1.9. LCC Specification

Rev A. 17 April 2020:
- Updated Specification--see red-lined changes

- Added Special Test Procedures by Montez Group
  Field Saturated Density Test
  Modified Falling Head permeability

TECHNICAL SPECIFICATIONS

FOR

SEAWALL LOT 337 / MISSION ROCK PROJECT PHASE 1

PERMEABLE / OPEN-CELL LIGHTWEIGHT CELLULAR CONCRETE – PLLC (31-20-00)

CITY OF SAN FRANCISCO, SAN FRANCISCO COUNTY CALIFORNIA

Engineer's Attest:

The following Technical Specifications have been prepared under the supervision of the undersigned, who hereby certifies that he/she is registered in the State of California.

Geotechnical Specifications Prepared by:

17 April 2020

~~28 February 2020~~

Scott A. Walker, P.E. NO. 63241 Date
Senior Associate
Langan Engineering and Environmental Services, Inc.

31 23 23.33
Permeable/Open-Cell Lightweight Cellular Concrete (P-LCC)

Geotechnical aspects of the specification were prepared by Langan Engineering and Environmental Services, Inc.

1. GENERAL
   1.1. DESCRIPTION
      1.1.1. Work Included: This work shall consist of batching, mixing, placing and testing P-LCC of the appropriate density as indicated by the specifications. A trained P-LCC installer shall furnish labor, material, equipment, and supervision for the installation of the P-LCC in accordance with the drawings and specifications.

   1.2. QUALITY ASSURANCE
      1.2.1. Use skilled labor that is thoroughly trained, experienced, and familiar with the specified requirements and the methods for proper performance of this work. P-LCC contractor shall have a minimum of 5 years of relevant experience with similar size and types of projects, and provide skilled supervision and craft labor subject to approval of owner.
      1.2.2. The P-LCC installer shall be approved in writing by Owner.

   1.3. SUBMITTALS
      1.3.1. The prime contractor shall list the product and qualified installer of the P-LCC and shall not employ any product or producer without the prior approval of the geotechnical engineer of record (GEOR).
      1.3.2. Product data: within 30 calendar days after award of the contract, the prime contractor shall submit a mix design for approval by the GEOR and civil engineer of record (CEOR)
         1.3.2.1. Manufacturer's specifications, catalog cut sheet, and other engineering data needed to demonstrate to the issuing authority compliance with the specified requirements.
      1.3.3. Mix Design: Submit a mix design that will produce a cast density that complies with those listed in Section 2.2.1 of this specification at point of placement and a compressive strength within the range listed in Section 2.2.1. Include laboratory data using the mix design verifying un-foamed density, final foamed density, permeability (cm/sec) and compressive strengths. Mix design shall include water/cementitious ratio and foam solution dilution ratio, in accordance with manufacturer's recommendations. The mix design should also include Field Permeability Check Testing, by testing the percolation rate in modified 6" x 12" cylinder molds, filled half-way. The mix design should also include field saturation testing by the special inspector.
      1.3.4. Work Plan: Submit a work plan before placement of P-LCC material. The plan shall include:
         1.3.4.1. Proposed construction sequence and schedule
         1.3.4.2. Type of equipment and tools to be used.
         1.3.4.3. Material list of items and manufacturer's specifications
         1.3.4.4. P-LCC lift thickness
         1.3.4.5. P-LCC cure time and minimum strength prior to placing the next lift
         1.3.4.6. QA/QC and testing items and protocols frequency.

2. PRODUCTS

2.1. MATERIALS

2.1.1. Foaming Agent: A foaming agent shall be used and shall comply with the standard specifications of ASTM C 869 when tested in accordance with ASTM C 796. Admixtures shall be tested by the foam concentrate manufacturer for compatibility with the foaming agent.

2.1.2. Cement: the Portland cement shall ~~comply with~~be Type 1/ Type 2 cement and comply with ASTM C 150. ~~Other supplemental cementitious material such as fly ash may be used when approved by the project engineer. Supplementary cementitious materials shall be tested prior to the start of the project for compatibility with the foaming agent.~~

2.1.3. Admixtures: admixtures for accelerating, water reducing, and other specific properties may be used when specifically approved by the GEOR. Admixtures shall be tested in mix design prior to the start of the project for compatibility with the foaming agent.

