BENTOMAT® AND CLAYMAX® SEAM FLOW DATA

In the early 1990s, Estornell and Daniel performed seam testing on Bentomat and Claymax GCLs in 8' x 4' steel tanks. When the manufacturers' recommended minimum overlap width of 6" was maintained, the overall hydraulic conductivity of the overlapped panels was about the same as the hydraulic conductivity of non-overlapped control panels. The GCLs in these tank tests self-sealed along the overlaps.

To obtain more current data, CETCO has recently tested all six of its geosynthetic clay liners (GCLs) for seam flow. A GCL Flow Box, manufactured by Trautwein Soil Testing Equipment of Houston, was used for these tests (Figures 1 and 2). Each GCL specimen was set up so that a 6-inch overlap seam is placed across the middle of the box. The flow box allows for a confining pressure to be applied through a rubber bladder. Outflow is measured from five separate compartments, allowing sidewall flow and flow through the GCL to be segregated from flow through the seam.

The three GCLs that are typically used in landfills (Bentomat ST, Bentomat DN and Claymax 200R) were tested at a confining pressure of 10 psi and a hydrostatic head of 1 foot. The three GCLs that are typically used in pond applications (Bentomat CL, Bentomat CLT and Claymax 600CL) were tested at a confining pressure of 1-2 psi and a head of 3 feet. Bentomat seams were enhanced with the recommended 0.25 lbs. per linear foot of granular bentonite. No bentonite was placed in Claymax seams.

As shown in the attached data, the flux through the seams quickly dropped to a level where leakage could not be detected. Again, Bentomat and Claymax GCLs, when properly installed showed their ability to self-seal along seam overlaps.

Reference: Estornell and Daniel, (1992), "Hydraulic Conductivity of Three Geosynthetic Clay Liners", *Journal of Geotechnical Engineering,* 118(10), pgs. 1592-1606.

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HORIZONTAL SEAM FLOW RATE EVALUATION

Project Name: Claymax 600CL With Unsealed Seam

Project No.: 99-118 Report Date: 1/29/01

Sample Type: Claymax 600CL Start Date : 10/10/99

Confining Press.: 1.0 Seal Area : 309.7 sq cm

Permeant : Deionized Water Initial Head : 3 ft.

* Average of last three readings.
Flow is measured in gallons per linear foot of seam per hour.

Date	Total Time (min)	Actual Time (min)	Outflow (cc)	Flow (gal./ft./hr)	Average Flow* (gal./ft./hr)	Flux ($m^3/m^2/sec$)	Average Flux* ($m^3/m^2/sec$)
10/10/99	0.0	0.0	0.00	0.000		0.00E+00	
	64.0	64.0	0.00	0.000		0.00E+00	
	200.0	136.0	0.00	0.000		0.00E+00	
	324.0	124.0	0.00	0.000		0.00E+00	
10/11/99	0.0		0.00	0.000			
	165.0	165.0	0.00	0.000		0.00E+00	
	420.0	255.0	0.00	0.000		0.00E+00	
10/12/99	0.0		0.00	0.000			
	168.0	168.0	0.00	0.000		0.00E+00	
	393.0	225.0	0.00	0.000		0.00E+00	
10/13/99	1705.0	1312.0	0.00	0.000		0.00E+00	
10/14/99	3169.0	1464.0	0.00	0.000		0.00E+00	
10/24/99	0.0		0.00	0.000			
	349.0	349.0	0.00	0.000		0.00E+00	
10/25/99	1792.0	1443.0	0.00	0.000		0.00E+00	
10/26/99	3164.0	1372.0	0.00	0.000		0.00E+00	
10/27/99	4666.0	1502.0	0.00	0.000	0.000	0.00E+00	0.00E+00

Final Flux 0.0E+00 m3/m2/sec

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HORIZONTAL SEAM FLOW RATE EVALUATION

Project Name: Flow Rate Evaluation Through 6" Seam

Project No.: 98-100 Report Date: 1/29/01

Sample Type: Claymax 200R Start Date : 6/16/98

Confining Pres 10.0 Seal Area : 309.7 sq cm

Permeant : Deionized Water Initial Head : 1 ft.

* Average of last three readings.
Flow is measured in gallons per linear foot of seam per hour.

