

PART 5 – GEOTECHNICAL INVESTIGATIONS

«HAYR EV VORDI TITIZYANNER» LTD

Rehabilitation of Yerevan WWTP Engineering-geological and
Geotechnical investigations Program

Report

Contract № 3

Client

«ARTELIA» Group



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Table 1 (Labor researches for natural soil's physical-mechanical properties)

Introduction

According to << Artelia>> Group given technical task the rehabilitation of Yerevan WWTP geotechnical investigations program should be done. On april-may 2013 engineering investigation program has been completed by the geologists of << Hayr ev Vordi Titizyanner>> Ltd. During the investigation following researches have been done

1. Column-mechanical drilling-110.0 running meter
 - ❖ 2 boreholes drilling each 30 running meter deep
 - ❖ 1 borehole 20 running meter
 - ❖ 1 borehole 30 running meter deep(20 running meter deep Piesometer installation)
2. Determine physical-mechanical characteristics for 15 taken samples
3. CPT implementation experiment (each on 1.5 m deep) during of the continuous drilling
4. Report preparation

Field engineering-geological investigation program has been done by H. Titizyan. Labor researches have ben done by << Hayr ev Vordi Titizyanner>> Ltd.

Research field is located in Aeracia block, Shengavit district in Yerevan, Republic of Armenia.

Geomorphologically it's located on a high space left side from Hrazdan river.From morphological viewpoint the area characterized as flat area (absolute characters 885-890m).

Area's climate mostly characterized with mild winters and hot summers. The average annual air temperature flaps from 12 till 14 C, the average annual amount of precipitation is 350-4000mm: Snow shelter saved till 1.0-1.5 month. power is not higher than 0.2-0.4m, cooling zone maximum is -0.4-0.5m.

The area's geological structure is represented by four-aged class cobblestone sediment, capacity higher than 30 meters. The area's seismic zone coincides with the 3rd seismic zone of nine-point intensity (by MSK-64 table,maximum horizontal acceleration $A_{max}=0.4g$, speed $V=32cm/second$)

In the area till 30 meters deep no ground water were found .

1. Engineering-geological conditions

For ascertaining features for Aerecia block , Shengavit District, Yerevan republic of Armenia investigative browser and labor researches have been done resulting that the area is separated into 4 layers.

Layer №1^a Padding natural soil pebble-cobblestone sediment natural soil till 25% sand filling, capacity 4.0-4.5m.

Layer №1 dusty sand-claysand natural soil till 15 % sand content, capacity 3.5-5.0m.

Layer №2 Lower fourth-aged class cobblestone-pebble sediment natural soil till 25% sand filling, capacity 8.0-15m.

Layer №2^a Lower forth-aged class pebble- cobblestone sediment natural soil till 40% claysand and sand filling, capacity 2.0-17.0m.

2. Natural Soil physical-mechanical charecteristics

In the results of dynamic penetration of the samples taken during the field geological investigation drilled borehole research , the area's layer sequence from the upside down is divided into following natural soils.

Layer №1^a Padding natural soil cobblestone-pebble sediment natural soil till 25% sand filling, capacity 4.0-4.5m. Is given construction order 4, because it's not going to be used as structure base.

Layer №1 dusty sand-claysand natural soil till 15 % sand content, capacity 3.5-5.0m. The layer has following physical-mechanical characteristics.

Solid particle density	2,36g/cm ³
Natural density	1,55g/cm ³
Natural Humidity	46%
The Skeleton Volume weight	1,05g/cm ³
Porosity	55%
Porosity Index	1,23
Internal friction angle	10°30'
Coherence	0,0225 Mpa
Deformation module	52 kg/cm ²

Allowable tension	0,5kg/cm ²
Plasticity	
Slide upper limit	64,6%
Slide lower limit	54%
Plasticity number	10,6
Ground seismic category	III-IV

The procedure for construction for collections №1 and №3- 33b/33b 2nd category

Particle-size distribution

Sand 14.74%

Dust 66.68%

Clay 18.58%

The natural soil is presented by particle-size distribution and plasticity number. In seismic terms it is able to dissolve and lose its durability.

Chemical analysis of the soil

Cl	0,213%
PH	6,9%
SO ₄	0,186%
CaCO ₃	2,85%
Dense refuse	0,211%

Layer №2 Lower forth-aged class cobblestone-pebble sediment natural soil till 25% sand filling, capacity 8.0-15m. The layer has the following physical-mechanical characteristics

Solid particle density	2,69g/cm ³
Natural Density	2,13g/cm ³
Natural Humidity	9%
The skeleton Volume Weight	1,95g/cm ³
Porosity	27,5%
Porosity Index	0,38
Internal friction angle	31°30'
Coherence	0,001 Mpa
Deformation module	420 kg/cm ²
Allowable tension	4kg/cm ²
Ground seismic category	II

The procedure for construction HSH IV-2-82 for №1 and №3- 6g/9g- IV category

Particle size distribution

Boulder	11,25%
Cobblestone	45,30%
Pebble	17,14%
Sand	24,13%
Dust	1,4%
Clay	0,78%

Chemical Analysis of the Soil

Cl	0,018%
PH	7,0%
SO ₄	0,046%
CaCO ₃	2,00%
Dense refuse	0,105%

Layer №2^a Lower forth-aged class cobblestone sediment natural soil till 40% claysand and sand filling, capacity 2.0-17.0m. The layer has the following phisical-mechanical characteristics

Solid particle density	2,70g/cm ³
Natural Density	1,99g/cm ³
Natural Humidity	12,4%
The Skeleton Volume Weight	1,77q/cm ³
Porosity	34%
Porosity Index	0,51
Internal Friction Angle	25 ⁰
Coherence	0,007 Mpa
Deformation module	266 kg/cm ²
Allowable tension	3,3kg/cm ²
Ground seismic category	II

The procedure for construction for HSSH IV-2-82 for №1 u №3- 6^g/9^g- IV category.

Particle size Distribution

Boulder	6,35%
Cobblestone	33,29%
Pebble	23,08%
Sand	31,08%
Dust	3,99%
Clay	2,21%

Chemical analysis of the Soil

Cl	0,115%
PH	7,0%
SO ₄	0,105%
CaCO ₃	2,20%
Dense refuse	0,148%

3.The results of field penetration

During the drilling in 1.5 meters deep in boreholes there has been field dynamic penetration with the hammer weight $P=65$ kg and from the $H=80$ cm high stroke from 50mm calipers to 10cm recession. In the results of experiment accordingly for this interval the deformation module for the natural soil has been determined(R. Hayfells, G. Amberg and A. Moose)by resolution.

$$E = \frac{R}{S}$$

E – is the deformation module for the natural soil kg/cm^2

S – is the area of the probe cm^2

R – is the power of dynamic stroke kg , which is counted by the following resolution

$$R = \frac{n \times P \times H}{h} + P$$

n - is the number of the strokes

P – is the weight of the hammer -65 kg

H – is the height of the hammer

h – is the recession of the probe 10 cm

The particle size distribution has been determined till the 0.25mm calipers for mechanical netting bolts, deeper than that the particle size distribution of samples has been determined in labor conditions: The physical-mechanical characteristic standards made in field and labor conditions are summarized in Table 1.

Below are represented the boreholes structures, their lithological description, the results of dynamic penetration, the numbers of taken samples and their intervals, also the photos of borehols's boxes.



4. The exploration of the boreholes geological-lithologic description and staple's Photos

Borehole №1

Located in: WWTP

Start date: 15/04/2013

Absolute mark: 885.72` X=4442821.36, Y=451511.15

End date: 21/04/2013

Scale 1:200	Layer Number	Depth/ m	Capacity/ m	Conventional Signs	Drilling Calipers	Lithologic Description	Penetration		Geologic Age
							depth	Stroke number	
2	1 ^a	4,0	4,0		d=151 mm	Padding natural soil cobblestone-pebble sediment natural soil till 25% sand filling			Q _{IV}
4									
6	2	8,0	4,0		d=151 mm	Cobblestone-pebble sediment natural soil till 30% sand filling	6,0	15	
8							7,5	14	
10	2 ^a	11,0	3,0		d=151 mm	Pebble-cobblestone natural soil till 30-35% claysand filling	9,0	8	
12							10,5	8	
12	2	12,6	1,6		d=151 mm	Cobblestone-pebble sediment till 25% sand filling	12,0	17	
14	2 ^a	20,0	7,4		d=132mm	Pebble-cobblestone natural soil till 30-35% claysand filling	13,5	9	
16							15,0	9	
18							16,5	7	
20							18,0	6	
22	2	25,0	5,0		d=112mm	Cobblestone-pebble natural soil till 20% sand filling	19,5	10	Q _I
24							21,0	16	
26	2 ^a	30,0	5,0		d=112mm	Pebble-cobblestone natural soil till 20 % claysand filling	22,5	17	
28							24	18	
30							25,5	8	
							27,0	7	
							28,5	9	
							30,0	9	

Are Taken sample 1` (6,0-7,0m), sample 2` (8,0-11,0m), sample 3` (11,0-12,0m), sample 4` (15,0-18,0m), sample 5` (23,0-24,0m), sample 6` (28,0-30,0m)









