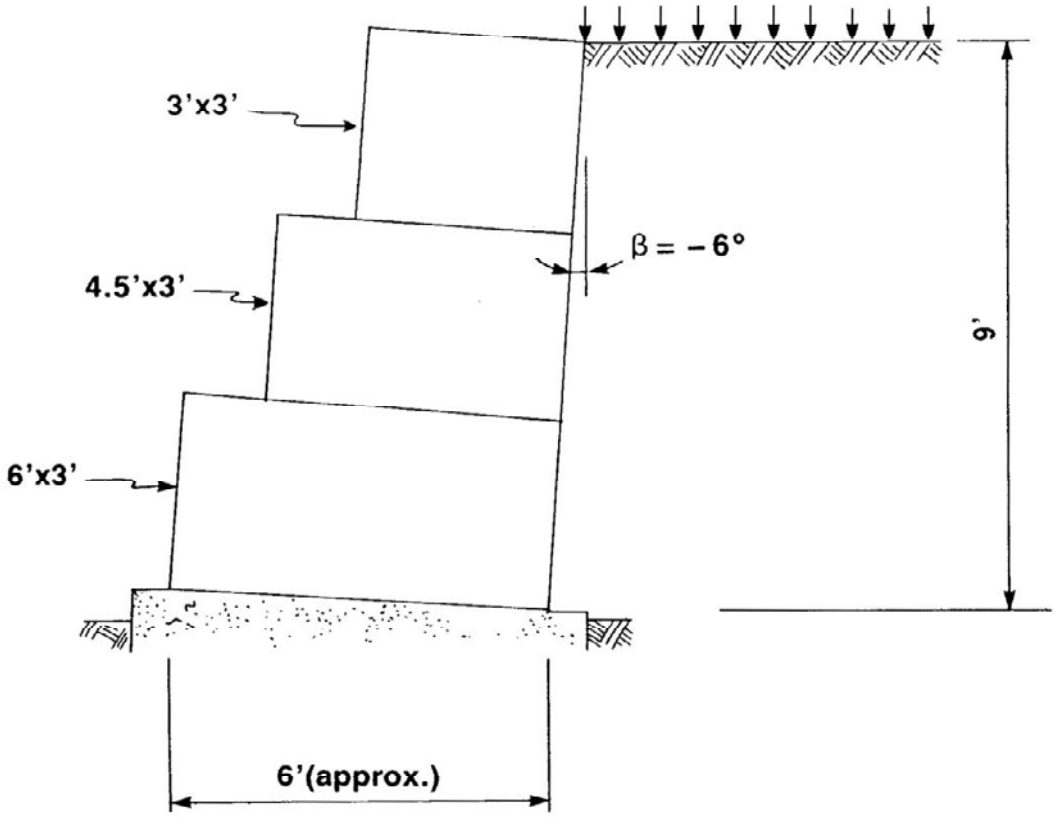
All safety factors are within limits. Stability checks at intermediate levels in the walls show similar results.



