Ministry of education and science of Ukraine
Poltava National Technical Yuri Kondratyuk University
Department of oil and gas recovery and geotechnics

JOURNAL

FOR LABORATORY WORK BY ENGINEERING GEOLOGY

for students of specialty
192 construction and civil engineering,
Educational level „bachelor” (full-time study)

Surname and initials of the student ____________________

Group ____________________

Evaluation of the test ____________________

Poltava 2017

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Approved by the University’s Board.
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El. code.

INTRODUCTION

The journal contains reference, graphical, tabular and factual material, as well as concise recommendations for laboratory work by engineering geology for students of specialty 192 construction and civil engineering, educational level „bachelor” (full-time study)

The journal is compiled on the basis of such preliminary methodological developments as "Journal for laboratory works on engineering geology" by the author - senior lecturer V.V. Kozak and "Journal for laboratory works on engineering geology and environmental protection" author - associate professor, candidate geological-mineralogical sciences A.A. Yakimenko.

Attention:

1. The implementation of laboratory work is preceded by listening to lectures on "Engineering Geology", as well as non-auditing work of students over relevant sections of the course.
2. Laboratory work is an important form of educational process that is aimed at assimilating and consolidating students' learning material and acquiring skills to perform practical tasks.
3. In order to obtain a credit for laboratory work, you must have a well-designed journal on laboratory work, signed by a teacher, as well as a complete picture of the exercises performed during the training sessions.

Laboratory work № 1

THE MOST IMPORTANT ROCK-FORMING MINERALS

Using Methodical instructions for laboratory work "The most important rock-forming minerals and rocks" (compiler - professor Yu.L. Vynnykov), and auxiliary materials and accessories, carefully read the properties of the three samples of minerals. After examining the external characteristics of minerals should refer them to the appropriate class and set the name.

<u>Sample № 1</u>

Signs of

1. Hardness _______________ 2. Luster ______________________________________
3. Color ____
4. Cleavage ____
5. Fracture ____
6. Habit ____
7. The species in nature ____
8. Special features ____
9. Using in production ____

____

Conclusion

1. Name of class ____
2. Name of mineral ____

<u>Sample № 2</u>

Signs of

1. Hardness _______________ 2. Luster ______________________________________
3. Color ____
4. Cleavage ____
5. Fracture ____
6. Habit ____
7. The species in nature ____
8. Special features ____
9. Using in production ____

____

Conclusion

1. Name of class ____
2. Name of mineral ____

Sample № 3

Signs of

1. Hardness ________________ 2. Luster ____
3. Color ____
4. Cleavage ____
5. Fracture ____
6. Habit ____
7. The species in nature ____
8. Special features ____
9. Field of application____
____

Conclusion

1. Name of class ____
2. Name of mineral ____

THE MOST IMPORTANT ROCKS

Using Methodical instructions for laboratory work “The most important rock-forming minerals and rocks” (compiler - professor Yu.L. Vynnykov), and auxiliary materials and accessories, carefully read the properties of the three samples of rocks (magmatic, metamorphic and sedimentary). After examining the external characteristics of rocks should refer them to the appropriate class and set the name.

Sample № 1

Signs of

1. Color ____
2. Structure ____
3. Texture ____
4. Mineral composition ____
5. Special features ____
6. Peculiar properties ____
7. Field of application____
____

Conclusion

1. Name of genetic species ____
2. Name of rock____

Sample № 2

Signs of

1. Color ____
2. Structure ____
3. Texture ____
4. Mineral composition ____
5. Special features ____
6. Peculiar properties ____
7. Using in production ____

____

Conclusion

1. Name of genetic species ____
2. Name of rock____

Sample № 3

Signs of

1. Color ____
2. Structure ____
3. Texture ____
4. Mineral composition ____
5. Special features ____
6. Peculiar properties ____
7. Using in production ____

____

Conclusion

1. Name of genetic species ____
2. Name of rock____

The most important rock-forming minerals and rocks

Each group of students selects 3 samples of minerals and conducts research characteristics as follows:

1. Determine sample hardness on the Mohs scale (1 – 10)
2. Determine luster surface sample split view (metallic, glassy, silky)
3. Determine sample color
4. Determine mineral cleavage
5. Determine appearance of fracture
6. Determine sample form
7. Determine special features
8. After examining the external characteristics of minerals should refer them to the appropriate class and set the name

9. All features and properties recorded in the log of laboratory work
10. Record of the form in the nature and field of application

Each group of students selects 3 samples of rocks: magmatic, metamorphic and sedimentary. Conducts research characteristics as follows:

1. Determine the sample color
2. Determine the structure of rocks
3. Determine the texture of rocks
4. Determine the mineral composition
5. Determine the special features and properties
6. After examining the external characteristics of rocks should refer them to the appropriate class and set the name
7. All features and properties recorded in the log of laboratory work
8. Write the field of application