Borehole №2

Located in: WWTP

Start date: 21/04/2013

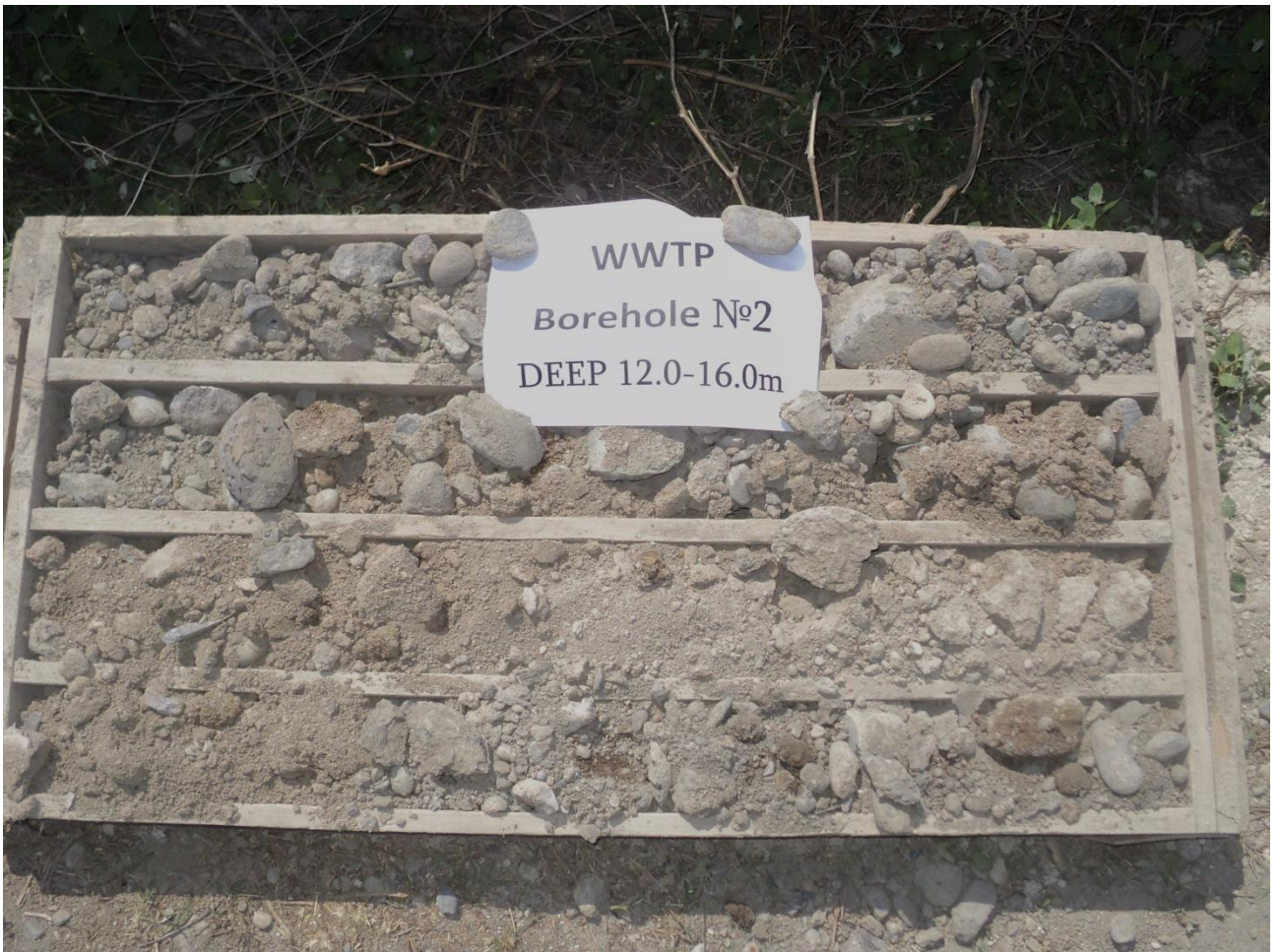
Absolute mark: 885.17 ` X=4442782.40, Y=451539.46

End date: 29/04/2013

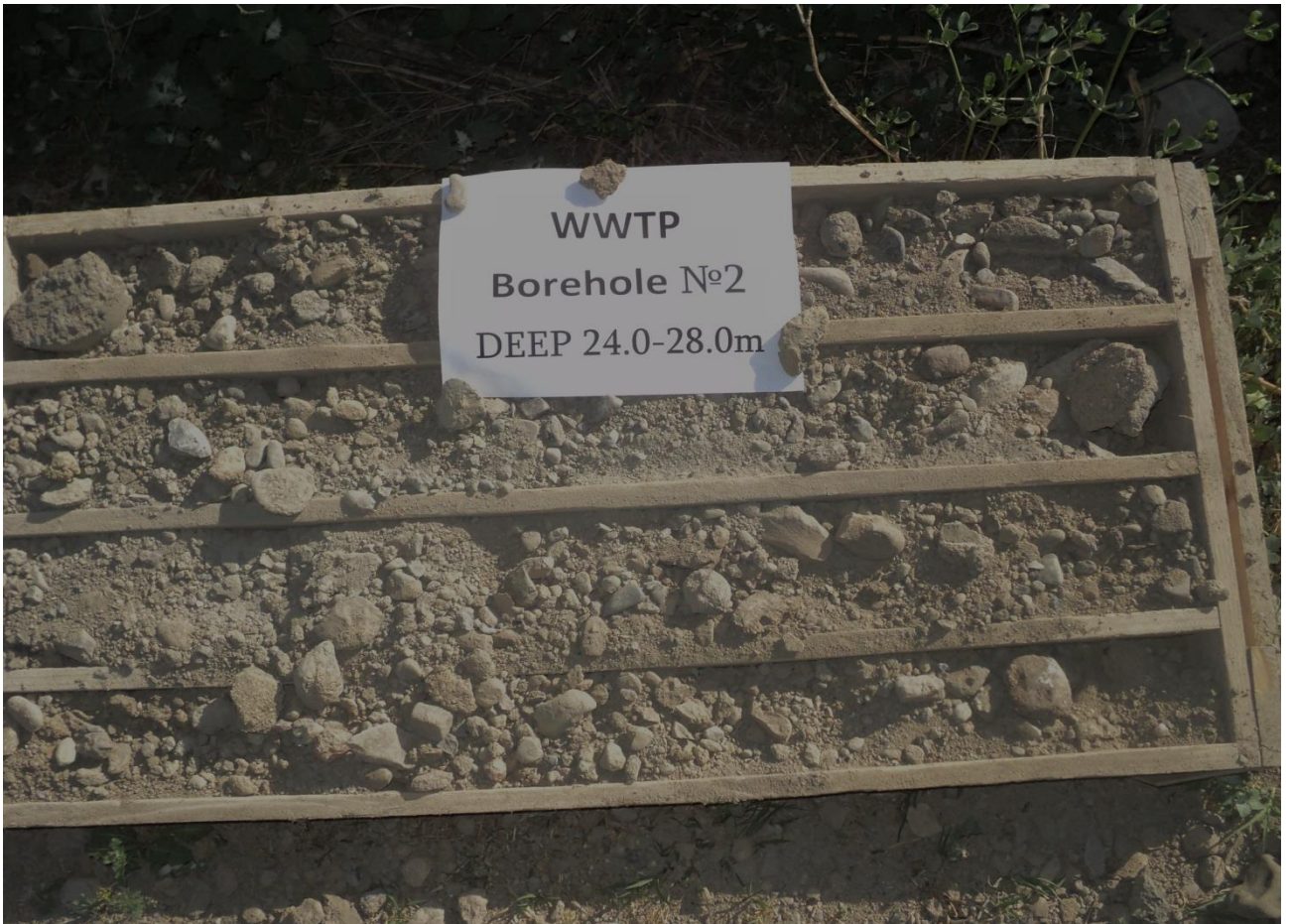
Scale 1:2 00	Layer Number	Depth/ m	Capacity y/m	Conventional signs	Drilling Calipers	Lithologic Description	Penetration		Geologic Age
							Depth	Stroke number	
2	1 ^a	4,5	4,5		d=151 mm	Padding natural soil cobblestone-pebble sediment natural soil till 25% sand filling, with 0.3m asphalt sheath			Q _{IV}
4									
6									
8	2 ^a				d=151 mm	Pebble-cobblestone natural soil till 30-35% claysand filling	6,0	6	Q _I
10							7,5	7	
12							9,0	8	
14							10,5	8	
16							12,0	8	
18							13,5	8	
20							15,0	8	
22							16,5	8	
24							18,0	9	
26							19,0	14,5	
28	21,0	15							
30	22,5	16							
	24	17							
	2				d=112mm	Cobblestone-pebble natural soil till 25% sand filling	25,5	15	Q _I
26							27,0	14	
28							27,5	8,5	
30	2 ^u	30,0	2,5			Pebble-cobblestone till 30-35% claysand	28,5	9	
							30,0	9	

Are taken sample 7` (6,0-9,0m), sample 8` (10,5-14,0m), sample 9` (15,0-18,0m), sample 10` (21,0-24,0m) and Sample 11` (27,0-30,0m),