A. Stepped Front Face **B. Stepped Back Face**

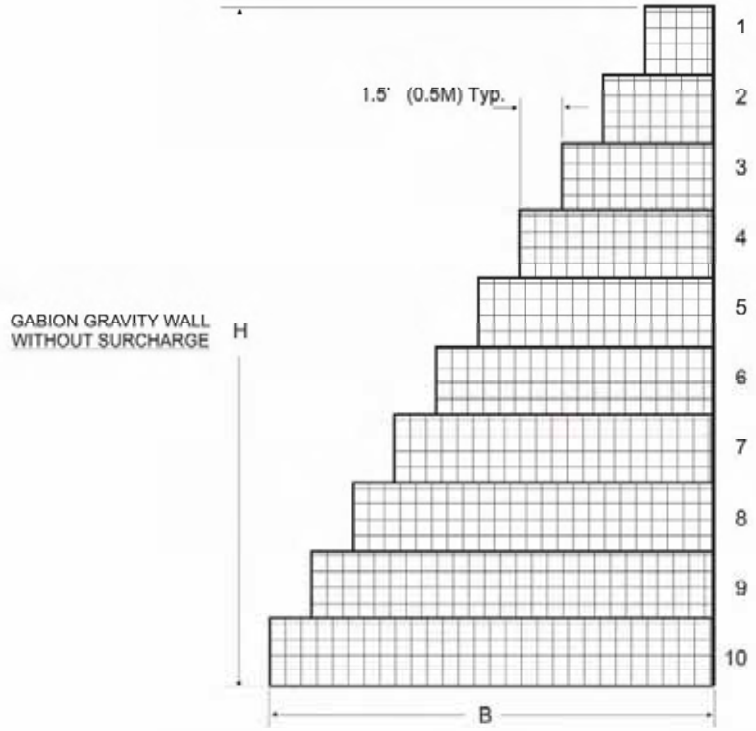
Gravity Wall Design

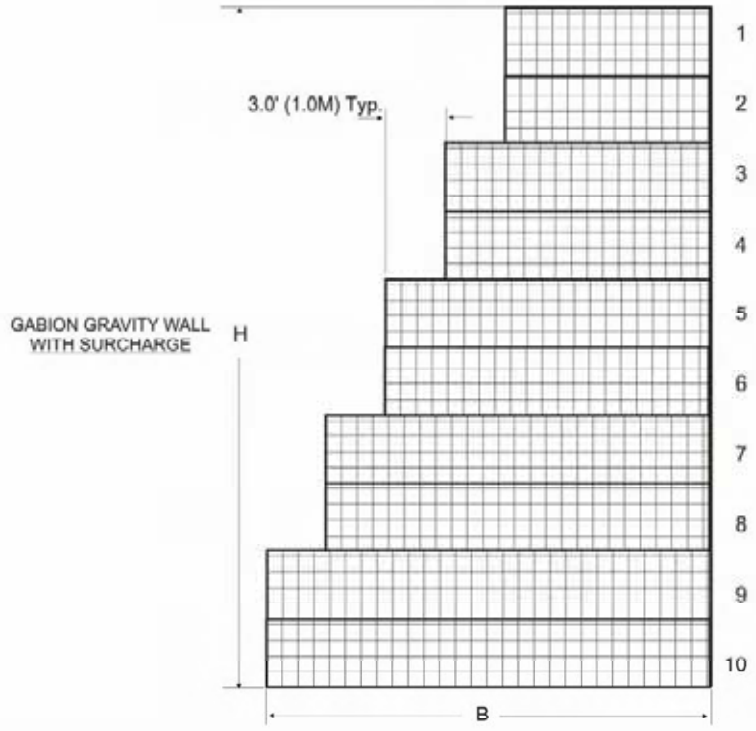
Figure 1



Cross Section for Example 1

GABION GRAVITY WALLS QUICK CROSS SECTION DESIGN GUIDE





NO. OF COURSES	ENGLISH FEET		METRIC METERS	
	H	B	H	B
1	3.0	3.0	1.0	1.0
2	6.0	4.5	2.0	1.5
3	9.0	6.0	3.0	2.0
4	12.0	7.5	4.0	2.5
5	15.0	9.0	5.0	3.0
6	18.0	10.5	6.0	3.5
7	21.0	12.0	7.0	4.0
8	24.0	13.5	8.0	4.5
9	27.0	15.0	9.0	5.0
10	30.0	16.5	10.0	5.5
	H	B	H	B
1	3.0	6.0	1.0	2.0
2	6.0	6.0	2.0	2.0
3	9.0	9.0	3.0	3.0
4	12.0	9.0	4.0	3.0
5	15.0	12.0	5.0	4.0
6	18.0	12.0	6.0	4.0
7	21.0	15.0	7.0	5.0
8	24.0	15.0	8.0	5.0
9	27.0	18.0	9.0	6.0
10	30.0	18.0	10.0	6.0

To increase the efficiency of MSE gabion walls, layers of wire mesh (Anchor Mesh) may be attached to the back face and embedded in the backfill. The Anchor Mesh layers in this reinforced soil wall will resist the active soil force, by a combination of friction on the wire surface and mechanical interlock with the soil. Reinforced soil walls generally use a single thickness of gabions. Design consists of (1) walls stability checks similar to that for gravity walls, assuming the gabions and the reinforced soil act together as one unit, and (2) checks for strength and pullout resistance of the reinforcement layers, to ensure such action. The considerations that differ from gravity wall design are discussed below.

Walls will typically be 6 degrees from vertical. To simplify calculations, assume wall is vertical for certain calculations as indicated in Example 2.

In checking overturning, sliding and bearing, the weight of the soil in the reinforced zone is included with the weight of the wall.

The tensile force in each layer of reinforcement is assumed to resist the active earth force over an incremental height of wall. Its calculated value must be limited to the tensile strength of the mesh divided by the safety factor (typically 1.85). Therefore: 3000/1.85=1620 lb/ft.

As in gravity wall design, the wall is designed to resist the force generated by a sliding wedge of soil as defined by Coulomb. The reinforcement at each layer must extend past the wedge by at least 3-feet, and by a distance sufficient to provide anchorage in the adjacent soil. Generally, this results in a B distance 0.5 to 0.7 times the height of the wall.

Additional equations used in the design of MSE walls, derived from statics are given in Example 2.

Example 2:

Given Data (See Cross Section, page 10)

Wall Height……	H =	24 ft (21 ft+3 ft embedment)
Wall Thickness……	T =	3 ft
Surcharge……	Q =	300 psf
Backfill slope angle……	=	0 deg
Back Face slope angle…	=	-6 deg
Soil friction angle……	=	35 deg
Soil density……	Ws =	120 pcf
Gabion fill density……	Wg =	100 pcf
Soil bearing pressure…	Pb =	4000 psf

(1) Determine if safety factors are within limits:

The trial value for dimension B was selected as 16.5 approximately 0.7H. Also see note near the end of part 2 below on trial selection of B to provide adequate embedment length. In these calculations, positive values are used for the sin and tan of and the sign in the equation changed as necessary.