The table to determine rock-forming minerals

Name of mineral	**Loadstone(magnetite)**	**muscovite**	**gypsum**
Name of class	oxide	silicate	sulfate
hardness	5.5 - 6.5	2 - 3	1,5 - 2
luster	metallic	glassy, nacreous	glassy, nacreous
color	black, not transparent	colorless, green, yellow	colorless, white, yellow
mineral cleavage	–	perfect in one direction	perfect in one direction
appearance of fracture	acinose, grainy	–	even, acinose, grainy
specific weight	45 - 53	27 - 31	23
sample form	cubic octahedron	in the form of stacks of thin plates	as crystals
form in the nature	Dense masses, granular inclusions	In igneous rocks, gneisses, schists	In the form of layers of sedimentary rocks
special features	Magnetic properties	divided into thin, elastic leaves	
field of application	ironstone	In the electro-technical industry	As a binder

The table to determine rocks

Name of rock	granite	limestone	shale
group	magmatic	sedimentary	metamorphic
color	grey, yellow, pink	white, light-grey, yellow	black, grey, green
structure	Fully-crystalline	Various	Incomplete-crystalline, fine-grained
texture	massive	massive, porous	shale
mineral composition	feldspar, quartz, biotite	calcite, dolomite	Clay minerals, biotite, muscovite, quartz
special features	Acidic rock mainly deep quartz 25 - 30%	Boil on weak solution of hydrochloric acid HCl	Matte luster, structure thin-slate
properties	R = 100 - 200 MPa	R = 7-200 MPa	γ = 26 - 28 kN/m^3 R = 20 - 60 MPa
field of application	Facing material, rubble	Production blocks and slabs. Raw material for lime production	Refractory products

Laboratory work № 2

CONSTRUCTION OF GEOLOGICAL SECTION

1. Draw a geological section area using geological map (Fig. 1).
2. The section is done at millimeter A4 paper.
3. We use the following scale: Horizontal - 1:25000; vertical - 1:5000.
4. Geological section plotted by segment AB that is given to each map (fig. 1) individually.
5. From below making retreat 5 cm and draw a line base.
6. On the left side of doing retreat 1 cm and draw a scale heights in scale (step 100 corresponds to 2 cm). Maximum horizontal mark is 900, minimum – 500. So draw a scale from 400 to 1000.
7. plotted on the line base segment AB on the scale of 1: 25000. As the scale of the map is the same, the cut segment measure ruler (fig. 1) and carry each other.
8. Next plotted points on the cut segment AB corresponding to its intersection with the horizontal. Sign them.
9. We transfer point of the cut line base up according to the scale heights.
10. We connect points consistently smooth line profile.
11. Then on our geological section we need to locate geological elements. On the geological map we transfer point of intersection of geological elements. Denotes those points on the line profile numbers.
12. Starting from the top profile connecting points with the same geological elements smooth lines.
13. The geological elements that are found only on one side have no exit on the surface profile. We connect them with line base.
14. Then we are hatching (shading) geological elements according to the legend. Draw conventional signs to the right of the geological section (fig. 1).