Borehole №3

Located in: WWTP

Start date: 29/04/2013

Absolute mark: 890.95` X=4442882.32, Y=451677.65

End date: 2/05/2013

Scale 1:200	Layer number	Depth/m	Capacity/m	Conventional signs		Drilling calipers	Lithologic Description	Penetration		Geologic Age
								Depth	Stroke number	
2	1	2,0	2,0			d=151 mm	Padding natural soil			Q _{IV}
4	1						Solid structure sandclay natural soil	3,0	3	Q _I
6								4,5	2	
8		7,0	5,0				6,0	3		
10					d=132mm	Cobblestone-pebble natural soil till 30% sand filling	7,5	12		
12	2							9,0	15	
14								10,5	14	
16								12,0	16	
18								13,5	13	
20						15,0	12			
					d=112m m		16,5	13		
18		18,0	11,0				18,0	6		
					d=93m m					
20	2	20,0	2,0				Pebble-cobblestone natural soil till 40% claysand	19,5	10	

Are taken Sample 12` (4,0-4,5m), sample 13` (5,0-5,5m), sample 14` (9,0-12,0m), sample 15` (18,5-20,0m),





Borehole №4

Located in: WWTP

Absolute mark: 885.86` X=4442800.85, Y=4515602.64

Start date:3/05/2013

End date: 18/05/2013

Scale 1:200	Layer Number	Depth/m	Capacity/m	Conventional signs	Drilling Calipers	Lithologic Description	Borehole clip	Peasometer installation	Geologic Age
2	1	3,0	3,0		d=168mm	Solid structure dusty sandclays containing till 10-12% sand	Is clipped a pipe d=146 mm length till 20m depth	Have been installed d=50mm calipers Peaso meter with plastic pipe	Q _{IV}
4	2					Cobblestone-pebble natural soil till 25% sand filling			
6									
8									
10									
12	2 ^a	16,0	13,0		d=151µm	Pebble-cobblestone natural soil 40% claysand			
14									
16									
18									
20	2	24,0	8,0		d=132µm	Cobblestone-pebble natural soil till 20-30% sand filling			
22									
24									
26	2 ^a	30,0	4,0			Pebble-cobblestone natural soil till 40 % claysand			
28	2 ^a								
30									

It has been reduced plastic pipe(Peasometer L=20 m deep,inch which L6m is strainer) . The borehole is filled from down till 17 m by washed sand,d=1-2mm, after that 1m capacity bentonite clay ,and higher filled with sand and on top is located iron pipe with valve.







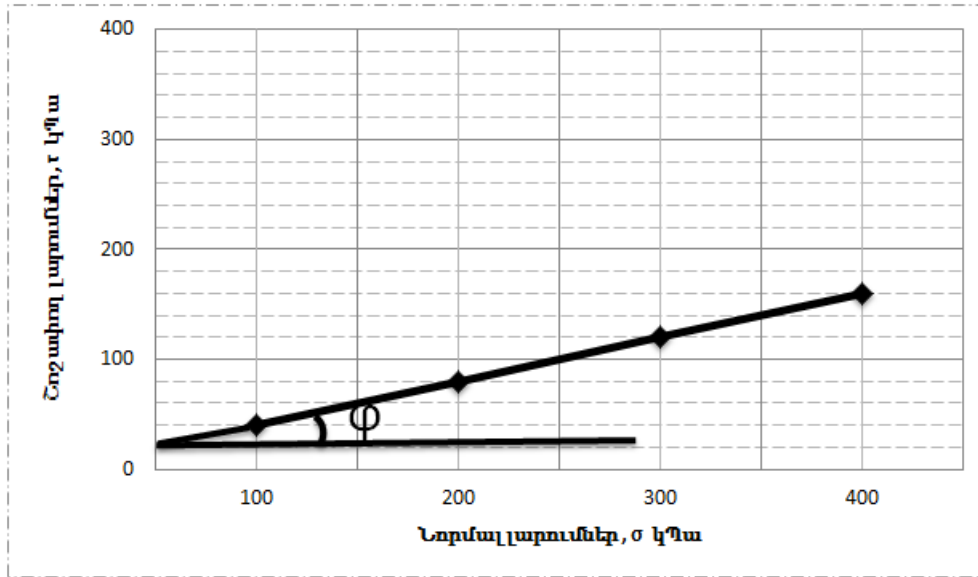


5. The results of Ground slide resistance reasearch

Internal friction angle and coherence quantities have been №1^a done by the M - 10 tool with d=300mm calibers circuits for not connected soil (Layer №2nd Layer №2^a and for conneced soil(Layer №1) slide resistance has been determined by GGP-2 tool,regulatory tensions till $\sigma=400\text{kpa}$: The results are presented below

The results of the Ground slide resistance reasearch

Ground structure	Scoop Number	Samlpe depth	Layer Number	Object name
Natural	Borehole 3	5,0-5,5	№1	WWTP



Physical characteristics for the expermental sample.

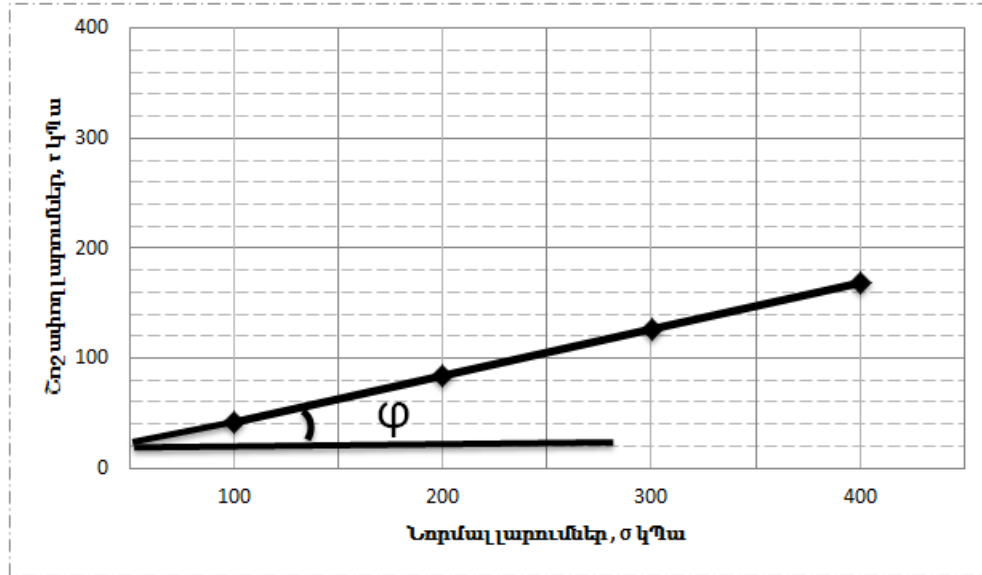
Natural Humidity W, %	Plasticity			Density g/cm ³			Porosity	Porosity Index
	Upper limit	Lower limit	Pl. number	Solid particle	Natural density	Skeleton volume weight		
45	64,6	54	10,6	2,32	1,58	1,09	53	1,12

The results for Slide resistance

№	Normal tensions σ kPa	Tangent tensions τ kPa	Internal friction coefficient τφ°	Internal friction angle φ°	Specific connection C, kg/cm ²	Ground moisture after experiment W, %
1	100	40	0,176	10°	0,2	47
2	200	80				
3	300	120				
4	400	160				

The results of the Ground slide resistance reasearch

Ground structure	Scoop Number	Samlpe depth	Layer Number	Object name
Natural	Borehole 3	4,0-4,5	№1	WWTP



Physical characteristics for the experimental sample.

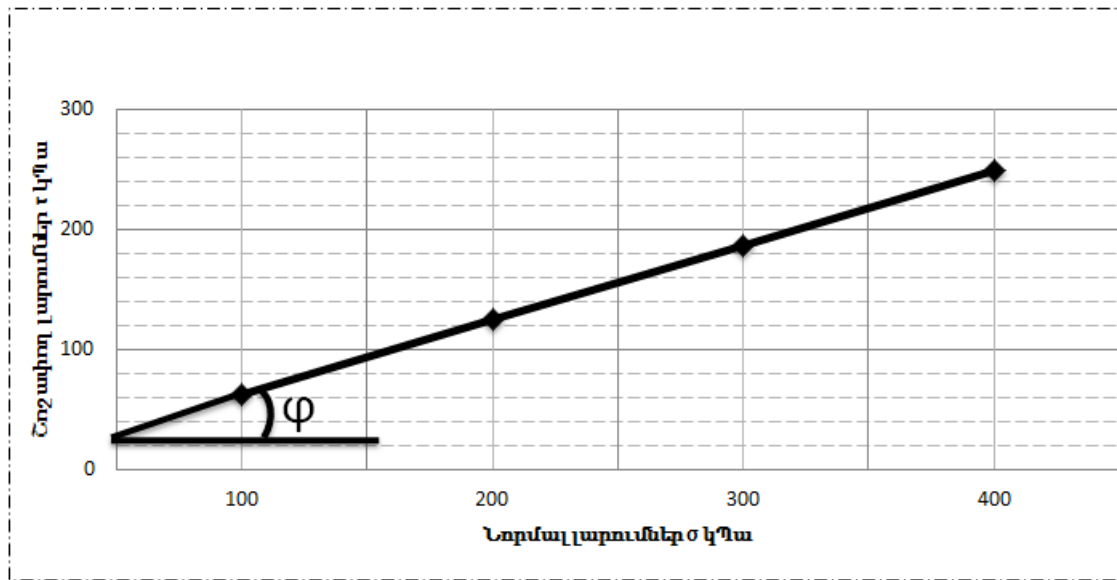
Natural Humidity W, %	Plasticity			Density g/cm ³			Porosity	Porosity Index
	Upper limit	Lower limit	Pl. number	Solid particle	Natural density	Skeleton volume weight		
48	60,6	49,3	11,3	2,40	1,52	1,02	57	1,35

The results for Slide resistance

№	Normal tensions σ kPa	Tangent tensions τ kPa	Internal friction coefficient tφ°	Internal friction angle φ°	Specific connection C, kg/cm ²	Ground moisture after experiment W, %
1	100	42	0,194	11°	0,2	50
2	200	84				
3	300	126				
4	400	168				

The results of the Ground slide resistance reasearch

Ground structure	Scoop Number	Samlpe depth	Layer Number	Object name
Natural	Borehole 1	6,0-7,0	№2	WWTP



Physical characteristics for the expermental sample.