Pressure coefficient from Equation 2 is K_a=0.23

Active earth force, P_a, from Equation 1A is

$$P_a = 0.23(120 \times 24^2/2 + 300 \times 24)$$
$$= 9605\, lb/\, ft$$

Vertical distance to P_a from Equation 5 is

$$d_a = \frac{24(24 + 3 \times 300/120)}{3(24 + 2 \times 300/120)}$$
$$= 9.22\, ft$$

Overturning moment from Equation 6 is

$$M_o = 9.22 \times 9605$$
$$= 88{,}600\, ft - lb/\, ft$$

Weight of gabions is

$$W_g = (3 \times 24 \times 100$$
$$= 7200\, lb/\, ft$$

Horizontal distance to Wg is

$$d_g = t/2 + (H/2)\tan$$
$$= 3/2 + (24/2)\tan 6$$
$$= 2.76\, ft$$

Weight of surcharge is

$$W_g = qb$$
$$= q(B - t - H\tan\ )$$
$$= 300(1.65 - 3 - 24\tan 6)$$
$$= 300(10.98)$$
$$= 3290\, lb/\, ft$$

Horizontal distance to W_q is

$$d_q = b/2 + H\tan\ + t$$
$$= 10.98/2 + 24\tan 6 + 3$$
$$= 11.01\, ft$$

Weight of soil wedge is

$$W_s = (H\tan /2 + b)Hw_s$$
$$= (24\tan 6/2 + 10.98)24x120$$
$$= 35{,}250\, lb/\, ft$$

Horizontal distance to W_S is

$$d_S = \left[\begin{matrix} (H^2 \tan \quad)(H \tan \quad /3 + t) + (Hb) \\ (b/2 + H \tan \quad + t) \end{matrix} \right] w_S / W_S$$

$$= \left[\begin{matrix} (24^2 \tan 6)(24 \tan 6 / 3 + 3) + (24 x 10.98) \\ (10.98/2 + 24 \tan 6 + 3) \end{matrix} \right] \frac{120}{35250}$$

$$= 10.67 \; ft$$

Resisting moment from Equation 7 is

$$M_r = W_S d_S + W_g d_g + W_q d_q$$

$$= 35{,}250 \times 10.67 + 7200 \times 2.76 + 3290 \times 11.01$$

$$= 432{,}200 \; ft - lb / ft$$

Safety factor against overturning from Equation 4 is

$$SF_O = M_r / M_o$$

$$= 432{,}200 / 88{,}600$$

$$= 4.88 > 2.00$$

OK

Total vertical weight is

$$W_v = W_S + W_g + W_q$$

$$= 35{,}250 + 7200 + 3290$$

$$= 45{,}740 lb / ft$$

Safety factor against sliding from Equation 8 is

$$SF_S = \quad Wv / P_h$$

$$= \tan 35 \times 45{,}740 / 9605$$

$$= 3.33 > 1.50$$

OK

Reaction eccentricity from Equation 9 is

$$e = 16.5/2 - (432{,}200 - 88{,}600)45{,}740$$

$$= 0.738 \; ft$$

Limit of eccentricity from Equation 10 is

$$-2.75 \le e \le 2.75 \; ft$$

OK

Maximum base pressure from Equation 11 is

$$p = (45{,}740 / 16.5)(1 + 6 \times 0.738 / 16.5)$$

$$= 3520 \; psf < 4000 \; psf$$

OK

All safety factors are within limits. Stability checks at intermediate levels in the walls show similar results.

(2) Determine if reinforcement mesh is satisfactory

The pressure on any layer a distance z (ft) below the surface is

$$f_V = w_S z + q$$

$$= 120 z + 300 \; psf$$

The tensile strength on any layer of reinforcement in a vertical segment of soil of thickness S_V (ft), centered about the reinforcement layer, is

$$T = S_V K_a f_V$$

$$= 0.23 S_V f_V$$

Calculate T for each layer as follows

z (ft)	S_V (ft)	F_V (psf)	T (lb/ft)	T<1620 lb/ft?
3	4.5	660	683	Y
6	3.0	1020	704	Y
9	3.0	1380	952	Y
12	3.0	1740	1200	Y
15	3.0	2100	1449	Y
18	3.0	2460	1697	N
21	3.0	2820	1946	N
24	1.5	3180	1097	Y

The tensile force at 18 and 21 ft exceeded the limit. Therefore, insert an intermediate layer at 19.5 and 22.5 ft.