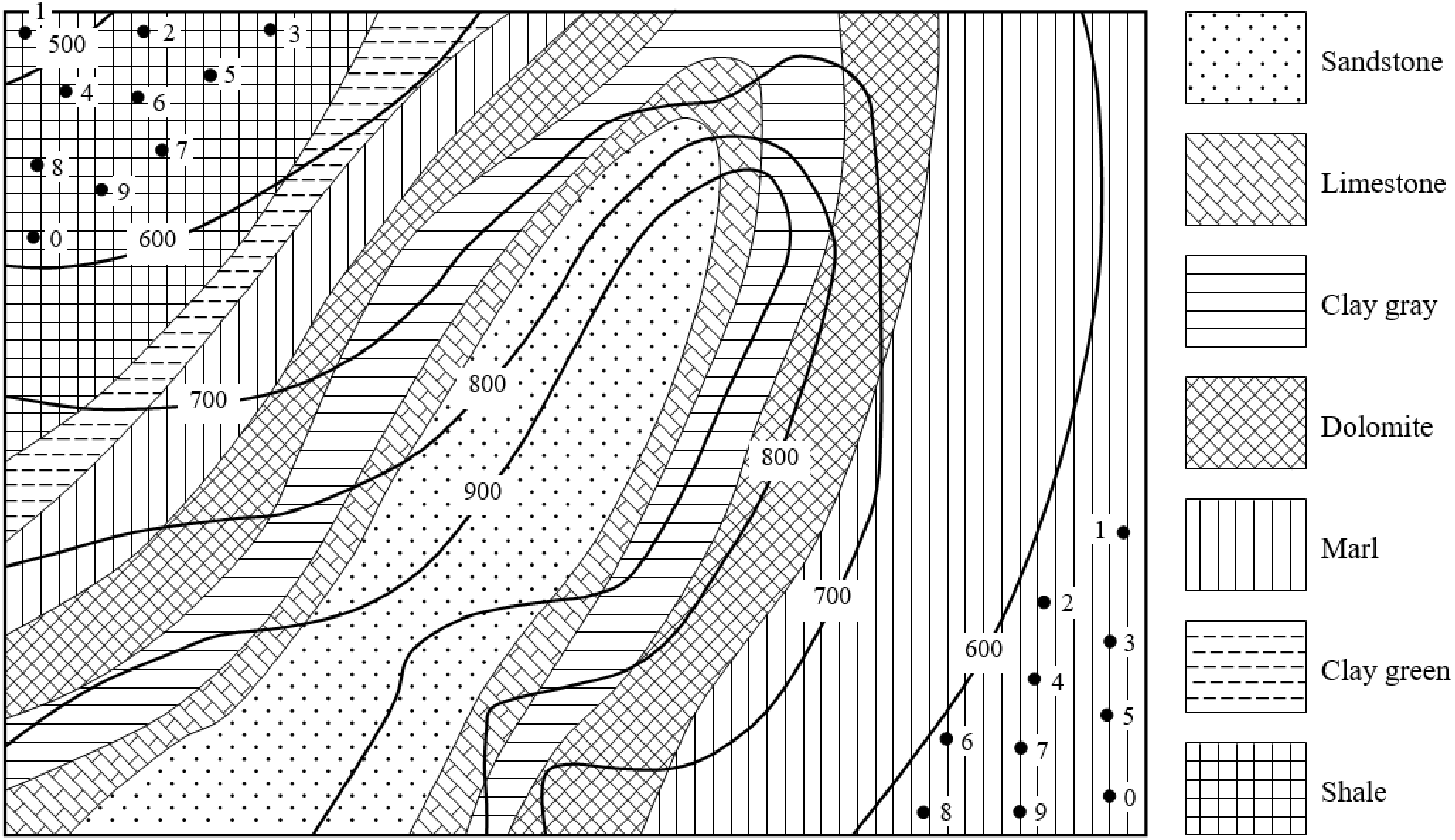


Fig. 1. Geological map of the area M 1:25000

Laboratory work № 3

DRAW MAP THE SURFACE OF GROUNDWATER IN THE HYDROIZOHIPS

1. Information about the features of the relief area, the depth of the location of groundwater, the distance between wells where groundwater identified given in Table 1. Soil permeability aquifers rocks and the average thickness of the aquifer are shown in Table 2. They are chosen on the variants individually.

2. Drawings performed on a piece of graph paper.

3. Drawings performed on a piece of graph paper. Start with drawing a grid of nine wells located in the corners of the squares of the distance ℓ (80 m) in the scale of 1: 1000 (Scheme Fig. 1).

4. At each well record its number, the absolute mark of mouth (the ground) in the numerator and the absolute mark the groundwater level in the denominator (the calculation). Mark the groundwater level is marked as the difference between the ground and the depth of GWL (Table. 1).

5. For mapping the topography and GWL use measuring grid. Find the highest and lowest mark surface and draw a parallel line to measuring grid at 1 m. Sign them.

6. First found on the sides of squares and diagonals integer values (at 1 m) marks the surface with a measuring grid (or interpolation).

7. Further, connecting identical in size marks smooth curves by pencil. So get horizontal system.

8. Then, using the same measuring grid squares on the sides and the diagonals are integer values (at 1 m) marks GWL, and then, connecting the same in size marks smooth curves blue paste is prepared hidroizohips system.

9. Continuous arrows on the map indicate the direction of general flow of groundwater.

10. On the map, select a segment perpendicular the lines hidroizohips to determine the hydraulic pressure.

11. Determine the hydraulic pressure for GWL marks at the ends of the segment in the direction of general flow of the expression

$$I = \frac{H_1 - H_2}{L}. \tag{5.1}$$

Where H1 and H2 - RGV mark; L - length of the segment, m.

