Pervious Concrete Options:

Darcy Columns For Clay Soils

Pervious concrete installations are the most cost effective when the stormwater is completely infiltrated so that there is no discharge into the storm sewer system. In sandy soils this is easily accomplished by placing pervious concrete directly on native soil. With soils having moderate clay content and low to moderate expansivity, complete infiltration can generally be accomplished by excavating down to eighteen inches below desired grade, and placing twelve inches of drain rock (clean ¾" or 1" crushed rock or gravel) on top of a filter fabric, with six inches of pervious concrete on top of the drain rock.

Because these soils of moderate clay content will percolate slowly, the drain rock reservoir provides a buffer against subgrade expansion and contraction while providing four to five inches of stormwater storage. The concept with these soil types is to build a large "bathtub" which can hold the stormwater until it can infiltrate slowly into the underlying soil.

But what does one do with soils which have substantial clay content and high expansivity? One design option is to over-excavate and place twelve inches of filter fabric and drain rock, just as with soils of moderate expansivity. A perforated drainage pipe is placed in the top portion of the drain rock layer, providing drainage to a retention area or into the storm sewer system. The principle here is to detain and treat the stormwater before release. This can be very effective in areas where the agencies require detention and treatment of stormwater before release, but is not as cost-effective as direct infiltration.

In many sites in northern California, areas with expansive clay soils are stratified with layers of soils more conducive to stormwater infiltration. In these cases, the use of ***Darcy Columns*** can be a very cost-effective method for achieving complete site infiltration. Darcy Columns are constructed by drilling approximately three-foot diameter holes to a depth that includes the well-draining soil strata, but at least five feet above the seasonal high ground-water level. The Darcy Columns are then filled with large rocks (great place for recycled concrete to be used!) or gravel. Most Darcy Columns are designed to be 10-30 feet deep.

Because of the high levels of head pressure on the water in the columns, the lateral infiltration of water through the more permeable strata is very substantial. The rate of this infiltration is governed by Darcy's Law – hence the term Darcy Columns. If there are layers of sandy soils in the underlying soil structure, the infiltration rate can be so great that you can't fill it to the top even with a fire hose!

By providing complete site infiltration, Darcy Columns allow one to realize the true economic benefits of a pervious concrete system even in clay soils. By eliminating underground piping, storm sewer tie-ins, retention ponds, bioswales, expensive sloped grading, etc. the overall site cost when using pervious concrete can be substantially less than if traditional pavements and BMPs are utilized.

In evaluating the use of Darcy Columns, the cost of constructing them is of obvious concern. Jon Ferla of Sacramento Drilling was kind enough to provide some estimates of the costs to drill and fill Darcy Columns – and it is surprisingly inexpensive. Please note that these are estimates only for planning purposes, each job is different and will require a separate quotation.

Assuming a job one hour away from Sacramento, the cost to drill five 36-inch diameter 30-foot deep holes would be just under $3,000, or $600 per hole. If ten such holes were desired, the incremental additional cost would only be just under $300 per hole, for a total cost of about $4400, or $440 per hole.

Jon estimated the gravel fill based on ¾" crushed rock at about $275 per 36" diameter X 30' deep hole. Other options with less expense may be locally available, but this gives one an idea of what should be the upper end cost.

What this comes down to is a cost estimate of about $875 per hole for 5 holes, $715 per hole for ten holes, and $650 per hole for 20 or more holes.

So how many Darcy Columns might one need? That will depend largely on the soil strata and the topography of the site. An example is given below for one type of soil strata.

A 36" diameter hole which is 30' deep has a volume of 212 cubic feet of water. Assuming a gravel fill with 40% void space, this gives 85 cubic feet of stormwater storage.

Area Drained Per Darcy Column	Inches of Rainwater Over the Pavement Area Storage Capacity of the Darcy Column	Inches of Rainwater Storage Capacity Over the Pavement Area Including the 12" Drain Rock Layer Below the Pavement	24 Hour Recharge Capacity Per Darcy Column in Inches of Rainwater Over the Pavement Area	24 Hour Capacity for Stormwater Over the Pavement Area Assuming 15 feet of Strata With an Infiltration Rate of 2 Inches Per Hour
100 sq ft	10.2	15.0	68.0	83.0
500 sq ft	2.0	6.8	13.5	20.3
1000 sq ft	1.0	5.8	6.5	12.3
2500 sq ft	0.4	5.2	2.7	7.9
5000 sq ft	0.2	5.0	1.4	6.4

Based on these assumptions and calculations, it would seem that one Darcy Column every 2,500 square feet would provide, in the Sacramento area, the capability of dealing with more than 1.7 times the 100-year storm event of 4.5 inches in 24 hours, and more than 2.2 times the 25-year storm event of 3.5 inches in 24 hours. System recharge of the 25-year storm would be approximately 31 hours.

Assuming a gravel filled, 36" diameter, 30' Darcy Column every 2,500 feet, the cost per square foot of pavement for this additional drainage would be estimated at:

Pervious Pavement Area	Cost of Darcy Columns	Cost per Square Foot of Pervious Pavement
5,000 sq ft	$ 1,840	$0.37
25,000 sq. ft	$ 7,150	$0.29
50,000 sq ft	$13,000	$0.26
100,000 sq ft	$26,000	$0.26

Add to this the costs of 12 inches of drain rock and additional excavation of somewhere between $1.00 and $1.50 per square foot, and one can see that in expansive clay soils underlain with drainable strata, that this approach should provide ability to infiltrate all of the stormwater for a cost of approximately $1.30 to $2.00 per square foot over the cost of just placing six inches of pervious concrete onto native soil.