Date	Total Time (min)	Actual Time (min)	Outflow (cc)	Flow (gal./ft./hr)	Average Flow* (gal./ft./hr)	Flux ($m^3/m^2/sec$)	Average Flux* ($m^3/m^2/sec$)
6/17/98	1256	1256	21.41	0.118		9.17E-09	
	1391	135	0.00	0.000		0.00E+00	
6/18/98	2455	1064	0.00	0.000		0.00E+00	
	2596	141	0.00	0.000	0.000	0.00E+00	0.00E+00
6/21/98	0	0					
	480	480	0.00	0.000		0.00E+00	
6/22/98	1440	960	0.00	0.000		0.00E+00	
	2864	1424	0.00	0.000	0.000	0.00E+00	0.00E+00
6/28/98	0	0					
	480	480	0.00	0.000		0.00E+00	
	1440	960	0.00	0.000		0.00E+00	
	2864	1424	0.00	0.000	0.000	0.00E+00	0.00E+00
6/29/98	0	0					
	1515	1515	0.00	0.000		0.00E+00	
6/30/98	2829	1314	0.00	0.000		0.00E+00	
	3110	281	0.00	0.000	0.000	0.00E+00	0.00E+00

Final Flux 0.0E+00 m3/m2/sec

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HORIZONTAL SEAM FLOW RATE EVALUATION

Project Name: Bentomat CLT w/ Granular Bentonite in Seam

Project No.: 00-051 Report Date: 1/29/01

Sample Type: Bentomat CLT Start Date : 4/10/00

onfining Press.: 2 psi Seal Area : 309.7 sq cm

Permeant : Deionized Water Initial Head : 3 ft.

* Average of last three readings.
Flow is measured in gallons per linear foot of seam per hour.

Date	Total Time (min)	Actual Time (min)	Outflow (cc)	Flow gal./ft./h	Average Flow* (gal./ft./hr)	Flux ($m^3/m^2/sec$)	Average Flux* ($m^3/m^2/sec$)
4/10/00	0.0	0.0	0.00	0.000		0.00E+00	0.00E+00
	140.0	140.0	22.39	0.014		8.61E-08	4.30E-08
4/11/00	1388.0	1248.0	3.16	0.017		1.23E-09	4.36E-08
	1727.0	339.0	0.15	0.000		4.67E-11	6.36E-10
4/12/00	2844.0	1117.0	0.24	0.001		4.54E-11	4.61E-11
4/13/00	4616.0	1772.0	0.11	0.001	0.001	1.28E-11	2.91E-11
	0.0		0.00	0.000			
4/25/00	1426.0	1426.0	0.00	0.000		0.00E+00	0.00E+00
4/30/00	0.0		0.00	0.000			
	413.0	413.0	0.00	0.000		0.00E+00	0.00E+00
5/1/00	1414.0	1001.0	0.00	0.000		0.00E+00	0.00E+00
5/2/00	2895.0	1481.0	0.00	0.000		0.00E+00	0.00E+00
5/3/00	3925.0	1030.0	0.00	0.000		0.00E+00	0.00E+00
5/4/00	5016.0	1091.0	0.00	0.000	0.000	0.00E+00	0.00E+00

Final Flux **0.00E+00**

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HORIZONTAL SEAM FLOW RATE EVALUATION

Project Name Flow Rate Evaluation Through 4" Seam w/ 1/4 lb. Bentonite per Linear Foot of Seam
Project No.: 98-100 Report Date: 1/29/01
Sample Type: Bentomat ST Start Date : 4/29/98
Confining Pre 10 psi Seal Area : #########

Permeant : Deionized Water Initial Head : 3 ft. (91.4 cm)
* Average of last three readings.
Flow is measured in gallons per linear foot of seam per hour.

Date	Total Time (min)	Actual Time (min)	Outflow (cc)	Flow (gal./ft./hr	Average Flow* (gal./ft./hr)	Flux ($m^3/m^2/sec$)	Average Flux* ($m^3/m^2/sec$)
		10 psi Confining Pressure					
4/30/98	1340	1340	0.00	0.000		0.00E+00	
5/3/98	3806	2466	0.00	0.000		0.00E+00	
	3921	115	0.00	0.000		0.00E+00	
	4020	99	0.00	0.000		0.00E+00	
	4243	223	0.00	0.000		0.00E+00	
5/4/98	5254	1011	0.00	0.000	0.000	0.00E+00	0.00E+00

Final Flux 0.0E+00 m3/m2/sec

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HORIZONTAL SEAM FLOW RATE EVALUATION

Project Name: Flow Rate Evaluation Through 6" Seam

Project No.: 98-100 Report Date: 1/29/01

Sample Type: Bentomat DN Start Date : 7/1/98
1/4 lb. of granular bentonite per linear foot of seam added
Confining Press.: 10 psi Seal Area : 309.7 sq cm

Permeant : Deionized Water Initial Head : 1 ft.