Recalculate the following revised table:

z (ft)	S_V (ft)	F_V (psf)	T (lb/ft)	T<1620 lb/ft?
3	4.5	660	683	Y
6	3.0	1020	704	Y
9	3.0	1380	952	Y
12	3.0	1740	1200	Y
15	3.0	2100	1449	Y
18	2.25	2460	1273	Y
19.5	1.5	2640	911	Y
21	1.5	2820	973	Y
22.5	1.5	3000	1035	Y
24	0.75	3180	549	Y

The tensile force is now within allowable limits at all layers.

The minimum embedment length past the wedge to provide a safety factor of 1.5 against pullout in any layer is

$$L_{em} = 1.5T/(2\Gamma f_v \tan\ )$$

Where Γ is a "scale correction factor" assumed as 0.65.

$$L_{em} = 1.5T/(2x0.65 f_v \tan 35)$$
$$= 1.65T/f_v$$

At the top of the wall, the distance, X, to the wedge failure plane from the back of the wall is

$$X = H\tan(45 - /2) - H\tan$$
$$= 24\tan(27.5) - 24\tan(6)$$
$$= 11.54\ ft$$

At any layer, the length of embedment past the wedge is

$$L_e = B - t - X(H - z)/H$$
$$= 16.5 - 3 - 11.54(24 - z)/24$$
$$= 1.956 + 0.481z$$

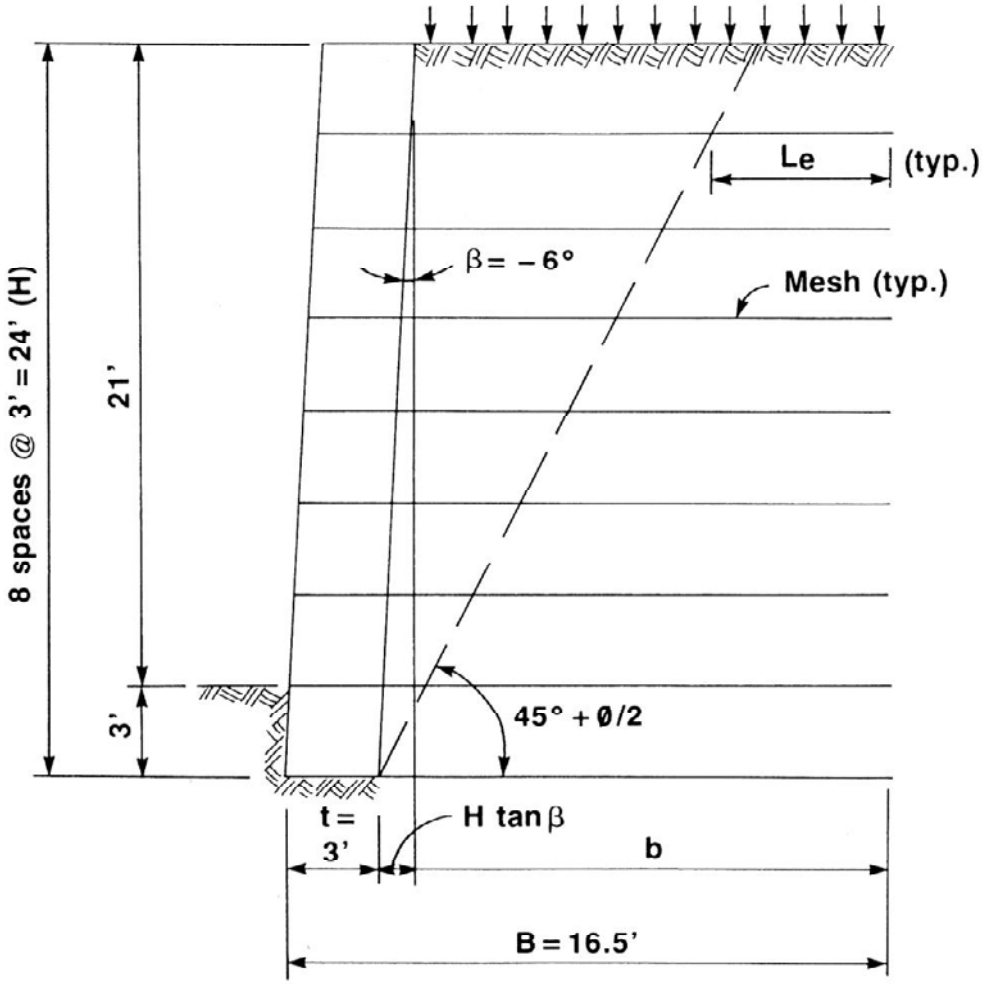
[Note: L_e can be calculated for the top layer of reinforcement initially, when selecting B, to make sure it is at least 3-feet. If not, increase B for the trial design.]