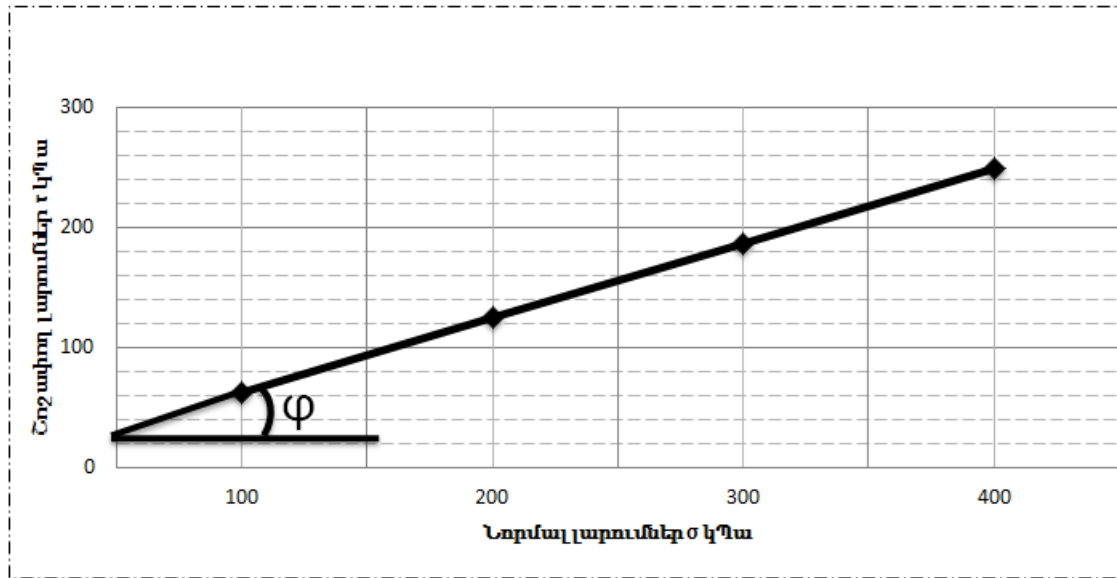
Natural Humidity W, %	Plasticity			Density g/cm ³			Porosity	Porosity Index
	Upper limit	Lower limit	Pl. number	Solid particle	Natural density	Skeleton volume weight		
9	-	-	-	2,69	2,11	1,93	28,2	0,39

The results for Slide resistance

№	Normal tensions σ kPa	Tangent tensions τ kPa	Internal friction coefficient $t\phi^\circ$	Internal friction angle ϕ°	Specific connection C, kg/cm ²	Ground moisture after experiment W, %
1	100	63,5	0,624	32°	0,01	10
2	200	127				
3	300	190.5				
4	400	254				

The results of the Ground slide resistance reasearch

Ground structure	Scoop Number	Samlpe depth	Layer Number	Object name
Natural	Borehole 3	9,0-12,0	№2	WWTP



Physical characteristics for the expermental sample.

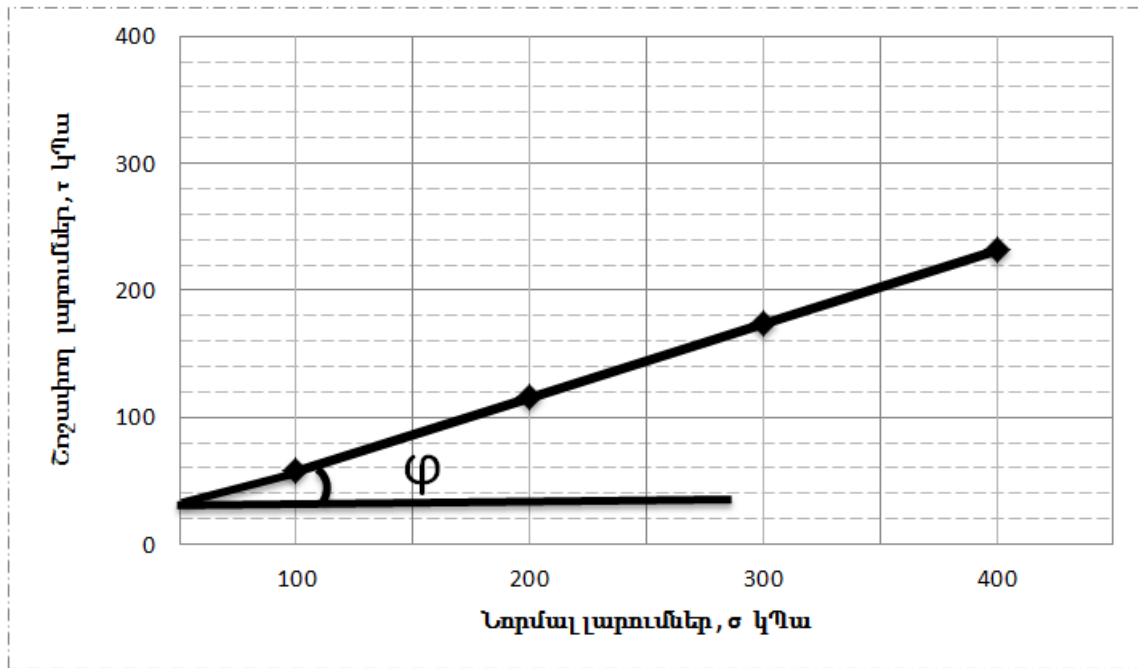
Natural Humidity W, %	Plasticity			Density g/cm ³			Porosity	Porosity Index
	Upper limit	Lower limit	Pl. number	Solid particle	Natural density	Skeleton volume weight		
9	-	-	-	2,69	2,14	1,96	27,1	0,37

The results for Slide resistance

№	Normal tensions σ kPa	Tangent tensions τ kPa	Internal friction coefficient $t\phi^\circ$	Internal friction angle ϕ°	Specific connection C, kg/cm ²	Ground moisture after experiment W, %
1	100	63,5	0,625	32°	0,01	10
2	200	127				
3	300	190.5				
4	400	254				

The results of the Ground slide resistance reasearch

Ground structure	Scoop Number	Samlpe depth	Layer Number	Object name
Natural	Borehole 1	11,0-12,0	№2	WWTP



Physical characteristics for the expermental sample.

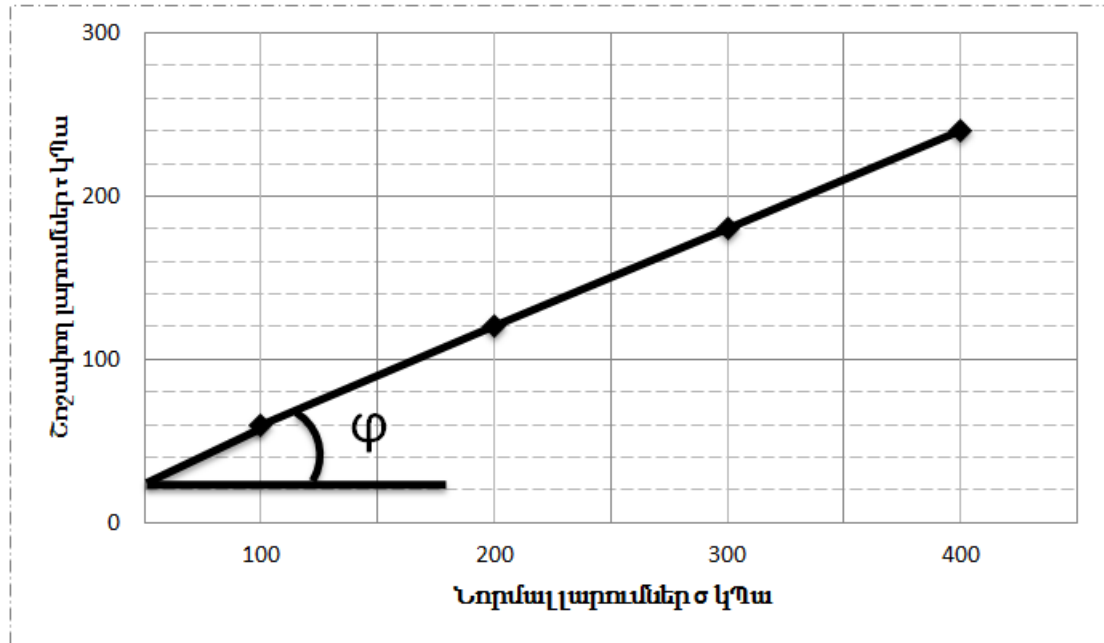
Natural Humidity W, %	Plasticity			Density g/cm ³			Porosity	Porosity Index
	Upper limit	Lower limit	Pl. number	Solid particle	Natural density	Skeleton volume weight		
11	-	-	-	2,69	2,20	1,98	26.4	0,36

The results for Slide resistance

№	Normal tensions σ kPa	Tangent tensions τ kPa	Internal friction coefficient tφ°	Internal friction angle φ°	Specific connection C, kg/cm ²	Ground moisture after experiment W, %
1	100	58.7	0,577	30°	0,01	12
2	200	117.4				
3	300	176.1				
4	400	234.8				

The results of the Ground slide resistance reasearch

Ground structure	Scoop Number	Samlpe depth	Layer Number	Object name
Natural	Borehole 1	23,0-24,0	№2	WWTP



Physical characteristics for the expermental sample.