* Average of last three readings.
Flow is measured in gallons per linear foot of seam per hour.

Date	Total Time (min)	Actual Time (min)	Outflow (cc)	Flow (gal./ft./hr)	Average Flow* (gal./ft./hr)	Flux ($m^3/m^2/sec$)	Average Flux* ($m^3/m^2/sec$)
7/5/98	512	512	17.87	0.040		1.88E-08	
7/6/98	1715	1203	21.41	0.113		6.72E-09	
7/7/98	2516	801	0.00	0.000		0.00E+00	
	2844	328	0.00	0.000		0.00E+00	
7/8/98	3904	1060	0.00	0.000		0.00E+00	
7/9/98	5312	1408	0.00	0.000	0.000	0.00E+00	0.00E+00
	0	0					
7/13/98	1055	1055	0.00	0.000		0.00E+00	
7/14/98	2499	1444	0.00	0.000		0.00E+00	
	2661	162	0.00	0.000		0.00E+00	
7/15/98	3913	1252	0.00	0.000	0.000	0.00E+00	0.00E+00

Final Flux 0.0E+00 $m^3/m^2/sec$

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HORIZONTAL SEAM FLOW RATE EVALUATION

Project Name: Flow Rate Evaluation Through 6" Seam
1/4lb. Granular bentonite added to seam
Project No.: 98-220 Report Date: 1/29/01

Sample Type: Bentomat CL Start Date : 9/20/98

onfining Press. 1psi Seal Area : 464.5 sq cm

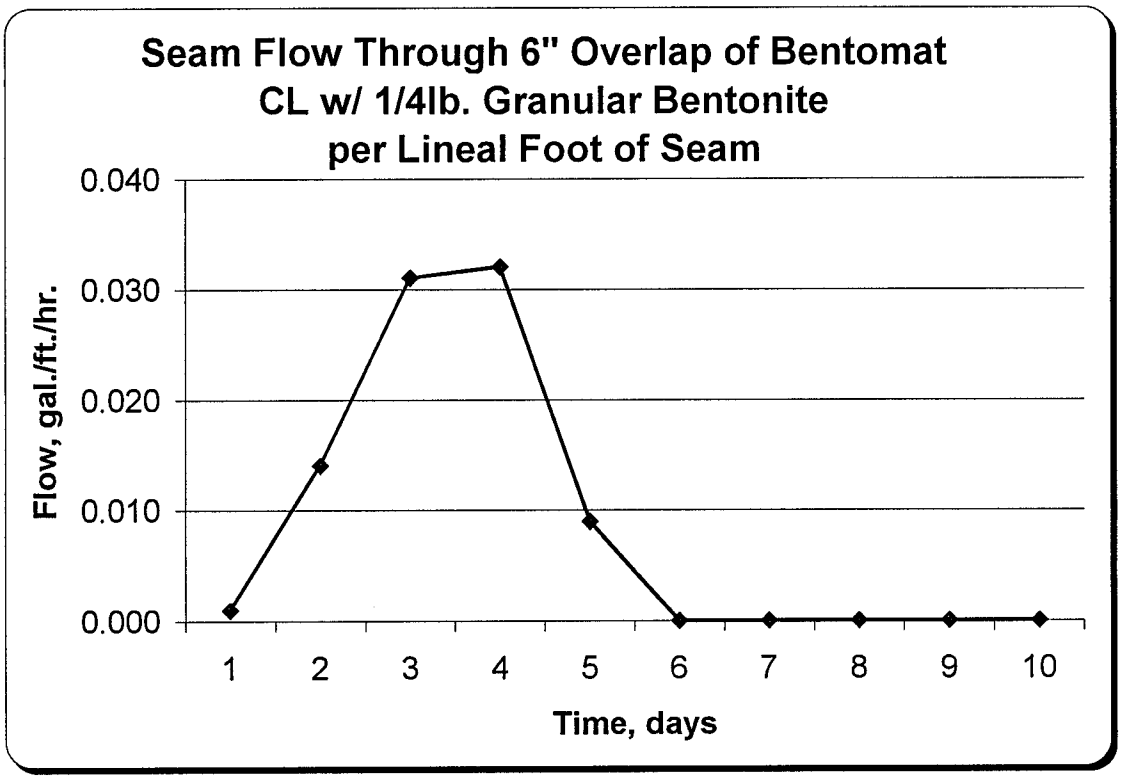
Permeant : Deionized Water Initial Head : 3 ft.