2.1.4. Water: use water that is potable and free from deleterious amounts of alkali, acid, and organic materials, which would adversely affect the setting or strength of the P-LCC.

2.1.5. Filter Fabric: Shall have permeability equal to or greater than that of the P-LCC. Filter fabric shall also have a maximum apparent opening size (AOS, ASTM D4751) of 0.212 mm (U.S. sieve size 70).

2.2. PROPERTIES

2.2.1. Two types of P-LCC are to be supplied for the project: (1) general P-LCC to be applied across the site at multiple depths and (2) high density P-LCC to be cast only in the upper two feet of the LCC section. P-LCC shall meet the following properties:

General P-LCC			
	Target	Maximum	Minimum
General Cast Density, pcf (ASTM C 796)	26	28	24
Compressive Strength at 28 Days, psi (ASTM C 495)	NA	200	50
Coefficient of Permeability, cm/sec (ASTM D 2434 – modified)	0.1 (1E-1)	NA	0.005 (5E-3)
Saturated Density, pcf	55	68	50

High Density P-LCC – to be cast only within upper two feet of overall P-LCC section			
	Target	Maximum	Minimum
Cast Density of LCC, pcf (ASTM C 796)	30	32	28
Compressive Strength at 28 Days, psi (ASTM C 495)	NA	200	80
Coefficient of Permeability, cm/sec (ASTM D 2434 – modified)	0.1 (1E-1)	NA	NA
Saturated Density, pcf	55	68	50

3. EXECUTION

3.1. Subgrade: Subgrade to receive P-LCC material shall be free of all loose and extraneous material. Light compaction equipment may be employed to tamp lose material. Subgrade shall be uniformly moist, and any excess water standing on the surface shall be removed. The subgrade shall be approved by the GEOR before placing filter fabric and P-LCC material.

3.2. Curing: A minimum 12-hour curing period between lifts is required. Backfill or other usual loadings, including additional lifts of P-LCC, on the P-LCC shall not be permitted until the P-LCC has attained a compressive strength of at least 5 psi.

3.3. Weather Conditions: If ambient temperatures are anticipated to be below 40 degrees F within 24 hours after placement, the mixing water shall be heated when approved by the manufacturer of the foaming agent or placement shall be prohibited. Placement shall not be allowed on frozen ground.

3.4. Batching and Mixing: Cellular concrete shall be job site batched, mixed with the foaming agent and placed with specialized equipment certified by the manufacturer of the cellular concrete lightweight material. Cement and water may be premixed and delivered to the job site and the foaming agent added on site. Dilution ratio shall be adjusted as needed per manufacture's recommendation to achieve required end product.

3.5. Placement:

3.5.1. Place P-LCC in lifts not to exceed 36 inches in thickness, unless otherwise recommended by the P-LCC manufacturer and approved by the GEOR.

3.5.2. After curing for minimum of 12 hours, any crumbling area on the surface shall be removed before the next layer is placed. Surface stepping to achieve grade and super elevation shall not be less than 6 inches in thickness. Grades of up to 5 percent may be made by adding a thickening agent to the mix in conformance with the manufacturer's recommendation.

3.5.3. Subgrade and P-LCC should be protected from water inundation until the P-LCC is sufficiently cured and has sufficient overlying weight so it does not become buoyant.

3.5.4. Freshly placed P-LCC should be protected from rain until it has been sufficiently cured to prevent damage.

3.5.5. Freshly placed P-LCC should be cured at least 3 hours before exposed to

vibrations higher than a peak particle velocity 0.05 inches per second – such as those that may be generated during ground improvement activities.

3.6. Handling: Avoid excess handling of P-LCC according to industry standards.

3.7. Filter Fabric: Use filter fabric between P-LCC and adjacent soil and between P-LCC and shoring, where shoring will be removed after P-LCC placement.

4. QUALITY CONTROL TESTING BY CONTRACTOR AND OWNER

4.1. DENSITY CONTROL

4.1.1. During placement of the initial batches, check the un-foamed and foamed densities for each 100 cubic yards of P-LCC or as recommended per the GEOR and adjust the mix as required to obtain the proper water to cement ratio per the approved mix design and specified cast density at the point of placement per ASTM.