Calculate L_e and L_{em} for each layer as follows:

z (ft)	F_V (psf)	T (lb/ft)	L_e (ft)	L_{em} (ft)	$L_e > L_{em}$?
3	660	683	3.40	1.71	Y
6	1020	704	4.84	1.14	Y
9	1380	952	6.29	1.14	Y
12	1740	1200	7.73	1.14	Y
15	2100	1449	9.17	1.14	Y
18	2460	1273	10.62	0.85	Y
19.5	2640	911	11.34	0.59	Y
21	2820	973	12.06	0.59	Y
22.5	3000	1035	12.78	0.59	Y
24	3180	549	13.50	0.28	Y

The embedded length of reinforcement in each layer is greater than the minimum required for pullout and is also at least 3-feet. Reinforcement design is satisfactory with mesh added at the 19.5 and 22.5-foot levels.

General Note: Every effort has been made to ensure the accuracy and reliability of the information presented herein. Nevertheless, the user of this brochure is responsible for checking and verifying the data by independent means. Application of the information must be based on responsible professional judgment. No express warranties of merchantability or fitness are created or intended by this document. Specification data referring to mechanical and physical properties and chemical analyses related solely to test performed at the time of manufacture in specimens obtained from specific locations of the product in accordance with prescribed sampling procedures.



Cross Section for Example 2

Table I

Angles of Internal Friction and Unit Weights of Soil*

Soil Type	Soil Condition	Angle of Internal Friction (deg)	Soil Density, w (lb/ft)
Course sand, sand & gravel	Compact soil	40	140
	Loose	35	90
Medium sand	Compact soil	40	130
	Loose	30	90
Fine silty sand, sandy silt	Compact soil	30	130
	Loose	25	85
Uniform silt	Compact soil	30	135
	Loose	25	85
Clay-silt	Soft/medium	20	90/120
Silty clay	Soft/medium	15	90/120
Clay	Soft/medium	0/10	90/120

*F.S. Merritt, Ed., “Standard Handbook for Civil Engineers” McGraw-Hill, 1983

Table II

Active Pressure Coefficient, K_a

		= 10	= 15	= 20	= 25	= 30	= 35	= 40
-6	0	0.68	0.56	0.45	0.37	0.29	0.23	0.18
-6	5	0.74	0.6	0.49	0.39	0.31	0.24	0.19
-6	10	0.94	0.67	0.53	0.42	0.33	0.26	0.2
-6	15		0.89	0.59	0.46	0.35	0.27	0.21
-6	20			0.82	0.52	0.39	0.29	0.22
-6	25				0.75	0.44	0.32	0.24
-6	30					0.67	0.37	0.26
-6	35						0.58	0.3
-6	40							0.49
0	0	0.7	0.59	0.49	0.41	0.33	0.27	0.22
0	5	0.77	0.63	0.52	0.43	0.35	0.28	0.23
0	10	0.97	0.7	0.57	0.46	0.37	0.3	0.24
0	15		0.93	0.64	0.5	0.4	0.32	0.25
0	20			0.88	0.57	0.44	0.34	0.27
0	25				0.82	0.5	0.38	0.29
0	30					0.75	0.44	0.32
0	35						0.67	0.37
0	40							0.59
5	0	0.73	0.62	0.52	0.44	0.37	0.31	0.25
5	5	0.8	0.67	0.56	0.47	0.39	0.32	0.26
5	10	1	0.74	0.61	0.5	0.41	0.34	0.28
5	15		0.98	0.68	0.55	0.45	0.36	0.29
5	20			0.94	0.62	0.49	0.39	0.31
5	25				0.89	0.56	0.43	0.34
5	30					0.83	0.5	0.37
5	35						0.76	0.43
5	40							0.68
10	0	0.76	0.65	0.56	0.48	0.41	0.34	0.29
10	5	0.83	0.7	0.6	0.51	0.43	0.36	0.3
10	10	1.05	0.78	0.65	0.55	0.46	0.38	0.32
10	15		1.04	0.74	0.6	0.5	0.41	0.34
10	20			1.02	0.68	0.55	0.44	0.36
10	25				0.98	0.63	0.49	0.39
10	30					0.92	0.57	0.43
10	35						0.86	0.5
10	40							0.79
15	0	0.79	0.69	0.6	0.52	0.45	0.39	0.33
15	5	0.87	0.75	0.65	0.56	0.48	0.41	0.35
15	10	1.1	0.83	0.71	0.6	0.51	0.43	0.37
15	15		1.11	0.8	0.66	0.55	0.47	0.39
15	20			1.1	0.75	0.61	0.51	0.42
15	25				1.08	0.7	0.56	0.45
15	30					1.04	0.65	0.5
15	35						0.98	0.58
15	40							0.91

MGS

Modular Gabion Systems
A Division of C. E. Shepherd Company
2221 Canada Dry Street
Houston TX 77023

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Appendix G. Meteorological Data

From: Evin Erder evin.erder@gmail.com
To: "Kelly H. Wong" <ciao.kelly@gmail.com>, Sarah Cleary <sacleary@att.net>
Date: Fri, Mar 28, 2008 at 1:59 AM
Subject: Your report & meteorological data
Attachments: 8 files

Hi Kelly and Sarah:

I have just received your report for 2007. Thanks very much for this. I am also sending as attachments meteorological data for Polatlı for 1998-2006, and more detailed data for 2006 and 2007. There is no data available for dew point temperatures. This would have to be calculated in excell. Sarah, if you would like the formula for this, i can send it to you. Also, if you need any other data for 2006 which the meteorologists may have overlooked, please let me know.