12. Determine the amount of water that is filtered in unit time through unit area of section flow (A=1 m^2)

$$q = I \cdot k_f \cdot A. \tag{5.2}$$

13. Determine the expense flow groundwater flat 1 m wide with an average thickness of the aquifer ($A=h\cdot 1{,}0$)

$$q_n = k_f \cdot A \cdot I \,. \qquad (5.3)$$

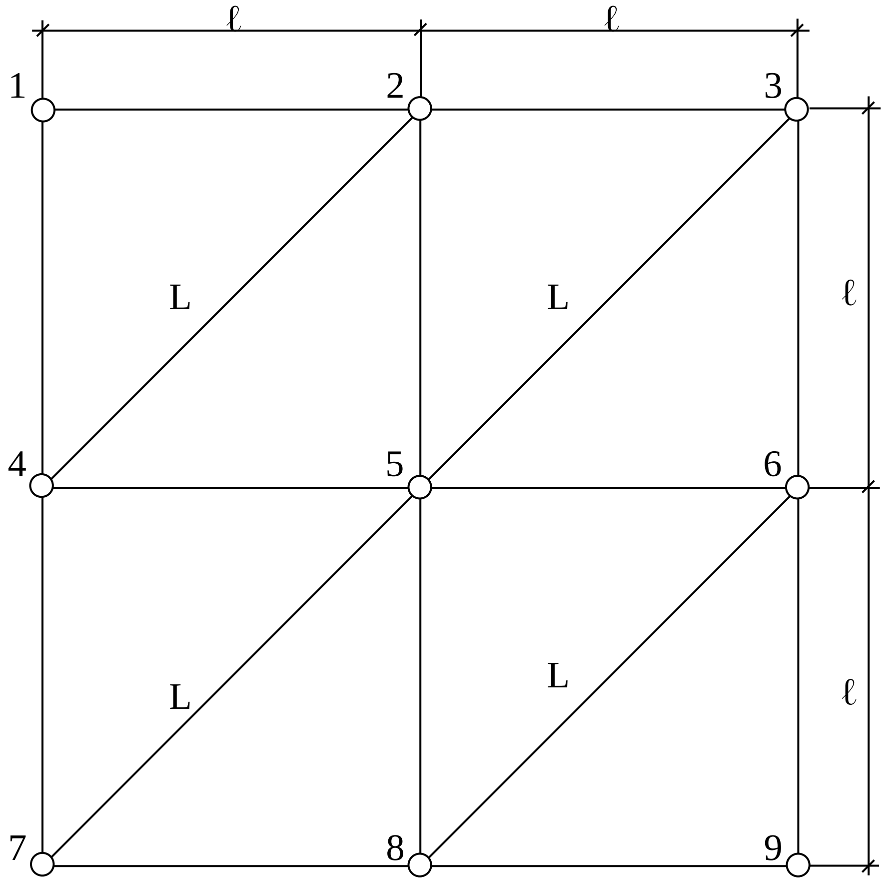


Fig. 1. Location of wells
Scale 1:1000

Table 1

Numbers of wells									the distance between wells ℓ, m
1	2	3	4	5	6	7	8	9	
$\frac{78{,}2}{2{,}5}$	$\frac{77{,}6}{1{,}6}$	$\frac{77{,}5}{2{,}0}$	$\frac{79{,}5}{2{,}4}$	$\frac{79{,}4}{1{,}8}$	$\frac{79{,}2}{2{,}5}$	$\frac{81{,}3}{1{,}7}$	$\frac{80{,}5}{0{,}8}$	$\frac{80{,}3}{2{,}3}$	80

Table 2

№ variant	1	2	3	4	5	6	7	8	9	10
soil permeability, k_f, m/day	7,9	14,0	8,5	11,3	7,8	13,4	10,5	9,7	12,2	8,6
the average thickness of the aquifer, *h*, m	6,3	7,0	6,8	5,8	5,6	7,3	6,5	6,0	5,5	7,5

Laboratory work № 4

CONSTRUCTING GEOTECHNICAL SECTION

1. Geotechnical sections are important documents geotechnical investigations. They give a visual representation of the nature of the occurrence of soils and hydrogeological conditions. Geotechnical sections build on pioneer excavations (pits and wells). They are placed on the area of the distance between them from 20 to 100 m. The construction of geotechnical section performing at least three pioneer wells.

2. Figure 2 shows the location of wells. Table 1 shows the horizontals marks, wellhead and distance between wells. Indicates the data in Figure 2.

3. The construction of geotechnical section performed on graph paper.

Table 1

The horizontals marks, m			The distance between wells, m	The wellhead marks, m		
a	*b*	*c*	*ℓ*	*w.1*	*w.2*	*w.3*
72,00	72,50	73,00	30,0	72,30	72,70	73,10