4.1.2. Field saturated density test procedures developed and prepared by the special inspector shall be performed on one sample for each 100 cubic yards of P-LCC or as recommended per the GEOR. GEOR to review and approve test procedures prior to commencement of work.

4.2. COMPRESSIVE STRENGTH: The compressive strength shall be tested under ASTM C 495 except as follows:

4.2.1. Four (4) specimens (one 7-day and three 28-days) shall be taken for each 100 cubic yards of P-LCC or as recommended per the GEOR. Unless otherwise approved, the specimens shall be 3 x 6 inch cylinders. During molding, place the LCC in 2 equal layers and raise and drop the cylinders 1 inch, 3 times on a hard surface or lightly tap the side or bottom of the cylinder to close any accidental entrained air. No rodding is allowed.

4.2.2. Specimens must be covered and protected immediately after casting to prevent damage and loss of moisture. Specimens shall be moist cured in the molds for ~~7~~6 and 25 days and air dry a minimum of 24 hours and minimum of 72 hours before the 7-day and 28- day compressive strength testing, respectively. Specimens shall not be oven dried.

4.2.3. Contractor should maintain process control "run" charts of un-foamed and foamed density, field percolation result, and compressive strength data, updated daily for review by Owner's representative, and distributed weekly to applicable project team members.

4.3. PERMEABILITY:

4.3.1. Proof of permeability (per ASTM D 2434 – Modified) of the proposed P-LCC mix design shall be provided in the mix design submittal. If there is any change to the mix design during production, additional permeability testing will be required. Two samples per week should be cast per ASTM D 2434 and shipped to Castle Rock Consulting for testing.

4.3.2. Field falling head permeability per procedures prepared by the special inspector performed on every 500 cubic yards placed, with a minimum of two samples per day. Falling Head permeability test procedures to be reviewed and approved by GEOR prior to commencement of work.

4.4. MOCK UP TEST SECTION: One mock up test section shall be installed prior to construction to prove out the contractor's construction methods.

4.5. Side-by-side sampling and testing by QC and QA staff should occur once daily during the LCC placement on the ~~Pilot Project~~ Mock Up Test Section to identify any issues. At least one set of permeability samples should also be taken for saturation and drain down density and a permeability verification on the Mock Up Test Section.

4.6. UNFOAMED SLURRY TESTING: Test unfoamed slurry density periodically during foaming

to verify actual density (PCF) is +/- 1.5% of target. Target to be established in mix submittal.

4.7. QUALITY ASSURANCE INSPECTIONS & ACCEPTANCE TESTING BY OWNER'S AGENCY

4.7.1. Owner shall employ a qualified Special Inspector to observe LCC placement and test LCC as described below. Special inspector is required to have a current ACI Concrete Field Testing Technician - Grade 1 Certification.

4.7.2. Daily Inspections should include review of previous day's density testing of un-foamed and foamed test data, field permeability~~colation~~ test results, any 7-day & 28-day compressive strength data, and location of samples taken. Initially use mix design for 7-day to 28-day strength correlation, switching to project data when three sets are available to predict 28-day strengths.

4.7.3. Perform one side-by-side comparison test with Contractor every 1000 cubic yards, and verify saturation density, ~~&~~ drain-down densit~~ics~~y, compressive strength, and field permeability ~~(per ASTM D 2434) values~~ every 1,000 cubic yards placed, or whenever the field percolation rates are more than 20% lower than the mix design values.

4.7.4. Perform one laboratory permeability (ASTM D2434) every 5,000 cubic yards, with samples obtained from the 1,000 cubic yard side-by-side comparison from Section 4.7.3.

4.7.5. City personnel may provide additional special inspection at the City's discretion.

5. ACCEPTANCE CRITERIA

5.1.1. Installed LCC shall be considered acceptable provided the testing performed in Section 4 achieve the specified properties specified in Section 2.

5.1.2. LCC work found out of tolerance to be removed and replaced. All material and labor required to perform remedial work or replace rejected LCC shall be provided at no cost to the Owner.

SPECIAL TEST PROCEDURES

- FIELD SATURATED DENSITY TEST

- FALLING HEAD PERMEABILTIY PROCEDURE

These test procedures added in Rev A, 17 April 2020

MONTEZ GROUP
Engineering & Construction Management

Montez Group Inc.