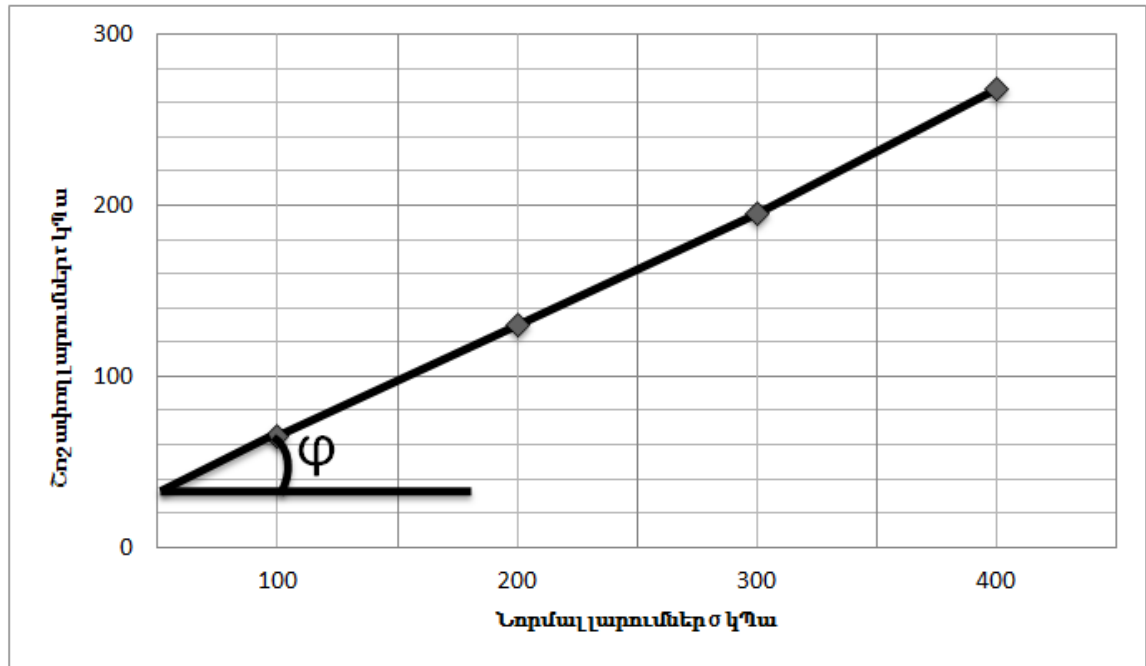
Natural Humidity W, %	Plasticity			Density g/cm ³			Porosity	Porosity Index
	Upper limit	Lower limit	Pl. number	Solid particle	Natural density	Skeleton volume weight		
9	-	-	-	2,69	2,15	1,97	26,7	0,36

The results for Slide resistance

№	Normal tensions σ kPa	Tangent tensions τ kPa	Internal friction coefficient $t\phi^\circ$	Internal friction angle ϕ°	Specific connection C, kg/cm ²	Ground moisture after experiment W, %
1	100	61.1	0,601	31°	0,01	10
2	200	122.2				
3	300	183.3				
4	400	244.4				

The results of the Ground slide resistance reasearch

Ground structure	Scoop Number	Samlpe depth	Layer Number	Object name
Natural	Borehole 2	21,0-24,0	№2	WWTP



Physical characteristics for the experimental sample.

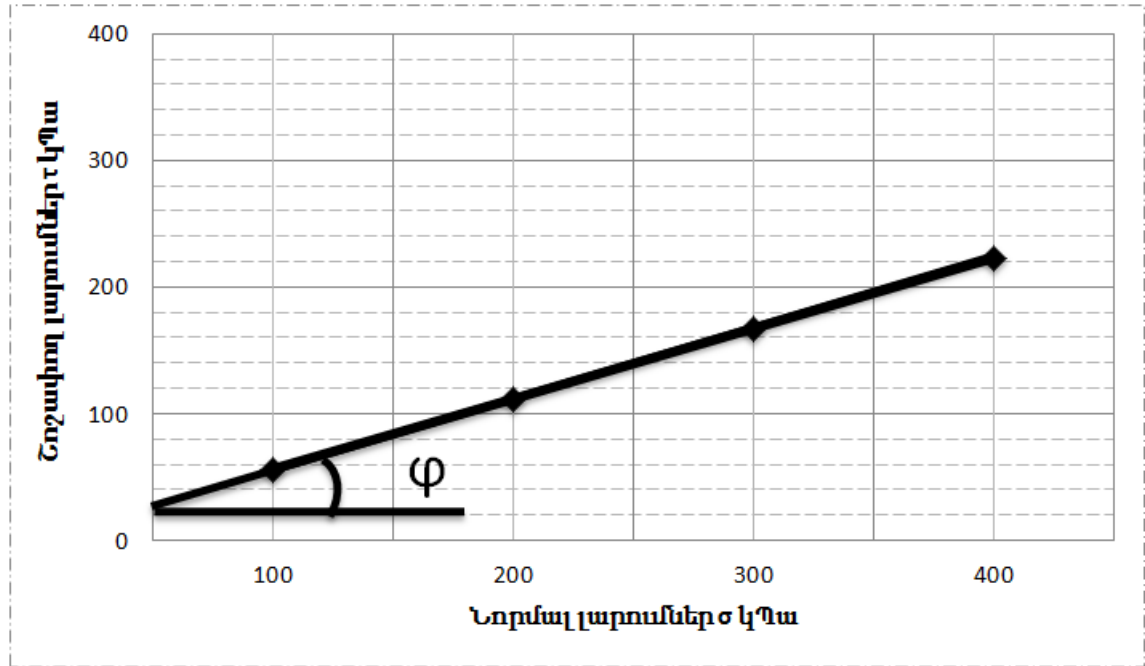
Natural Humidity $W, \%$	Plasticity			Density g/cm^3			Porosity	Porosity Index
	Upper limit	Lower limit	Pl. number	Solid particle	Natural density	Skeleton volume weight		
8	-	-	-	2,69	2,06	1,9	29,4	0,41

The results for Slide resistance

№	Normal tensions σ kPa	Tangent tensions τ kPa	Internal friction coefficient $t\phi^\circ$	Internal friction angle ϕ°	Specific connection $C, kg/cm^2$	Ground moisture after experiment $W, \%$
1	100	65.9	0,649	33°	0,01	9
2	200	131.8				
3	300	197.7				
4	400	263.6				

The results of the Ground slide resistance reasearch

Ground structure	Scoop Number	Samlpe depth	Layer Number	Object name
Natural	Borehole 1	8.0-11.0	Nº2 ^m	WWTP



Physical characteristics for the expermental sample.

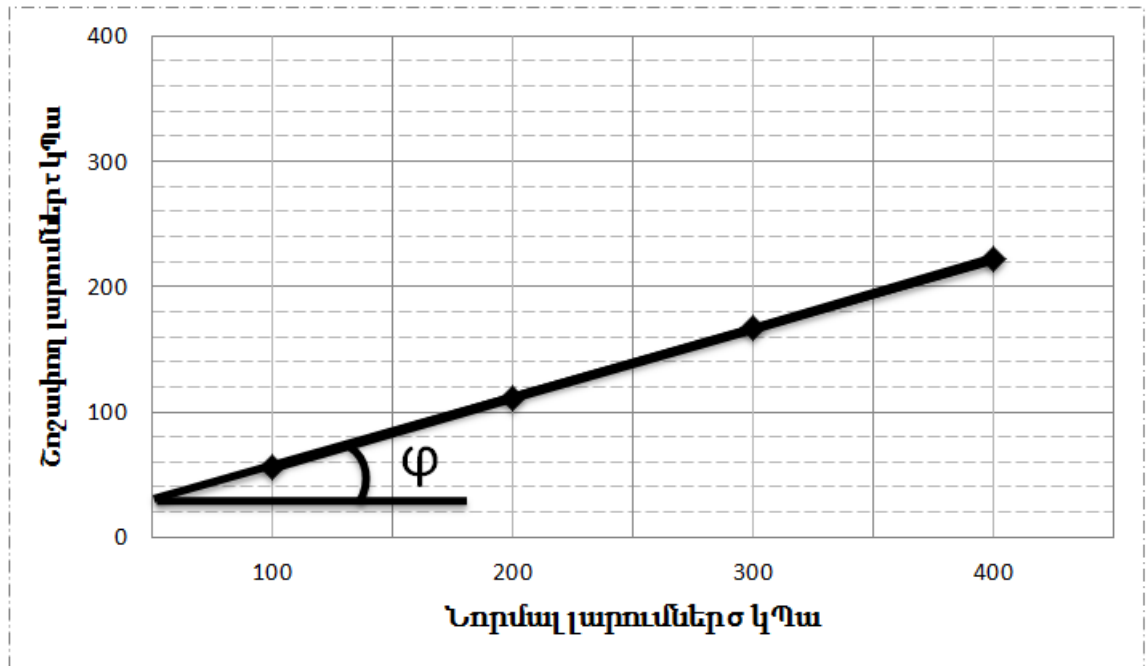
Natural Humidity W, %	Plasticity			Density g/cm ³			Porosity	Porosity Index
	Upper limit	Lower limit	Pl. number	Solid particle	Natural density	Skeleton volume weight		
12	28.3	24.1	4.2	2,70	2,00	1,78	34	0,51

The results for Slide resistance

Nº	Normal tensions σ kPa	Tangent tensions τ kPa	Internal friction coefficient $t\phi^\circ$	Internal friction angle ϕ°	Specific connection C, kg/cm ²	Ground moisture after experiment W, %
1	100	55,8	0.487	26°	0.07	13
2	200	111,6				
3	300	167,4				
4	400	223,2				

The results of the Ground slide resistance reasearch

Ground structure	Scoop Number	Samlpe depth	Layer Number	Object name
Natural	Borehole 1	15.0-18.0	Nº2 ^m	WWTP



Physical characteristics for the experimental sample.