The translation for the title of the data sheets is as follows:

T.C.: (Türkiye Cumhuriyeti, or Republic of Turkey)

Ministry of the Environment and Forests
General Directorate of National Meteorological Works
Directorate of Electronic Information
Ankara

I am also sending a song as an attachment which i hope you will like. It is called "Gökyüzünde Bölük Bölük" and is about a crane released to take flight, and the song says, if you cannot make it past the mountain, you can return... It reminded me of Gordion.

Looking forward to working together again this summer.
Evin

8 attachments

Page 1.xls 19K
Polatlı-Table 1.xls 53K
Page 2.xls 19K
Polatlı-Table 2.xls 19K
Page 3.xls 19K
01-GÖKYÜZ..(1).mp3 4464K
Page 4.xls 19K
Page 5.xls 19K

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ÇEVRE ve ORMAN BAKANLIĞI
DEVLET METEOROLOJİ İŞLERİ GENEL MÜDÜRLÜĞÜ
Elektronik Bilgi İşlem Merkezi Şube Müdürlügü
ANKARA

Total rainfall (mm)

Station 17728
Station name POLATLI
YEAR 2007

DAY	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	0.0	0.2	8.8	4.6		0.0	0.0	0.3	0.0	0.0	0.0	0.0
2	0.0	7.6	0.0	0.4	3.7	0.0	0.0	0.4	0.0	0.0	0.5	0.2
3		4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	
4	8.1	0.4	2.5		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	11.6	0.0	6.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	13.0	0.3
6	0.1		0.0	9.3	0.0	0.0	0.0	0.0	0.0	0.0	5.1	33.5
7				0.1	0.0	2.6	0.0	0.0	0.0	0.0	3.7	3.9
8		0.0	0.0	0.0	0.0	9.2	0.0	0.0	0.0	0.0	0.0	0.8
9	0.0	0.0	0.0	0.0	0.2	6.2	0.0	0.0	0.0	0.0	2.2	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2
11		0.0	0.0	0.0	0.0	4.6	0.0	0.0	0.0	0.2	8.0	0.8
12	0.0		0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.2	12.1
13	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.3
14		0.0	0.3	0.0	0.0	0.0	2.2	0.0	0.0	15.2	6.8	1.2
15	0.0	2.3	0.9	0.0	0.0	0.0	0.0	0.0	0.0	5.2	0.6	
16	0.0	0.2	0.1	0.1	0.0	7.6	0.0	0.0	0.0	0.5	0.0	1.9
17				0.5		0.4	0.0	0.0	0.0	0.0	0.0	0.2
18		0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19		0.0	0.0	3.3	5.8	0.0	0.0	0.0	0.0	0.0	0.9	0.0
20	6.7	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
21			0.0	0.0	5.8	0.0	0.0	0.0	0.0	0.0	15.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	0.1	0.0
23		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8		
24		0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25		0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.1		
26		0.0	0.1	0.0	0.3	0.0	0.0	3.0	0.0		0.0	
27	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
28	11.3		1.6	0.1	0.0	0.0	0.0	6.3	0.0	0.0	14.1	0.0
29	1.0		0.1	6.0	1.4	0.0	0.0	0.0	0.0	0.0		0.0
30	0.4		0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.8		0.0		0.0		0.0	0.0		0.0		0.0

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Elektronik Bilgi İşlem Merkezi Şube Müdürlügü
ANKARA

Maximum Temperature (°C)