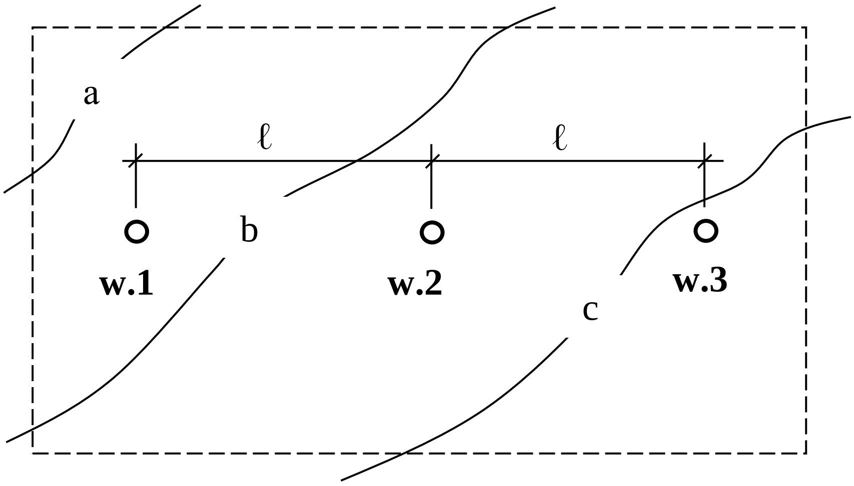


Fig. 2. Location of wells

4. Table 2 given thickness of 3 engineering-geologic elements (EGE). Using data from Table 2, determine the thickness of three engineering-geologic elements and depth of groundwater. Having added thickness of 3 layers get an array depth 10 m.

Table 2

Wells									depth of groundwater, m
№ 1			№ 2			№ 3			
The thickness of EGE, м									
topsoil	EGE-2	EGE-3	topsoil	EGE-2	EGE-3	topsoil	EGE-2	EGE-3	
0,50	2,85	6,45	0,45	2,90	5,85	0,55	2,75	6,05	2,50

5. On a scale of 1: 100 plot line marked on graph paper. Below retreat 7 cm, left - 6 cm. Marks on the scale markings 10 from 64 to 74 m.

6. From the scale retreat 1 cm and draw well №1. The width of the well is 5 mm. Mark wellhead is in Table 1.

7. From the well №1 in scale 1: 500 plotted the well №2 and №3. The distance between wells is 30 m, the scale is 6 cm.

8. Connecting the top of wells straight lines.

9. From each wellhead plotted the thickness of the first layer - topsoil. Thickness EGE given in the Table. 2.

10. Connecting points between the first layer wells straight line.

11. Draw a second layer thickness (EGE-2) from the end of the first layer in each well. Also connect a straight line.

12. Similarly plotted thickness of the third layer (EGE-3).

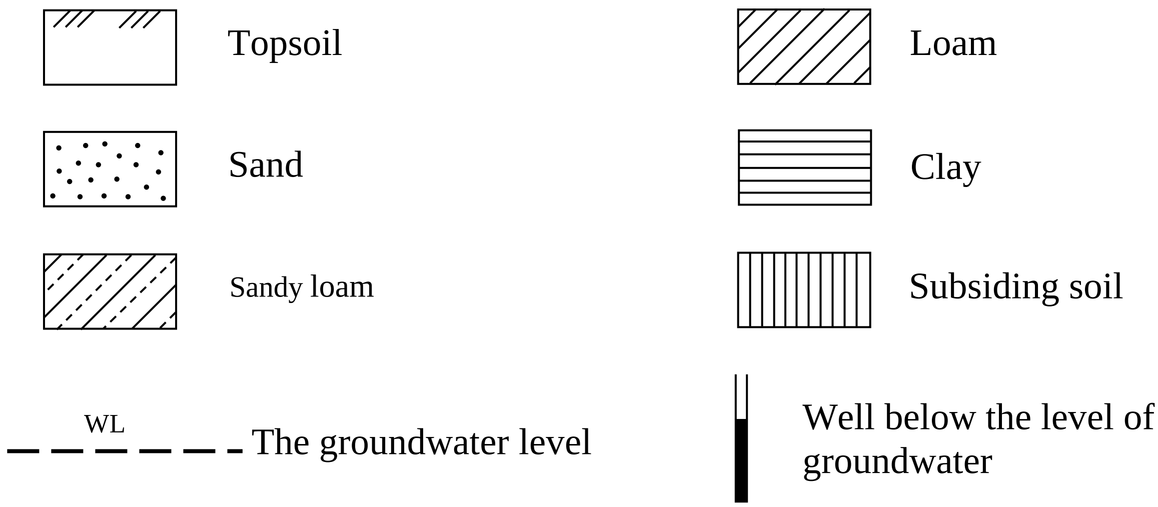
13. Signs thickness of each layer from the surface of the section. The first layer of each well rewrite of Table 2. Then gradually add each layer and record the result at each well.

14. Lays groundwater level in the section. The depth of the groundwater is 2.5 m. From wellhead marks subtract depth of groundwater and lay on the scale of the section.