Field Saturated Density of PLCC Test Procedure

Prepared: February 28, 2020

SUBMITTAL No.:
Field Saturated Density of PLCC Test Procedure

This submittal has been reviewed for the Geotechnical aspects of the design only. Contractor is responsible for all corrections indicated hereon, for dimensions quantities, fabrications, construction techniques, and coordination with other contractors, subcontractors and suppliers. This review does not authorize changes to the contract requirements unless stated in a separate letter or change order.

☒ NO EXCEPTIONS TAKEN ☐ AMEND & RESUBMIT
☐ EXCEPTIONS NOTED ☐ REJECTED-SEE COMMENTS

Checked By: P. Brady **Date:** 28 February 2020

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MONTEZ GROUP
Engineering & Construction Management

Table of Contents

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1.0 Equipment List

1. 4x8” Cylinder Mold
2. Bucket/Wheel Barrel for Taking Samples for 6x12” Molds
3. Unit Weight Air Pot (Used in ASTM C138)
4. 5-gallon Bucket of Water
5. Scale
6. Caliper
7. File or Scraper
8. Cylinder Stripping Tool or Box Cutter

2.0 Significance and Use

The Field Estimation of Saturated Density Test Procedure provides the Saturated Density of Permeable Lightweight Cellular Concrete (see appendix 2 for example of calculation).

3.0 Sampling Procedure

Sampling procedure for PLCC is like taking samples of compressive strengths of LCC (ASTM C39 except mold sizes used are 4x8”.

1. Take and label 4x8” mold
2. Gather material in bucket or other container to transport material from placement location to sampling location
3. Use measuring cup, trowel or container to transfer material into 4x8” mold
4. Fill mold in 2 to 3 lifts up to top. Each lift should be consolidated by tapping the side of mold to release bubbles.
5. Place lid on sample
6. After samples are taken, handle carefully to location to allow to cure undisturbed for at least 24 hours

4.0 Testing Procedure

1. Sample will be cured for 3 days prior to testing
2. Carefully strip the PLCC sample from the cylinder mold using a cylinder stripping tool or box cutter without disturbing sample.
3. Use a file or scraper to remove about ¼” of material from the top and bottom ends of the cylinder to roughen the surface and expose the cellular structure while ensuring sample’s corners are still squared. If larger amounts of material must be removed, a hand saw can be used, but be sure to square the ends as best

as possible with the file.

4. Measure the height of the PLCC cylinder. Measure to the nearest 1/8”. Take the average of 3 to 4 heights around the circumference of the cylinder. Record this value (A).
5. Fully submerge the PLCC cylinder in a full 5-gallon bucket of water, upright and weighting the cylinder down to prevent floatation. Keep the cylinder fully submerged for at least 30 minutes. Multiple cylinders can be submerged simultaneously, provided they remain identified.
6. Weight a standard concrete air pot assembly, pot and cap, and record the tare weight (B).
7. Fill the air pot completely with water, with the cap on, fill and remove excess air through the petcocks as though for a concrete air test, close the petcocks when full.
8. Dry the air pot assembly off with a rag or cloth, weight the water filled assembly and record this value (C).
9. Remove the cap from the air pot and place it beside the bucket containing the submerged PLCC cylinder. The air pot should be full of water.
10. Quickly transfer the submerged PLCC cylinder from the water bucket to the air pot, submerging the cylinder completely.
11. Holding the PLCC cylinder under water with one hand, place the air pot cap on with the other and clamp it down.
12. Fill the air pot assembly completely with water through the petcocks, closing the petcocks when full.
13. Again dry the entire assembly off with a rag or cloth, weigh and record this value (D).
14. Calculate the Saturated Density
    a. See Appendix Sample – Test Results & Table of Calculations

5.0 Appendix

1. Sample – Test Results

FIELD ESTIMATION OF SATURATED DENSITY OF PLCC
Test Method Provided by
CASTLE ROCK CONSULTING
TEST DATA SHEET

Project Name: Misson Rock -Lightweight Cellular Concrete Mock-up CEL # 10-37339PW