* Average of last three readings.
Flow is measured in gallons per linear foot of seam per hour.

Date	Total Time (min)	Actual Time (min)	Outflow (cc)	Flow gal./ft./h	Average Flow* (gal./ft./hr)	Flux ($m^3/m^2/sec$)	Average Flux* ($m^3/m^2/sec$)
9/20/98	5.0	5.0	0.00	0.000		0.00E+00	
	15.0	10.0	0.00	0.000		0.00E+00	
	30.0	15.0	0.00	0.000		0.00E+00	
	60.0	30.0	0.00	0.000		0.00E+00	
	75.0	15.0	0.00	0.000		0.00E+00	
	105.0	30.0	0.00	0.000		0.00E+00	
	190.0	85.0	0.00	0.000		0.00E+00	
	215.0	25.0	0.00	0.000		0.00E+00	
	230.0	15.0	0.00	0.000		0.00E+00	
	240.0	10.0	0.00	0.000		0.00E+00	
	265.0	25.0	0.00	0.000	0.000	0.00E+00	0.00E+00
9/21/98			0.00				
	95.0	95.0	0.00	0.000		0.00E+00	
	150.0	55.0	0.00	0.000		0.00E+00	
	240.0	90.0	0.00	0.000		0.00E+00	
	360.0	120.0	0.00	0.000		0.00E+00	
	405.0	45.0	0.00	0.000	0.000	0.00E+00	0.00E+00
9/22/98			0.00				
	45.0	45.0	0.00	0.000		0.00E+00	
	100.0	55.0	0.00	0.000		0.00E+00	
	240.0	140.0	0.00	0.000		0.00E+00	
	325.0	85.0	0.00	0.000		0.00E+00	
	405.0	80.0	0.00	0.000	0.000	0.00E+00	0.00E+00

9/23/98							
	55.0	55.0	0.00	0.000		0.00E+00	
	115.0	60.0	0.00	0.000		0.00E+00	
	230.0	115.0	0.00	0.000		0.00E+00	
	340.0	110.0	0.00	0.000	0.000	0.00E+00	0.00E+00
9/24/98							
	95.0	95.0	0.00	0.000		0.00E+00	
	260.0	165.0	0.00	0.000		0.00E+00	
	320.0	60.0	0.00	0.000		0.00E+00	
	395.0	75.0	0.00	0.000	0.000	0.00E+00	0.00E+00
9/27/98							
	230.0	230.0	0.00	0.000		0.00E+00	
	310.0	80.0	0.00	0.000	0.000	0.00E+00	0.00E+00
9/28/98							
	105.0	105.0	0.00	0.000		0.00E+00	
	240.0	135.0	0.00	0.000	0.000	0.00E+00	0.00E+00
9/29/98							
	45.0	45.0	0.00	0.000	0.000	0.00E+00	0.00E+00
9/30/98							
	70.0	70.0	0.00	0.000		0.00E+00	
	240.0	170.0	0.00	0.000	0.000	0.00E+00	0.00E+00
10/1/98							
	100.0	100.0	0.00	0.000		0.00E+00	
	220.0	120.0	0.00	0.000	0.000	0.00E+00	0.00E+00