Given the substantial costs of taking land out of service for retention areas, and costs of storm sewer infrastructure, this additional per square foot cost generally translates into substantial overall project savings.

Description of Darcy's Law:

Darcy's law is a simple proportional relationship between the instantaneous discharge rate through a porous medium, the viscosity of the fluid and the pressure drop over a given distance.

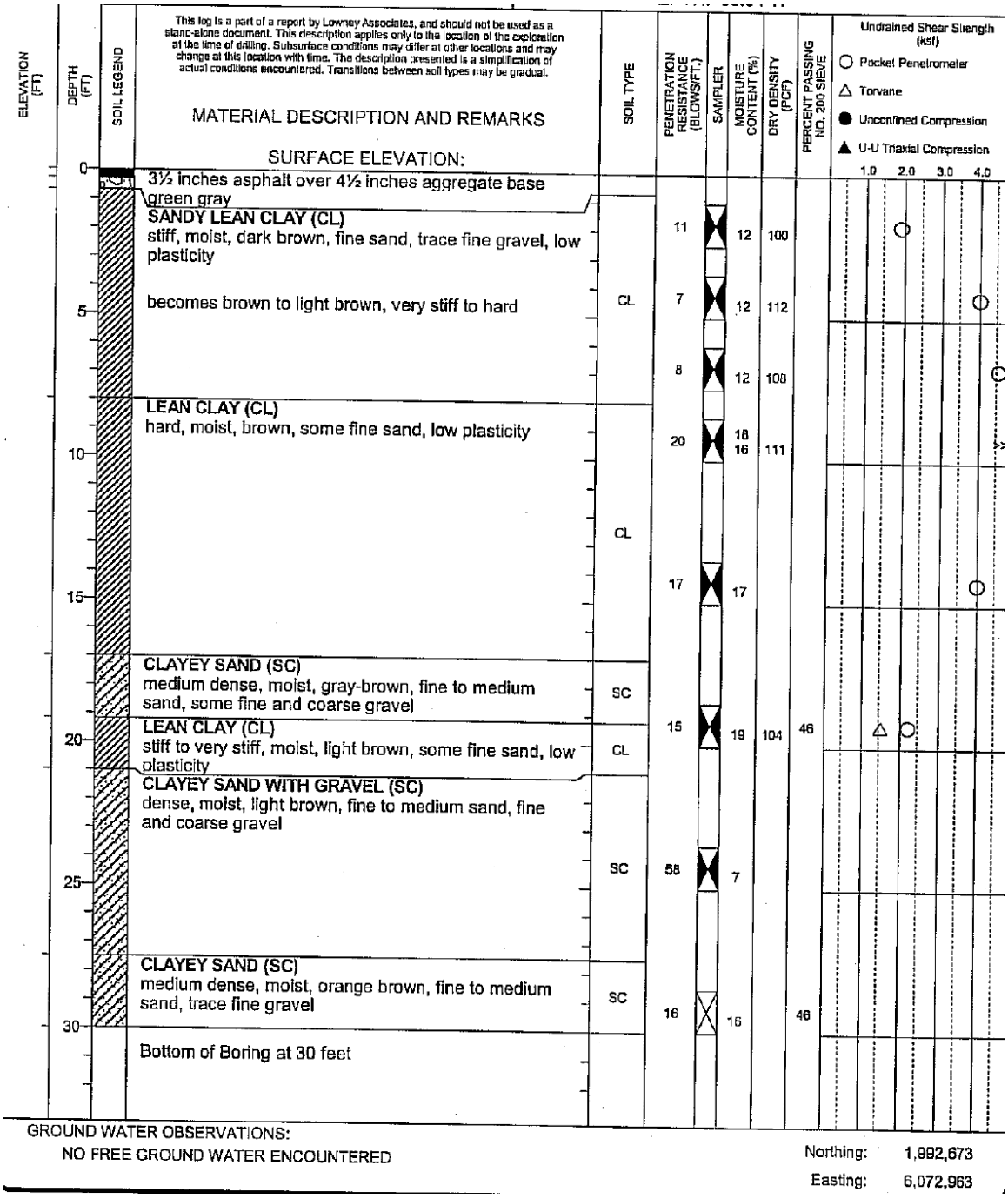
$$Q = \frac{-\kappa A}{\mu} \frac{(P_b - P_a)}{L}$$

The total discharge, Q (units of volume per time, e.g., cm^3/s) is equal to the product of the permeability of the medium, κ, the cross-sectional area to flow, A, and the pressure drop, all divided by the viscosity, μ and the length the pressure drop is taking place over.

Sedimentation Concerns:

Designers may express concerns about sedimentation and ultimate failure of Darcy Columns due to reduction in flow rates due to sedimentation. Note that the top layer of pervious concrete acts as an effective barrier to surface soil, which is a common cause of clogging and failure of traditionally designed dry wells. As noted numerous times in the literature on pervious concrete, surface sediment is trapped in the top 3/8" of the pervious concrete layer. This sedimentation reduces flow rates through the pervious concrete, but rarely below 1 gallon per minute per square foot (equal to 90 inches of rain per hour).

A more legitimate concern is sediment infiltration into the gravel layer of the Darcy Column from the sidewalls of the columns. Based on the soil types, the geotechnical engineer may require that the Darcy Columns be lined with a non-woven geotextile filter fabric. This is often not required, though, as the pressure of the water in the Darcy Column and the outward pressure of the gravel fill material tends to prevent soil intrusion into the Darcy Column.



Boring log which shows well-draining soils below 17 feet in depth below layers of clay. Note that groundwater was not encountered. This site is an excellent example of a site suitable for Darcy Column utilization.

For further pervious concrete information see www.concreteresources.net and click on the tab marked “Pervious Concrete”.

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