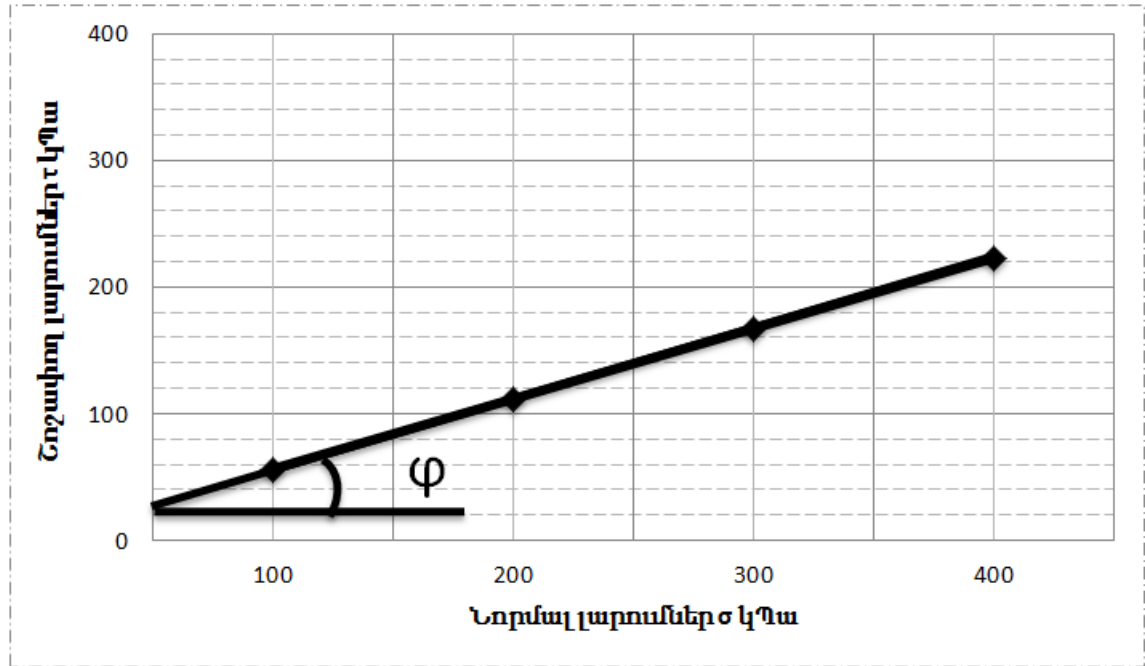
Natural Humidity W, %	Plasticity			Density g/cm ³			Porosity	Porosity Index
	Upper limit	Lower limit	Pl. number	Solid particle	Natural density	Skeleton volume weight		
12	29.8	25.0	4.8	2,70	2.01	1,79	34	0,51

The results for Slide resistance

Nº	Normal tensions σ kPa	Tangent tensions τ kPa	Internal friction coefficient $t\phi^\circ$	Internal friction angle ϕ°	Specific connection C, kg/cm ²	Ground moisture after experiment W, %
1	100	55,6	0.466	25°	0.09	13
2	200	111,2				
3	300	166,8				
4	400	222,4				

The results of the Ground slide resistance reasearch

Ground structure	Scoop Number	Samlpe depth	Layer Number	Object name
Natural	Borehole 1	28.0-30.0	Nº2 nd	WWTP



Physical characteristics for the expermental sample.

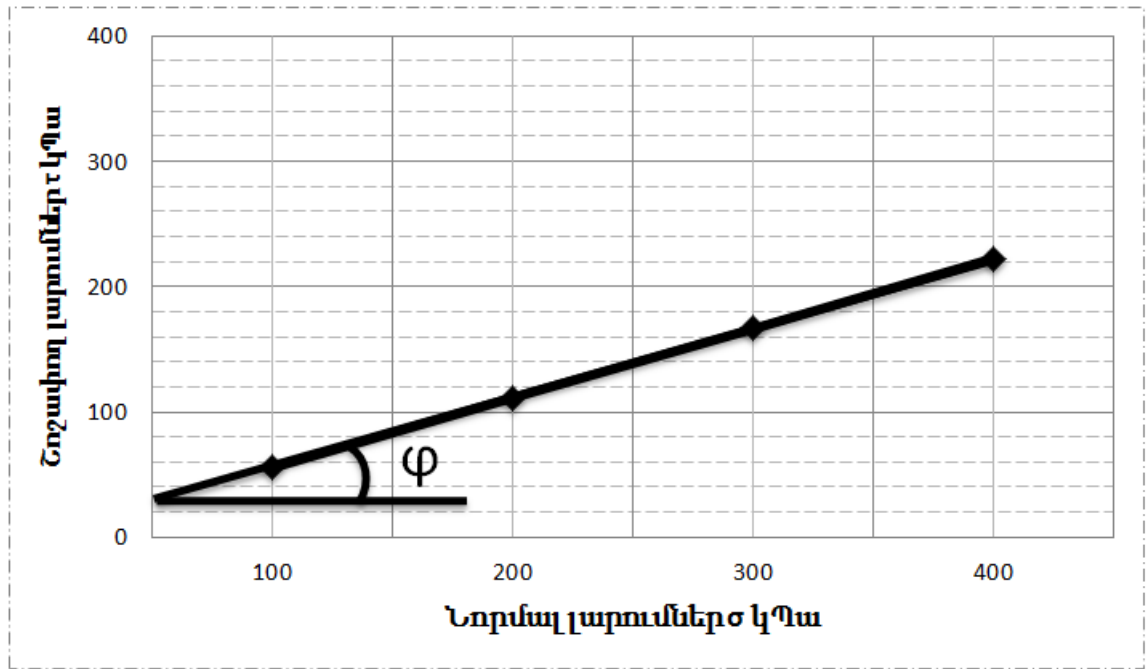
Natural Humidity W, %	Plasticity			Density g/cm ³			Porosity	Porosity Index
	Upper limit	Lower limit	Pl. number	Solid particle	Natural density	Skeleton volume weight		
13	29.0	24.0	5.0	2,70	1.98	1,75	35	0,54

The results for Slide resistance

Nº	Normal tensions σ kPa	Tangent tensions τ kPa	Internal friction coefficient $t\phi^\circ$	Internal friction angle ϕ°	Specific connection C, kg/cm ²	Ground moisture after experiment W, %
1	100	55,8	0.487	26°	0.07	14
2	200	111,6				
3	300	167,4				
4	400	223,2				

The results of the Ground slide resistance reasearch

Ground structure	Scoop Number	Samlpe depth	Layer Number	Object name
Natural	Borehole 2	6.0-9.0	Nº2 ^m	WWTP



Physical characteristics for the experimental sample.

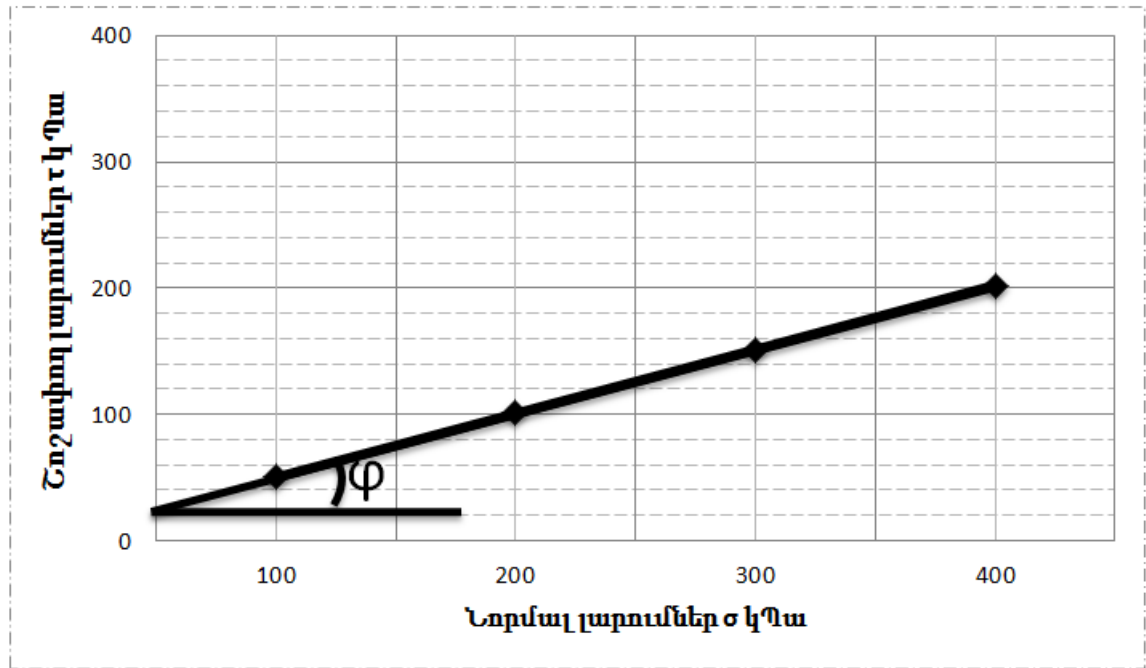
Natural Humidity W, %	Plasticity			Density g/cm ³			Porosity	Porosity Index
	Upper limit	Lower limit	Pl. number	Solid particle	Natural density	Skeleton volume weight		
12	29.1	25.0	4.1	2,70	1.97	1,76	35	0,54