Final Flux 0.0E+00 m3/m2/sec



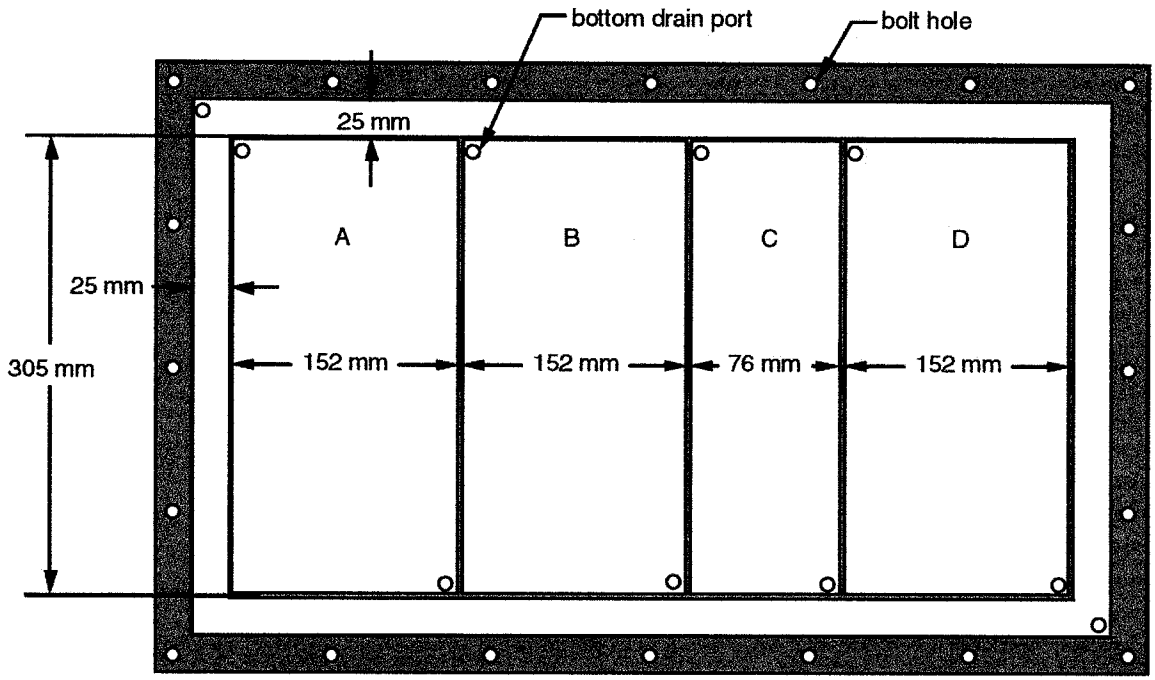


Figure . Top View of GCL Flow Box with Lid Removed

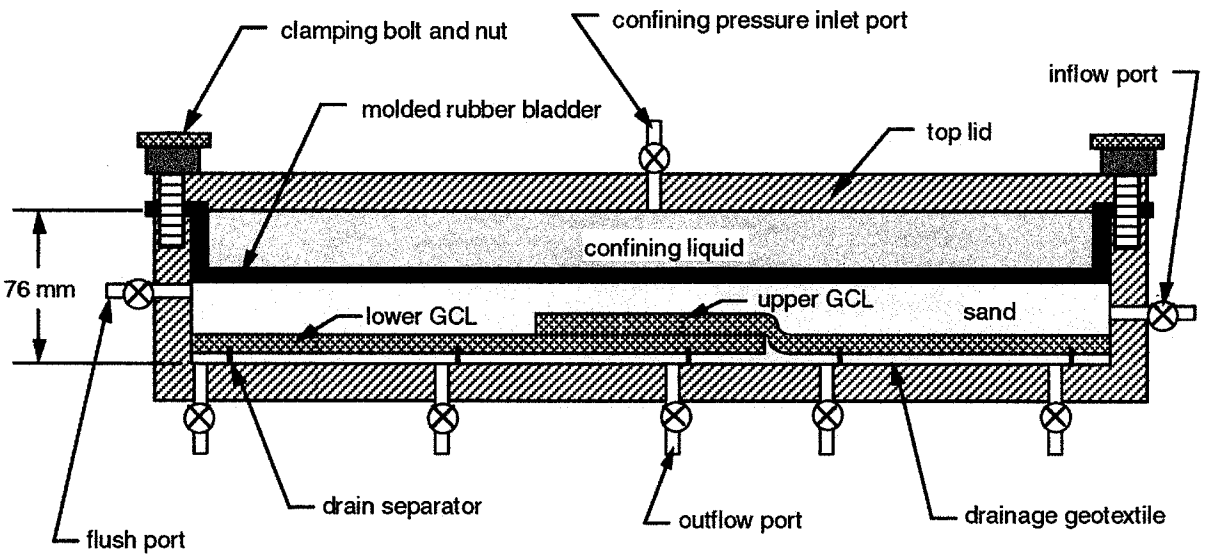


Figure . Cross Section View of GCL Flow Box In Which a GCL Overlap is Illustrated