Sample Date: 12/17/2019 Sampled By: David Chin Lab # N/A

Sample Location/Source: Set 1

Material Description/Condition : Lightweight Cellular Concrete

Test Data

	Measure 1	Measure 2	Measure 3	Measure 4
Cylinder Heights, in	7.82	7.87	7.83	7.83

A. Average Cylinder Height (in)	7.84
B. Air pot assembly tare weight (pot + Cap), lb	17.70
C. Air pot assembly tare weight filled with water, lb	33.50
D. Air pot assembly with water + cylinder, lb	33.15
E. Cylinder Volume, (12.57 x A)/1728, cf	0.0570
F. Displacement water weight, 62.4 x E, lb	3.56
G. Full pot water weight, C-B, lb	15.80
H. Balance Water weight, G-F, lb	12.24
I. Approximate Saturated Unit Weight, (D-H-B)/E	**56.26** **pcf**

Tested By: Y.Han
Date Tested: 12/31/2019

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2. Sample – Table of Calculations

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Field Saturated Density | Updated | Input Data

					A1	A2	A3		A Avg	B	C	D	E	F	G	H		
Item #	Location	Description	Cast Date	Date Tested	Cylinder Height (in)	Cylinder Height (in)2	Cylinder Height (in)3	Cylinder Height (in)4	Cylinder Height Average (in)	Airpot assembly tare weight (pot +	Air pot assembly tare weight filled with water	Air pot assembly with water + cylinder	Cylinder Volume	Displacement water weight	Full pot water weight	Balance water weight	Approximate Saturated Unit Weight	Comments
11	Mission Rock Pilot Lift #3	Set1	12/17/2019	12/31/2019	7.82	7.87	7.83	7.83	7.84	17.70	33.5	33.15	0.0570	3.56	15.80	12.24	56.26	

MONTEZ GROUP
Engineering & Construction Management

Montez Group Inc.

Falling Head Field Permeability Test Procedure

Prepared: February 28, 2020

SUBMITTAL No.:
Falling Head Field Permeability Test Procedure

This submittal has been reviewed for the Geotechnical aspects of the design only. Contractor is responsible for all corrections indicated hereon, for dimensions quantities, fabrications, construction techniques, and coordination with other contractors, subcontractors and suppliers. This review does not authorize changes to the contract requirements unless stated in a separate letter or change order.

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☐ EXCEPTIONS NOTED ☐ REJECTED-SEE COMMENTS

Checked By: P. Brady **Date:** 28 February 2020

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1.0 Equipment List

1. Modified 6x12” Cylinder Mold
    a. 6x12 Molds w/ Lids (Molds used for ASTM C31)
    b. Scribing Tool
    c. Tape
    d. 100 grit sandpaper
2. Bucket/Wheel Barrel for Taking Samples for 6x12” Molds
3. 5 Gallon Bucket
4. Heavy Wire Screen or 12” Brass Sieve
5. Steel Ruler
6. Stopwatch
7. Water

2.0 Significance and Use

The Falling Head Field Permeability Test Procedure provides another method of calculating the Permeability Constant (K) while being able to perform in the field.

$$K = \frac{L}{T} ln \frac{h_1}{h_2}$$

Where:

K = Coefficient of Permeability in cm/sec

L = Sample Length in cm

h_1 = Initial elevation of the water surface

h_2 = Final elevation of the water surface

T = Average time in seconds from h_1 to h_2.

3.0 Preparing 6x12” Modified Cylinder Molds

1. Take a 6x12” cylinder mold and place open end upside down
2. Cut off the bottom of mold
3. Measure 6” from cut end of mold and mark a line on the inside with scribing tool
4. Use the 100 grit sandpaper and roughen the inside of the mold from 6” measurement to the cut end

5. Sand inside face of lid of cut end
6. Place lid on bottom (cut end) of mold
7. Tape lid on cylinder mold

4.0 Sampling Procedure

1. Take and label prepared modified 6x12” mold
2. Gather material in bucket or other container to transport material from placement location to sampling location
3. Use measuring cup, trowel or container to transfer material into modified 6x12” mold
4. Fill mold in 2 to 3 lifts up to pour line (approximately 6” mark). Each lift should be consolidated by tapping the side of mold to release bubbles.
5. After samples are taken, handle carefully to location to allow to cure undisturbed for at least 24 hours
6. Cover open tops of molds with another 6x12” lid or other suitable material to prevent moisture loss while curing