15. Connecting point of groundwater straight dotted line, write down the depth groundwater.

16. Indicates soil layers numbers. Hatching under the legend. EGE-2 - loam, EGE-3 - sand.

17. In engineering-geological section showing the legend:



18. Under the engineering-geological sections placing table 3.

19. The slope is determined by the ratio of the difference marks wellhead to the distance between them *(w.1-w.2)/l.*

Legend

Table 3

№ of the well	1	2 3
The wellhead marks	72,30	72,70 73,10
The distance between wells	30,00	30,00
The groundwater mark	69,80	70,20 70,60
The slope	0,013	0,013

Laboratory work № 5

DETERMINATION GRAIN-SIZE COMPOSITION OF SANDY SOIL

1. Grain-size composition is determined the sandy soil by sifting soil sample through a sieve column. Sandy soil take weight 100 g.
2. Weight of each sieve written on it.
3. Weighted sand is placed on a top sieve and close the lid.
4. Sifting sand are horizontal vibrations of the column sieves on the table for 1 min.
5. Then the sieve with a sand is weighing. Subtracted weight of empty sieve and record the results in table 1 (paragraph 1)
6. The total mass of residues must different from the mass of sample no more than 1%. The difference is added or subtracted from the mass fractions in proportion to their share so that the total mass fractions was 100%. Results also placed in Table 1 (paragraph 2).
7. Then write down amount of mass fractions in Table 1, paragraph 3. For this mass fraction "> 1,00" rewrite in 1 column. Then add mass fraction "1 - 0,5" and written in the second column. Next to the sum of mass the first two fractions add mass fraction "0,5 - 0,25" and write in the third column. The last value - is the sum of the all mass fractions and it is 100%.
8. In the fourth paragraph of Table 1 write down sum of mass fractions in reverse order. Determine similarly the third paragraph, but start with the last value fraction "< 0.10" and added consistently mass of each fraction from right to left.
9. According to Table 1 (point 4) depicting the total curve the grain-size composition of the sandy soil in semi-logarithmic scale (Fig. 1) On a vertical is the factions content in percent. In the horizontal - size fractions.

Table 1

	Index	The diameters of holes sieves *d*, mm				
		1,00	0,50	0,25	0,10	pallet
		The dimensions of the fractions, mm				
		> 1,00	1 - 0,50	0,50 - 0,25	0,25 - 0,10	< 0,10
		1	2	3	4	5
1	The mass fractions, g					
2	factions content, %					
3	The amount of mass fractions ↑					
4	The amount of mass fractions ↓					

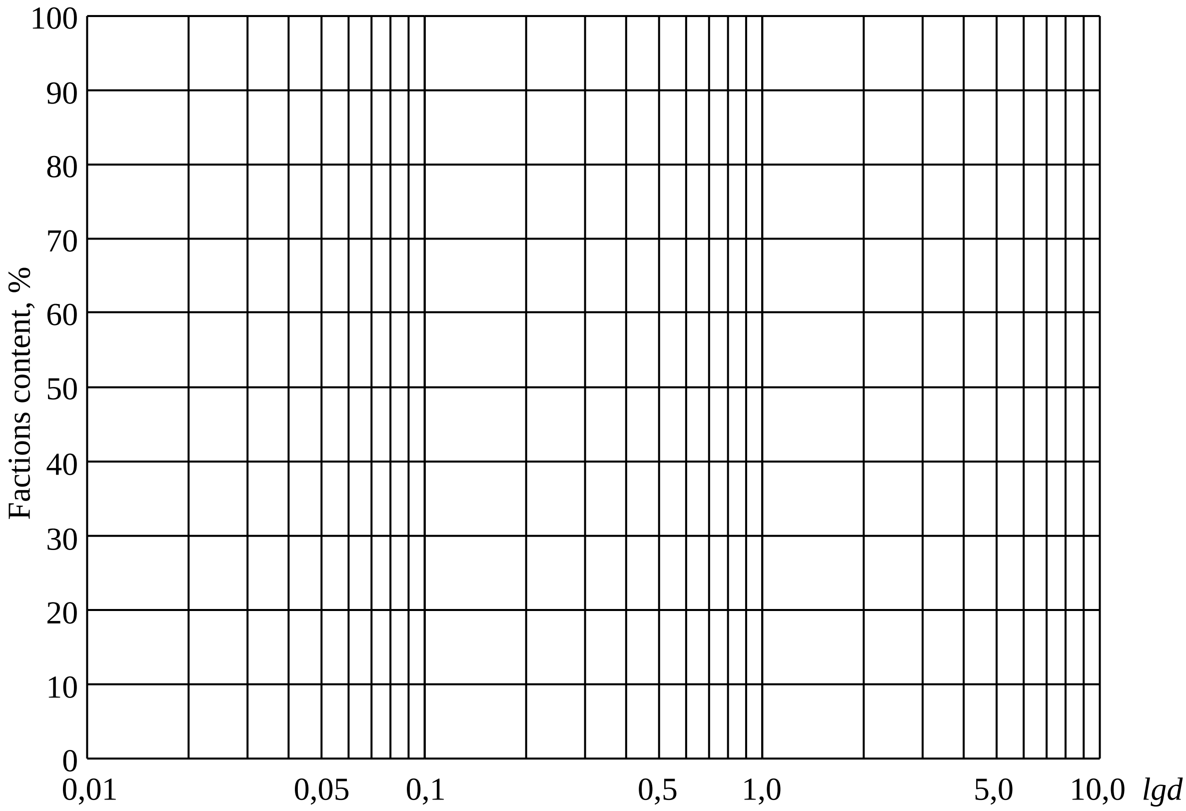


Fig. 1. The total curve the grain-size composition of the sandy soil in semi-logarithmic scale

10. Determine d_{60}, d_{10} - particle diameter, mm, less than in the soil which contained respectively 60% and 10% of the particles (by weight), using a graph of grain-size composition (Fig. 1).