The results for Slide resistance

Nº	Normal tensions σ kPa	Tangent tensions τ kPa	Internal friction coefficient $t\phi^\circ$	Internal friction angle ϕ°	Specific connection C, kg/cm ²	Ground moisture after experiment W, %
1	100	55,6	0.466	25°	0.09	13
2	200	111,2				
3	300	166,8				
4	400	222,4				

The results of the Ground slide resistance reasearch

Ground structure	Scoop Number	Samlpe depth	Layer Number	Object name
Natural	Borehole 2	10.5-14.0	Nº2 ^m	WWTP



Physical characteristics for the experimental sample.

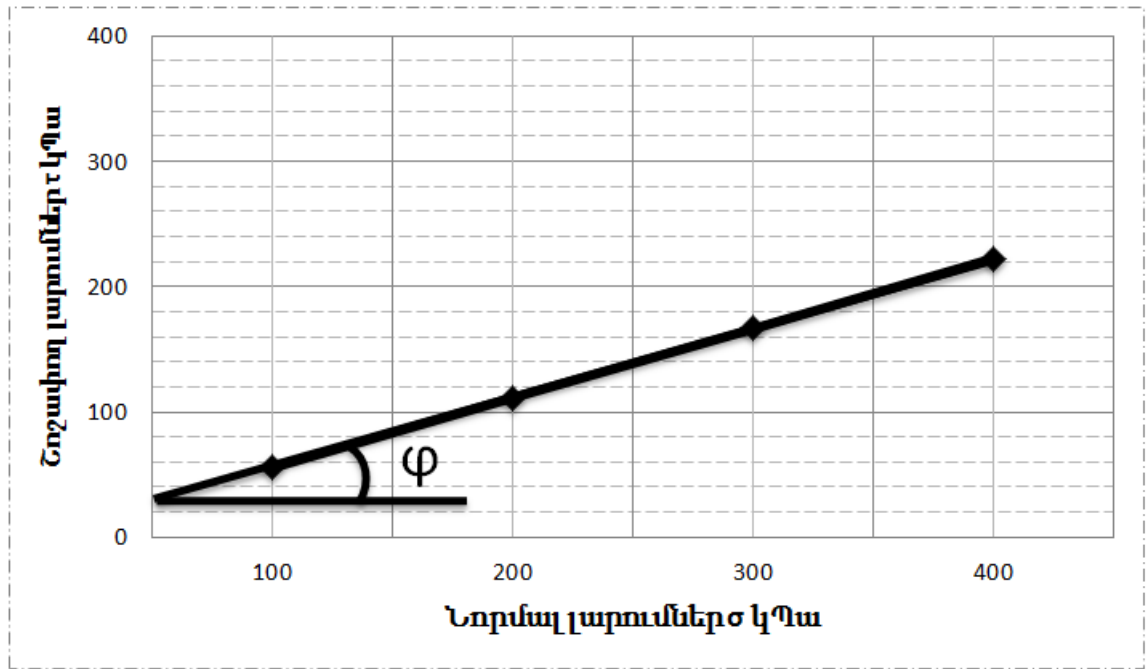
Natural Humidity W, %	Plasticity			Density g/cm ³			Porosity	Porosity Index
	Upper limit	Lower limit	Pl. number	Solid particle	Natural density	Skeleton volume weight		
12	29.6	25.0	4.6	2,70	1.97	1,77	34	0,51

The results for Slide resistance

Nº	Normal tensions σ kPa	Tangent tensions τ kPa	Internal friction coefficient $t\phi^\circ$	Internal friction angle ϕ°	Specific connection C, kg/cm ²	Ground moisture after experiment W, %
1	100	50.5	0.445	24°	0.06	13
2	200	101				
3	300	151.5				
4	400	200				

The results of the Ground slide resistance reasearch

Ground structure	Scoop Number	Samlpe depth	Layer Number	Object name
Natural	Borehole 2	15.0-18.0	Nº2 ^m	WWTP



Physical characteristics for the experimental sample.

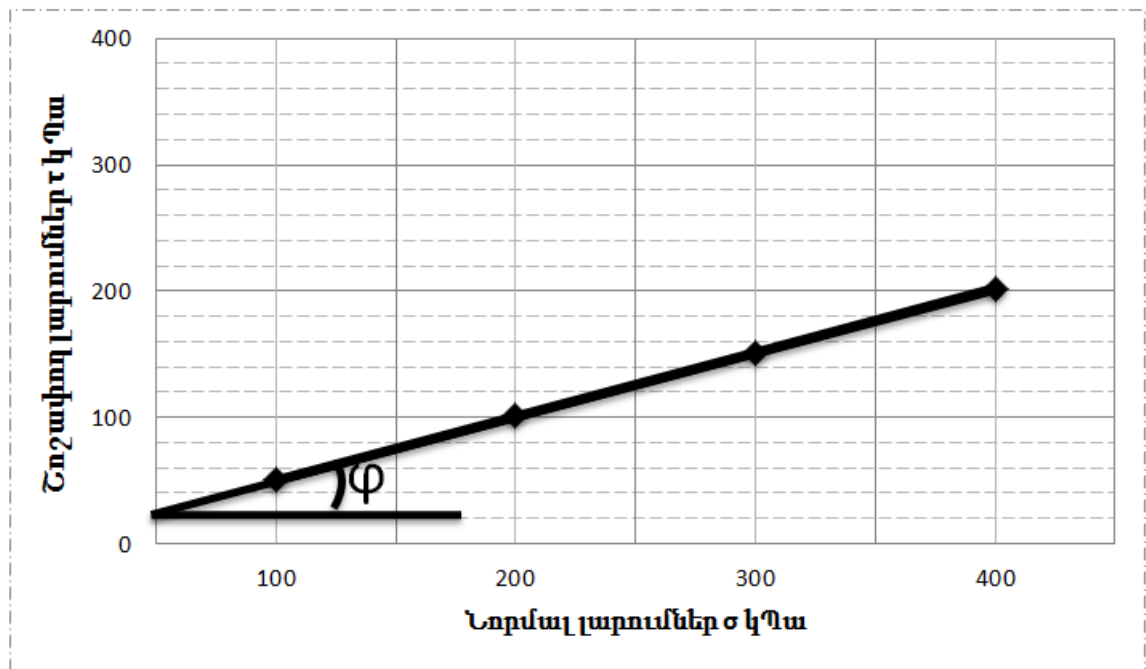
Natural Humidity W, %	Plasticity			Density g/cm ³			Porosity	Porosity Index
	Upper limit	Lower limit	Pl. number	Solid particle	Natural density	Skeleton volume weight		
12	29.2	25.0	4.2	2,70	1.98	1,77	34	0,51

The results for Slide resistance

Nº	Normal tensions σ kPa	Tangent tensions τ kPa	Internal friction coefficient $t\phi^\circ$	Internal friction angle ϕ°	Specific connection C, kg/cm ²	Ground moisture after experiment W, %
1	100	55,6	0.466	25°	0.09	13
2	200	111,2				
3	300	166,8				
4	400	222,4				

The results of the Ground slide resistance reasearch

Ground structure	Scoop Number	Samlpe depth	Layer Number	Object name
Natural	Borehole 2	27.0-30.0	Nº2 ^m	WWTP



Physical characteristics for the experimental sample.