Station 17728
Station name POLATLI
YEAR 2007

DAY	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	4.5	4.4		8.2		28.7	29.0	39.0	36.4	26.7	21.5	12.4
2	10.3	2.1		9.8	21.4	29.5	29.6	28.6	36.7	27.5	19.0	5.4
3	13.8	-0.3	13.9	9.5	20.2	30.9	29.6	31.2	36.8	29.2	16.0	7.0
4	1.1	-0.1	13.8	13.8	24.1	30.4	29.4	34.1	34.5	28.7	18.1	12.8
5	1.5	-1.1	7.6	7.6	28.0	32.6	40.3	36.6	34.4	26.2	13.0	10.4
6	3.0	-0.3		13.2	29.9	26.0	33.7	37.7	32.2	25.2	9.0	7.0
7	3.3	0.2	12.1	16.4	32.8	24.8	27.8	32.9	31.2	26.6	9.1	5.0
8	2.4	2.8	14.4	18.1	27.9	20.9	31.8	31.4	25.7	27.7	9.5	7.1
9	4.7	4.6	16.3	16.3	25.6	24.8	33.1	32.1	21.4	27.6	9.4	11.9
10	0.6	7.1	17.8	16.8	26.1	23.2	33.8	33.6	24.0	27.4	13.4	12.1
11	-0.4	6.8	16.1		26.2	23.4	36.9	37.1	27.7	26.4	7.3	9.9
12	-1.2	6.2		17.0	26.5	25.5	38.2	38.0	29.2	28.0	13.5	11.9
13	0.4	10.5	5.3	16.1	29.0	28.3	32.4	34.4	24.0	24.9	11.3	6.5
14	-0.5	8.9	3.8	13.9	27.5	31.4	26.9	32.9	23.2	17.7	10.6	4.6
15		8.0	6.5	10.6	28.6	32.8	26.8	32.9	27.5	9.3	17.1	8.3
16		10.0	7.7	11.9	31.7	31.9	28.8	33.5	23.3	13.1	18.1	5.5
17	-2.9	9.0	11.8		30.9	30.1	31.5	33.4	25.1	17.0	17.4	3.4
18		7.7	14.0	10.7	24.1	30.1	32.4	32.4	26.9	19.8	17.6	3.4
19		10.9	16.9	12.4	27.7	28.7	35.2	33.2	29.7	20.8	12.3	1.0
20		14.2	14.1		30.1	28.9	35.6	35.7	30.8	22.6	11.7	0.8
21	6.4		19.5	21.3	25.5	27.4	37.0	34.9	28.1	16.2	8.9	-0.6
22	9.7		18.2	21.5	27.1	29.8	37.0	34.2	25.9	17.9	9.4	2.2
23		11.8	23.9	16.2	28.0	32.8	36.7	33.5	25.2	24.4	7.7	3.4
24	14.2	9.1		17.3	29.0	37.0	36.7	31.9	20.7	20.3	3.0	21.9
25	11.0	7.2	11.7	20.9	29.8	31.6	38.1	32.6	22.0	17.2	3.7	4.8
26	12.0	8.7	9.4	22.9	32.3		38.9	32.4	27.1	16.8	8.2	-2.8
27	14.1	12.2	9.6	22.9	28.9	36.0	38.9	32.1	28.3	16.2	12.2	-2.1
28	0.7		7.1	17.8	29.3	37.4	37.5	28.5	29.6	16.7	2.6	-0.6
29	-1.3		12.4	15.8	26.8	32.4	37.9	30.3	29.7	20.5	2.8	1.0
30	1.7		17.4	20.2	31.6	29.8	38.5	32.2	27.9	16.2	6.1	2.7
31	1.8		15.7				38.1	34.7		16.5		4.4

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ANKARA

Minimum TEMPERATURE (°C)