11. Set the degree of heterogeneity of grain-size composition

$$C_v = {d_{60}}/{d_{10}} . \qquad (5.1)$$

If $C_v \leq 3$ – sand homogeneous, if $C_v > 3$ – inhomogeneous.

12. From Table 2 specify the sand

Table 2

Sand	The size of grains, particles, *d*, mm	factions content, %, from the mass
grave	> 2	> 25
coarse	> 0,5	> 50
medium coarse	> 0,25	> 50
grail	> 0,10	≥ 75
silty	> 0,10	< 75

13. For the 3rd paragraph of Table 1 tested the conditions percentage contents particle fractions. Sieve diameter > 2 we didn`t use because the sand grains of this diameter were not. So sand isn`t gravel.

If the mass fractions diameter >0.5 less than 50%, the condition is not satisfied, and the sand is not the medium coarse. Proceed to the next check fraction sand. If the condition is met, then write the appropriate name sand.

Full name of sand is ____________________________________

Laboratory work № 6

DETERMINATION OF PLASTICITY INDEX AND LIQUIDITY INDEX OF CLAY SOIL

Determination humidity at the yield limit W_L:

1. For the work first prepare a paste of clay soil. Dried soil triturated in mortar, sifting it through a sieve with holes of 2 mm and kneaded with distilled water until creamy state. Pasta filled with metal cup and spatula leveling the soil surface.

2. On the surface paste quietly dipped Vasilyev cone balancer weight 76 g. If the cone dipped into the soil to a depth of 1,0 cm (the mark) for 5 seconds, humidity of the soil is at the yield limit W_L.

If the cone during this time immersed to a depth of less than or more than 1.0 cm, in the soil accordingly add water or dry soil and after mixing experiment is repeated until the cone to plunge into risk.

3. To determine the humidity first weighed empty weighing bottle (q_1). Then in the weighing bottle are placed more than 10 g of soil paste, weigh it (q_2). Next, dried in the drying oven at 110 degrees (for laboratory work is allowed to dry on an electric hot plate) to constant weight when the humidity is 0 (q_3).

Determination humidity at the plasticity limit W_P:

4. To determine humidity of the soil at the plasticity limit take a piece of soil and roll it into a glass to cord with a diameter of 3 mm. In training purposes you can roll on paper. When the soil begins to break up into separate pieces (length 3-10 mm), believe that its humidity is at the plasticity limit W_P.

5. To determine the humidity first weighed empty weighing bottle (q_1). Then in the weighing bottle are placed more than 10 g of soil paste, weigh it (q_2). Next, dried in the drying oven at 110 degrees (for laboratory work is allowed to dry on an electric hot plate) to constant weight when the humidity is 0 (q_3).

The experimental results are entered in Table 6.1.

Table 6.1

Humidity	№ weighing bottle	Weigh empty weighing bottle q_1, g	Weigh weighing bottle with soil paste q_2, g	Weigh weighing bottle with dry soil q_3, g	Humidity of the soil $W = \frac{q_2 - q_3}{q_3 - q_1} 100\%$
yield limit W_L					
plasticity limit W_P					

6. By the formula to calculate the humidity at the yield limit W_L and humidity at the plasticity limit W_P (tab. 6.1). Humidity is expressed as a percentage or share units.

7. Name of clay soil is determined by the **plasticity limit** (in percentage):

$$I_P = W_L - W_P, \tag{6.1}$$

sandy loam $1 \le I_P \le 7$;
loam $7 < I_P \le 17$;
clay $I_P > 17$.

If I_P=____________________ the soil is _________________________

8. **Liquidity index** is determined by the formula

$$I_L = \frac{W - W_P}{W_L - W_P}, \tag{6.2}$$

where W – Humidity soil in the natural state.

9. Determine the type of clay soil for the liquidity index I_L.

Table 6.2

Loam and clay	**Liquidity index**	**Sandy loam**
hard	$I_L < 0$	hard
semisolid	$0 \le I_L \le 0,25$	plastic
low-plasticity	$0,25 < I_L \le 0,50$	
high-plastic	$0,50 < I_L \le 0,75$	
fluid-plastic	$0,75 < I_L \le 1,0$	
fluid	$I_L > 1,0$	fluid

Conclusion. Soil is____
____

Laboratory work № 7

DETERMINATION OF SAND FILTRATION COEFFICIENT

A. <u>By the approximate Hazen formula.</u>

on the results of determine heterogeneity sand:

$$k_f = C \cdot d_{10}^2 \cdot \tau, \text{ m/day,} \qquad (7.1)$$

where C – empirical coefficient, which for homogeneous sand taken as equal 1000 and for heterogeneous – 600;

d_{10} – particle diameter, which establish the curve of sand grain size (l.w. № 5);

τ – temperature coefficient determined by the formula

$$\tau = 0{,}7 + 0{,}03 \cdot t°, \qquad (7.2.)$$

$t°$ – water temperature °C.