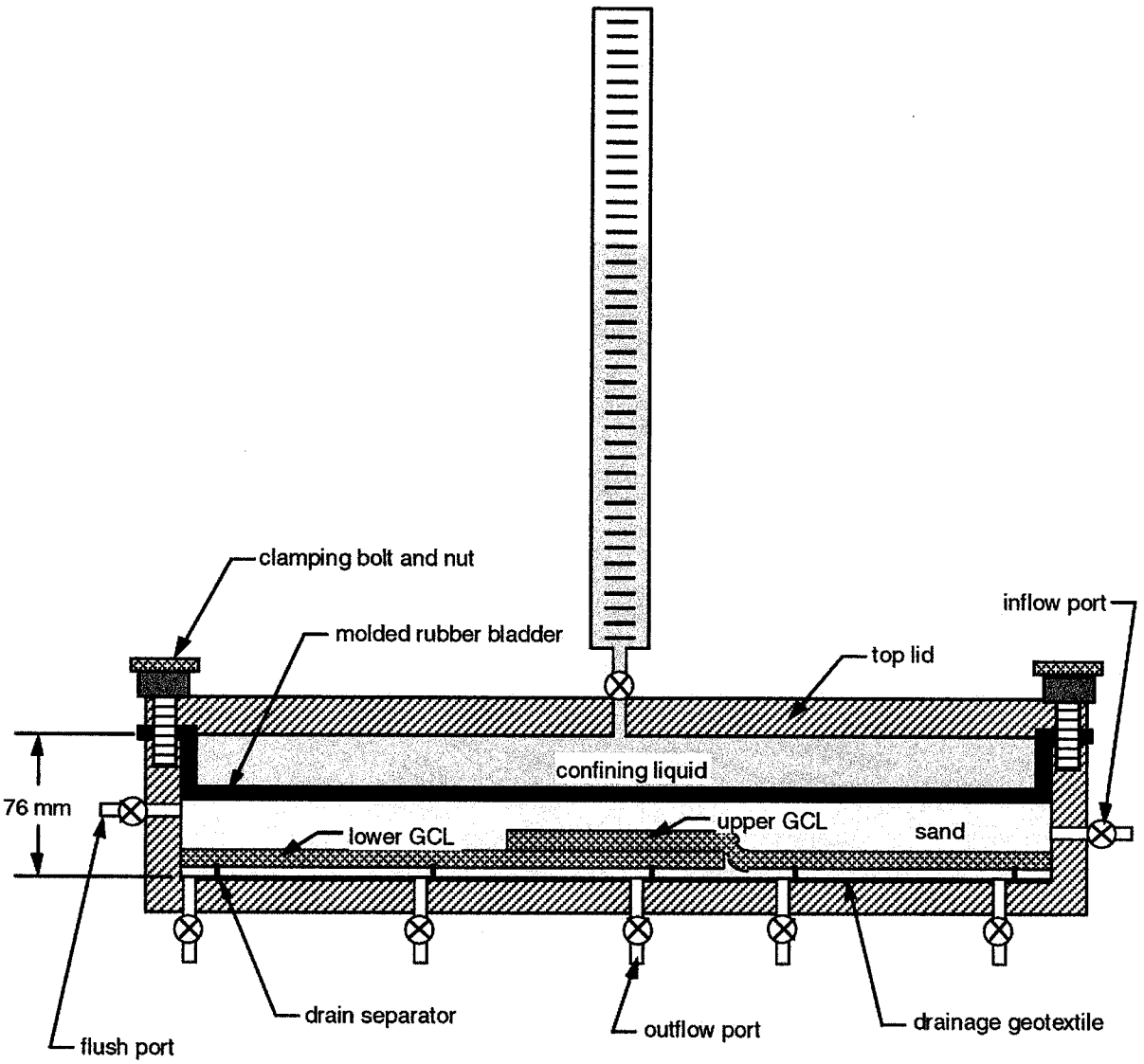


Figure . Cross Section View of GCL Flow Box In Which a GCL Overlap is Illustrated. Confining Pressure Applied Via a Water Column Contained in an Acrylic Standpipe