Station 17728
Station name POLATLI
Year 2007

DAY	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1		-7.3	3.0	5.0	9.4	14.2	15.4	21.2	19.7	10.4	9.4	1.7
2	-6.5	-0.3	0.4	-0.5	9.6	11.9	20.1	20.2	20.8	8.3		-4.3
3	0.7	-3.7	7.0	0.3	8.4	14.4		13.5	18.2	13.4	7.4	-3.1
4	1.1		1.1	-2.4		15.6	25.1	17.6	18.1	15.1	3.7	-0.5
5	-0.2	-10.4	2.9	4.4		17.1	17.2	19.0	17.6	9.4	9.9	6.9
6	-0.6	-7.5	0.4	3.8	11.3	17.2	18.6	20.2	16.6	9.4	7.6	4.1
7	-2.8	-9.9	-2.2	3.5	15.1	9.5	13.5	18.3	14.7	9.2	3.7	2.8
8	-5.5	-6.9	-0.4	3.3	16.2	12.1	12.4	17.7	16.3	11.1	3.6	-0.3
9	-6.1	-3.2		5.6	12.1	11.4	14.7	16.7	11.3	13.8	1.4	0.9
10		-4.4	2.2	0.8	12.1	13.2	16.1	17.4	6.5	13.1	0.4	6.8
11	-7.7	-3.3	3.8	1.3	9.8	11.1	17.2	19.6	10.3	12.7	1.4	3.7
12	-5.9	-2.2		5.2	11.6	10.2	18.0	20.2	11.3	13.3	1.2	4.9
13	-2.6	0.0	-2.3	0.6	9.5	12.0	19.4	19.3	13.3	11.4	4.8	5.4
14	-2.2	3.7	-2.8	0.2	7.9	16.5	14.7	17.8	7.2	10.6	1.8	0.5
15	-2.0	2.8	-0.1	0.9	9.6	17.2	12.7	20.4	10.9	5.0	7.6	0.0
16	-2.7	0.1		1.8	10.0	13.8	12.1	18.5	12.9	0.1	6.5	0.6
17	-5.3	-2.7	-5.8	-0.9	15.3	15.0	13.3	18.1	6.8	2.7	6.5	-3.5
18		0.5	-2.6	4.5	15.9	15.9	15.2	17.9	10.9	4.3	5.9	-0.4
19	-7.3	-2.6	1.9	-0.8	11.0	14.7	16.0	18.9	10.1	6.0	7.6	-1.6
20		0.8	2.5	0.7	17.5	13.0	15.4	20.4	11.8	7.1	4.9	-1.5
21		-0.7		2.5	9.7	14.0	18.8	19.0	10.9	11.4	5.4	-1.1
22	-3.9	0.3	6.4	5.3	10.1	10.5	21.1	17.3	11.1		0.0	-2.5
23	-1.5		10.5	6.7	9.6	13.3	21.2	19.3	13.9	12.9	-2.2	-4.8
24	1.4	1.1	2.8	-0.6	10.2	16.9	19.9	18.2	13.1	8.9	-4.0	-5.3
25	1.7	-7.8	2.3		12.0	17.9	20.1	17.5	6.3	8.6	-1.9	-6.0
26	0.7	-6.4	-1.9	6.1	15.0	15.9	20.6	15.5	9.1	4.6		-5.4
27	2.2	-4.4	-3.1	9.2	13.0		21.9	16.8	12.7	3.3	6.9	-3.4
28		4.8	0.1	6.9	12.3	17.2	23.4	16.4	10.4	1.7	-1.6	-3.9
29			-3.1	8.2	15.4	20.5	19.5	16.5	11.9	5.3	-8.1	-8.0
30	-5.7		-0.7	1.7	12.7	16.4	20.1	17.3	12.4	6.9	-3.4	-9.2
31			7.0		14.5		23.9	18.1		2.7		-7.4

Appendix H. Plant Inventory

The following plant inventory was provided by Naomi Miller, archaeobotanist for the Gordion Excavation Project. Collection of data was assisted by Mac Marston, PhD candidate in archaeology at the University of California at Los Angeles (UCLA).

	TB 2 survey, 6/18/2008	Top	Top	Top	Top	Slope below	Slope below	Slope below	Slope below	Flat below	Flat below	Flat below	Flat below	E slope 6-27	E slope 6-27	E slope 6-27	E slope 6-27	E slope 6-27
	corrected seed/mudball order	Poa clumps	"seed-ed"	Poa mudballs	rocks	Poa clumps	"seed-ed"	Poa mudballs	rocks	Poa clumps	"seed-ed"	Poa mudballs	rocks	below 'sod'	below next to sod	below next to rocks	below plastic rock	below tyvek rock
	cover: †=get rid of it if possible	ca. 80%	say, 5%	say, <1%	say, 10%	100%	100%	90%	100%	cut by weeders; can't tell much		bare						
as	Anthemis		fl/fr	fl/fr		fl/fr		fl/fr*	fl					d*	d	d		d*
as	**Carduus nutans†**						fr						v					
as	**Chondrilla juncea†**								v									
as	**Lactuca serriola†**															v	v	
bo	Asperugo procumbens							s/d										
bo	Buglossoides arvensis cf						s/d											
bo	Heliotropium				fl				fl									
bo	Lappula patula					s/d												
bo	Rochelia disperma						s/d								d			
br	Alyssum nm 1648		s/d	s/d	s/d		s/d	s/d*	s/d	s/d		s/d	s/d			d		
br	Camelina rumelica					s/d												
br	**Descurainia sophia†**		d	s/d	fl/fr*		fl/fr/s	fl/fr/s*	fl/fr (big)					d		d	d	d
br	**Sisymbrium altissimum†**								fl/fr (big)									d
ch	Atriplex nm 1237			fr*	fr*	fl*	fl	fl*	fl			fl					v	fl*
ch	**Salsola ruthenica†**								v									
di	Scabiosa rotata		fr/s															
fa	Trigonella monantha									s/d								
ge	Erodium cicutarium																d	
la	Weidemannia orientalis							s/d										
po	Bromus tectorum		s/d	fr/s	fr/s	fr/s*	fr/s*	fr/s*	fr/s** (big)	fr/s	fr/s			s/d		s/d	s/d	s/d
po	Eremopyrum cf. triticeum		s	s	s*	fr	fr	fr	fr	fr				d/s				s/d
po	Hordeum murinum		s/d	s/d	s/d			fr/s						s/d	*s/d		s/d	
po	Poa bulbosum	s, dor-mant*		v									s, dormant					
po	Poa bulbosum var. vivipara		s*						fr/s									
po	Taeniatherum caput-medusae, planted							fr/s										
pol	Polygonum sp.							v										
ru	**Galium verum†**					fl	fl*			fl*								