B. <u>With universal tube "KF":</u>

1. Fill the cutting cylinder dry sand, set metal grid and close the lid.

2. Set Telescopic device to the mark of 0.6 (corresponding hydraulic gradient I = 0.6), and lower in the middle of the cutting cylinder.

3. The cylinder is filled with water to full water saturation sand. Withstand 2-5 minutes, then drained excess water.

4. In a glass measuring cylinder (Mariotte vessel) pour water and gently set it down a hole in the net.

5. Determine the time T when from the scale graduated cylinder filter off 25 - 50 cm^3 of water. For gradient I = 0.6 experiment is repeated twice and the results recorded in Table 7.1.

6. Lift the upper part of the telescopic device on gradient I = 0.8 and perform two similar experiments.

Then do the same with I = 1.0.

7. Filtration coefficient at a given temperature t ° water determined by the formula

$$k_f = \frac{864 \cdot Q}{T \cdot A \cdot I}, \text{ (m/day),} \qquad (7.3)$$

where Q – the volume of water that filter off during T, cm^3;

864 – dimensional factor for transfer k_f from cm/sec to m/day;

T – time filtration, sec;

A – sectional area of the cutting cylinder, *A*=25 cm^2;
I – hydraulic gradient.

8. To determine the coefficient of filtration water at standard temperature t = 10 ° C using the formula

$$k_f^{10} = {k_f}/{\tau}, \text{ (m/day)}. \qquad (7.4)$$

Table 7.1

The results of determination k_f using tubes "KF"

№ p/p	*hydraulic gradient* I	the volume of water that filter off *Q*, cm^3	time filtration *T*, sec			Filtration coefficient k_f, m/day		
			experiments		middle	separate	middle	by t°=10˚C
			1	2				
1	0,6							
2	0,8							
3	1,0							

Table 7.2

Comparison of determination k_f

Name of sand	Filtration coefficient k_f, m/day	
	By the formula Hazen	By the results of the experiments

Conclusion: filtration coefficient of the sandy soil k_f = m/day

Laboratory work № 8

DETERMINE THE DENSITY AND HUMIDITY OF UNCONSOLIDATED SEDIMENTS BY CUTTING RINGS

This method can be used for sedimentary rocks – clay, loam, sandy loam, sand, from which you can cut the sample by the cutting ring.

1. Using calipers measure the inner diameter and height of the cutting ring and determine its volume V (cm^3). Weigh the ring on the scales to the nearest 0.01 g and get weight rings g_1 (g). In this work we use the ring with already known mass and volume.

2. Ring set the sharp side to the tipped and leveled surface rock monolith. With a sharp knife carefully cut column of rock whose diameter of 1 mm more than the internal diameter of the ring. Ring gradually imposed on a column of rock. Excessive rock trimmed by the cutting edge of the ring. After column rock ledge above the upper edge of the ring, excessive rock cut flush with the bottom and top edge of the ring.

3. Ring with rock weighed at technical scales and get weight g_2. Defining rock weight $g = g_2 - g_1$, calculate its density (g/cm^3)

$$\rho = \frac{g}{V} \qquad (8.1)$$

4. To determine the humidity of rock, you put part of it (at least 10 grams) in a weighted weighing bottle, weigh this weighing bottle with soil, then dried soil in the oven at a temperature of about 105 ° C to constant weight it (see. L.W. № 6).

Determine the humidity by the formula:

$$W = \frac{q_2 - q_3}{q_3 - q_1} 100\% \qquad (8.2)$$

5. The density of the soil skeleton (or the density of dry soil) ρ_d (g/cm^3) determined by the formula:

$$\rho_d = \frac{\rho}{1 + W} \qquad (8.3)$$

6. The results of the determination of the rocks density and humidity recorded in Table 8:

Table 8

№	№ ring, № weighing bottle	Weight empty rings (weighing bottle) g_1 (q_1) g	Weight ring (weighing bottle) with the soil g_2 (q_2) g	Weight the sample of rock, g, g	Weight the weighing bottle with dry soil q_3, g	The volume of ring, V, cm^3	The density of the sample, ρ, g/cm^3	The density of the skeleton sample, ρ_d, g/cm^3	Humidity of the soil W, %
1					-				
				-		-			
2					-				
				-		-			
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