5.0 Testing Procedure

1. Sample will be cured for 3 days prior to testing
2. Place mold open side upside down and carefully remove tape and lid from bottom of mold. Ensure sides of mold will not break contact with samples.
3. Use scraper to scarify surface of bottom of sample and expose cellular structure
4. Turn mold upright and use scraper to scarify top surface and expose cellular structure and remove as little material as possible
5. With the cylinder mold with the open end up, press a ruler into the surface of the material to a depth of 1 inch, at the edge of the surface with the ruler oriented vertically. This is the depth scale for the falling head test. With one inch inserted, the next increment should be the 2” mark, corresponding to 1” of water above the surface, 3” will correspond to 2” of water, and so on
6. Fill a 5-gallon bucket completely with clean water
7. Place a heavy wire screen or 12” bass sieve on top of another, empty 5-gallon bucket. When the sample is removed from the water bucket, it will be transferred to the screen to allow it to drain freely
8. Submerge the mold, bottom surface first into the bucket of water, holding the top edges of the cylinder and pushing the sample down vertically, allowing water to infiltrate from the bottom and move upward through the cellular material
9. Keep mold submerged until water has infiltrated and covered the top surface of the material

10. Fully submerge the entire mold in the bucket, allowing the entire top half of the mold to fill with water
11. Holding the top edges of the mold, lift the entire mold vertically from the water and quickly transfer it to the screen over the empty bucket
12. The first run was to wash the water through to prime the sample. One the sample is prime, it is not necessary to re-prime the sample in between tests.
13. Get a stopwatch ready to record time
14. Repeat steps 8 to 11
15. With the stopwatch ready, start timing when the water level reaches the 5" mark (4" above the material surface).
16. Continue timing until the water level reaches the 2" mark (1" above the surface), stop timing.
17. Record the time (T in seconds) where Trial 1 is T_1, Trial 2 is T_2 etc…
18. Repeat steps 15 to 17 two more times, recording the time for the water level to drop from the 5" mark to the 2" mark, for a total of three trials.
19. Calculate all T per trial and average for T to input into coefficient of permeability, K
20. The approximate permeability coefficient can now be calculated from the average of the three recorded times by the falling head formula as shown in section 2.0:

$$K = \frac{L}{T} ln \frac{h_1}{h_2}$$

6.0 Appendix

1. Sample – Test Results

FALLING HEAD FIELD PERMEABILITY TEST
Test Method Provided by
CASTLE ROCK CONSULTING
TEST DATA SHEET

Project Name: Misson Rock -Lightweight Cellular Concrete Mock-up CEL # 10-37339PW
Sample Date: 12/23/2019 Sampled By: David Chin Lab # N/A
Sample Location/Source:
Material Description/Condition : Lightweight Cellular Concrete

Test Data

Tested By: Y.Han Date Tested: 12/31/2019

Trial #		Initial	1	2	
L, Length of Sample, cm		15.24	15.24	15.24	
h1, Initial elevation of the water surface, in		4	4	4	
h2, Initial elevation of the water surface, in		1	1	1	
Average time from h1 to h2	Min.	54	34	37	
	Sec.	46.15	32.25	44.36	AVG
Average Time in Seconds, sec		3286.15	2072.25	2264.36	2540.92
K, Coefficient of Permeability, cm/sec K=L/T*ln(h1/h2)					**0.008315**

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2. Sample – Table of Calculations

Falling Head Field Perm Updated Input Data

Item #	Location	Description	Cast Date	Date Tested	L (in Inches)	L (in cm)	h1 (Inches)	h2 (Inches)	Trial 1 T_A (in sec)	Trial 2 T_B (in sec)	Trial 3 T_C (in sec)	T_{avg} (in Sec)	K (in cm/sec)	Comments
10	Mission Rock Pilot Lift #4	Set1	12/31/2019	12/31/2019	6	15.24	4	1	3286.15	2072.25	2264.36	2540.92	8.31E-03	

K Coefficient of Permeability in (cm/Sec)
L Sample length in cm
h1 Initial elevation of water surface
h2 Final elevation of water surface
T Average time in seconds from h1 to h2

$K=(L/T)\ln(h1/h2)$