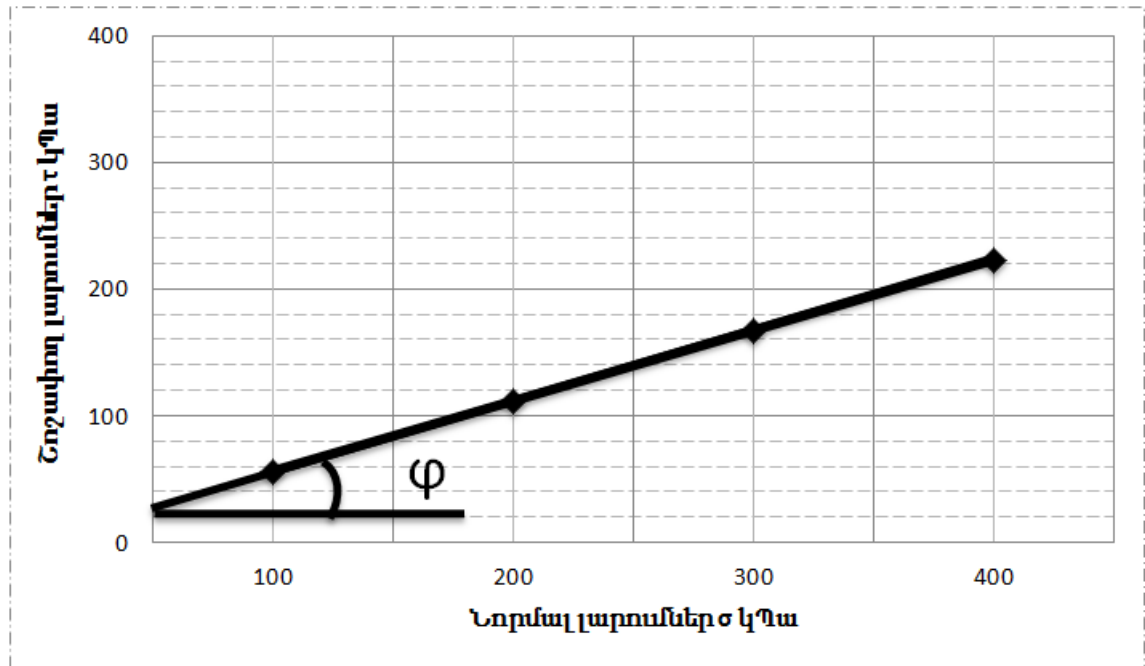
Natural Humidity $W, \%$	Plasticity			Density g/cm^3			Porosity	Porosity Index
	Upper limit	Lower limit	Pl. number	Solid particle	Natural density	Skeleton volume weight		
13	29.0	24.8	4.2	2,70	2.05	1,81	33	0,49

The results for Slide resistance

Nº	Normal tensions σ kPa	Tangent tensions τ kPa	Internal friction coefficient $t\phi^\circ$	Internal friction angle ϕ°	Specific connection $C, kg/cm^2$	Ground moisture after experiment $W, \%$
1	100	50.5	0.445	24°	0.06	14
2	200	101				
3	300	151.5				
4	400	200				

The results of the Ground slide resistance reasearch

Ground structure	Scoop Number	Samlpe depth	Layer Number	Object name
Natural	Borehole 3	18.5-20.0	Nº2 ^m	WWTP



Physical characteristics for the expermental sample.

Natural Humidity W, %	Plasticity			Density g/cm ³			Porosity	Porosity Index
	Upper limit	Lower limit	Pl. number	Solid particle	Natural density	Skeleton volume weight		
13	29.4	24.6	4.8	2,70	2.00	1,77	34	0,51

The results for Slide resistance

Nº	Normal tensions σ kPa	Tangent tensions τ kPa	Internal friction coefficient $t\phi^\circ$	Internal friction angle ϕ°	Specific connection C, kg/cm ²	Ground moisture after experiment W, %
1	100	55,8	0.487	26°	0.07	14
2	200	111,6				
3	300	167,4				
4	400	223,2				

6. Conclusions and Suggestions

Based on presented above following conclusions can be made

1. Investigated area's geological structure presented as four-aged class cobblestone-pebble and pebble-cobblestone sediment, capacity till 30m and more.
2. As the planned Building foundation will be used Layer №2 and Layer №2^a, because their characteristics are quite favorable for civic construction.
3. Remove Layer №1 after the foundation opening, in future replace it with cobblestone natural soil and make appropriate condensation.
4. Actual physical-geological phenomenons (landfall) in the researched area has been not noticed.
5. The area's seismic zone coincides with the 3rd seismic zone of nine-point intensity (by MSK-64 table, maximum horizontal acceleration $A_{max}=0.4g$, speed $V=32\text{m/second}$).
6. After the hole opening for the planned building form an act with appropriate specialists.

7. References

1. M R Meschyan <<Clay soil experimental stream>> Yerevan, 2005
2. N.A. Citovich <<Ground Mechanics>>, Moscow, 1963
3. Construction norms of Republic of Armenia- engineering researches for construction(2.01-99 Yerevan)
4. <<Seismic construction planning norms>>(6.02-2006 Yerevan)

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In the area of Yerevan WWTP ground mechanical properties

15 May 2013

Number N	Sample N	Borhole N	Deep, m	Granometr basic, %										Natural Humidity W, %	Density				Porosity %	Porosity Index	Slide upper limit	Slide lower limit	Plasticity number	Internal friction angle	Coherence Mpa	Deformation module kg/cm ²	seismic category	Allowable tension R, kg/cm ²	The procedure for construction Shk IV-2-82		
				Boulder mm	Cobblestone mm	Pebble mm	Sand mm					Dust mm	Clay mm		Solid particle density ρ _s , g/cm ³	Natural density ρ, g/cm ³	The Skeleton Volume weight ρ _a , g/cm ³														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28				
1	12	3	4.0-4.5	-	-	-	1.8	5.06	4.12	4.22	65.11	19.69	48	2.40	1.52	1.02	57	1.35	60.6	49.3	11.3	11	0.02	50	III	0.5	II				
2	13	3	5.0-5.5	-	-	-	2.83	4.18	3.58	3.65	68.25	17.51	45	2.32	1.58	1.09	53	1.12	64.6	54	10.6	10	0.02	55	III	0.5	II				
Average				-	-	-	2.31	4.62	3.85	3.94	66.68	18.6	46	2.36	1.55	1.05	55	1.23	62.6	51.6	10.9	10°30'	0.02	52	III	0.5	II				
				Layer №1 (sand-clays natural soil)																											
				Layer №2 (Cobblestone natural soil)																											
3	1	1	6.0-7.0	8.62	44.12	17.0	6.02	6.9	9.6	5.64	1.42	0.68	9	2.69	2.11	1.93	28.2	0.39	-	-	-	32	0.001	400	II	4.0	IV				
4	3	1	11.0-12.0	13.31	44.11	16.1	6.05	5.87	6.0	5.55	1.96	1.05	11	2.69	2.20	1.98	26.4	0.36	-	-	-	30	0.001	453	II	3.5	IV				
5	5	1	23.0-24.0	14.42	46.25	18.6	6.41	3.06	5.22	3.43	1.68	0.93	9	2.69	2.15	1.97	26.7	0.36	-	-	-	31	0.001	453	II	3.5	IV				
6	10	2	21.0-24.0	12.15	45.41	18.0	10.37	7.40	2.75	2.45	0.92	0.55	8	2.69	2.06	1.90	29.4	0.41	-	-	-	33	0.001	427	II	3.8	IV				
7	14	3	9.0-12.0	9.46	44.69	16.02	10.39	7.38	6.16	4.16	1.06	0.68	9	2.69	2.14	1.96	27.1	0.37	-	-	-	32	0.001	374	II	4.0	IV				
Average				11.25	45.30	17.14	7.85	6.10	5.93	4.25	1.40	0.78	9	2.69	2.13	1.95	27.5	0.38	-	-	-	-	31°30'	0.001	420	II	4.0	IV			
				Layer №2 ^м (Pebble natural soil)																											
8	2	1	8.0-11.0	6.48	30.69	26.02	9.88	9.02	8.06	3.85	4.04	1.96	12	2.70	2.00	1.78	34	0.51	28.3	24.1	4.2	26	0.007	215	II	3.0	IV				
9	4	1	15.0-18.0	7.51	32.93	24.00	6.81	10.11	7.86	4.12	4.21	2.45	12	2.70	2.01	1.79	34	0.51	29.8	25.0	4.8	25	0.009	241	II	3.2	IV				
10	6	1	28.0-30.0	6.53	34.97	23.5	9.31	8.12	7.01	5.02	3.66	1.88	13	2.70	1.98	1.75	35	0.54	29.0	24.0	5.0	26	0.007	241	II	3.2	IV				
11	7	2	6.0-9.0	6.32	34.81	24.3	10.22	7.51	7.11	4.00	3.51	2.22	12	2.70	1.97	1.76	35	0.54	29.1	25.0	4.1	25	0.009	188	II	2.9	IV				
12	8	2	10.5-14.0	5.46	36.25	23.0	6.62	9.68	8.51	4.55	3.92	2.01	12	2.70	1.97	1.77	34	0.51	29.6	25.0	4.6	24	0.006	215	II	3.0	IV				
13	9	2	15.0-18.0	4.28	37.16	20.0	10.34	9.45	8.60	4.11	4.08	1.98	12	2.70	1.98	1.77	34	0.51	29.2	25.0	4.2	25	0.009	224	II	3.1	IV				
14	11	2	27.0-30.0	8.12	29.0	27.0	9.13	8.34	8.23	3.64	3.88	2.66	13	2.70	2.05	1.81	33	0.49	29.0	24.8	4.2	24	0.006	241	II	3.2	IV				
15	15	3	18.5-20.0	6.11	30.51	24.0	10.56	9.38	8.44	3.83	4.66	2.51	13	2.70	2.00	1.77	34	0.51	29.4	24.6	4.8	26	0.007	268	II	3.3	IV				
Average				6.35	33.29	23.08	9.11	8.85	8.98	4.14	3.99	2.21	12.4	2.70	1.99	1.77	34	0.51	29.2	24.7	4.5	25	0.007	266	II	3.3	IV				



V. Titizyan