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Construction of Seismic Profiles and Seismic Hazard Assessment Considering Local Parameters on the Reconstruction Site Located on Ilia Chavchavadze Street, Dusheti

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ABSTRACT

Obtaining objective information on the engineering and geological properties of rock masses requires a broad range of studies, including geological, geotechnical, hydrogeological, and geophysical ones. The physical basis of engineering seismic acoustics is the close relationship between elastic wave parameters and the structural features, properties, and condition of the rock masses being studied.
This article examines the role of engineering geophysics in the construction of critical structures. Specific projects and their implementation methods are presented as examples.

Key words: *engineering geophysics, seismicity, rock massifs.*

Introduction

We conducted a series of works that involved the construction of seismic profiles and clarification of seismic hazard considering local parameters on the reconstruction site located at Ilia Chavchavadze Street #27, in the city of Dusheti.

Experimental Studies: Construction of Soil Seismic Profiles

Seismic profiling was carried out using the refraction wave method [1-13], obtaining data up to a depth of 30 meters. Additionally, the physical and mechanical parameters of the rocks were assessed based on the propagation velocities of elastic waves (both longitudinal and shear waves). A seismic profile 38 meters in length was constructed.

Figure 1 shows the study area and the location of the seismic profile. The corresponding start and end coordinates of the seismic profile, along with the absolute elevations in the WGS-84 coordinate system, are presented in Table 1.

Table 1. Start and end coordinates of seismic profiles with corresponding absolute heights. 1s indicates the start of the profile, and 1e indicates the end of the profile.

GPH #	X, m	Y, m	H, m
1s	475165	4659307	887
1e	475145	4659275	884

Fig. 1. Study area and schematic layout of seismic profiles.

Geophysical Investigations (Seismic Profiling)

Seismic profiling using the refraction wave method is one of the key techniques for investigating rock properties in solving engineering seismological problems. Our main objective was to study the structure of the given area and to determine the physical-mechanical parameters based on the velocities of longitudinal (P) and transverse (S) elastic waves.

For this purpose, the field seismic method of refracted waves was selected. The refraction wave method allows for the determination of the thicknesses of surface and deeper layers, as well as the velocities of elastic wave propagation within them.

The method is based on determining the arrival times of the first P and S waves from an elastic wave source to geophones arranged in a straight line. This makes it possible to calculate the velocity of the longitudinal wave.

Thus, the objective of the investigation was to determine the rock structure down to a depth of 30 meters and to define the following physical-mechanical parameters within the identified structural elements:

Table 2.

Vp m/sec	Longitudinal wave velocity
Vs m/sec	Transverse wave velocity
Vs/Vp	Velocity ratio
ρ gr/cm^3	Density
μ	Poisson's ratio
Ed Mpa	Young's dynamic modulus
Gd MPa	Shear dynamic modulus
Kd Mpa	Dynamic modulus of universal compression
D Mpa	Total deformation modulus
τ Mpa	Tensile strength limit

Note: Parameters 1–3 were obtained through field investigation, parameters 5–8 were calculated based on known theoretical relationships, while parameters 4, 9, and 10 were derived using available empirical correlations.

Seismic profiling was conducted using 10 Hz geophones spaced 2 meters apart. Seismic waves were induced by striking a special plastic plate with a 10 kg hammer. Both geophones and impacts were oriented along Z-Z and Y-Y axes. A five-shot point system was used, which included two shots at the beginning and end of the profile, one shot in the middle, and two off-end shots placed at a significant distance from the profile. This configuration enabled the acquisition of information down to a depth of 30 meters. Depending on the type of wave, the orientation of the impact was adjusted.

Wave recordings were made using a 24-channel engineering seismic station, model GEODE, manufactured by the American company GEOMETRICS. The direction of the impact varied depending on the wave type. Subsequently, interpretation was carried out using the licensed SeisImager software, also developed by GEOMETRICS. Seismogram analysis was performed, a geological cross-section was constructed, and the corresponding physical-mechanical parameters were evaluated.

Seismic profiling using the refraction wave method was carried out in the study area. A 38-meter-long seismic profile was acquired, providing subsurface information to a depth of 30 meters. Figure 1 shows the study area and the location of the seismic profile. The starting and ending coordinates of the profile, along with absolute elevations in the WGS-84 system, are presented in Table 3 below.

Table 3

GPH #	X, m	Y, m	H, m
1s	475165	4659307	887
1e	475145	4659275	884

Based on geophysical parameters, different engineering-geological elements (layers) have been identified, and the distribution of P-wave (VP) and S-wave (VS) velocities within them has been determined. The corresponding physical-mechanical parameters were also obtained. According to the constructed geophysical cross-section, three distinct layers are observed based on their physical properties (due to the lack of detailed engineering-geological information, identification is based on geophysical data and local visual observations, and is therefore somewhat conditional):

- **Layer 1** – Loose material, dry, decompressed;
- **Layer 2** – Clayey, highly decompressed;
- **Layer 3** – Clayey, presumably water-saturated.

Seismic Profile #1

Layer 1 extends from the surface down to a depth of 1.8–2.5 meters with the following seismic velocities: VP = 227 m/s; VS = 142 m/s.

Layer 2 lies beneath Layer 1 and varies in thickness from 0.5 to 7.0 meters. Its seismic velocities are: VP = 691 m/s; VS = 318 m/s.

Layer 3, observed down to a depth of 30 meters, is located below Layer 2 and has the following seismic velocities: VP = 876 m/s; VS = 433 m/s.

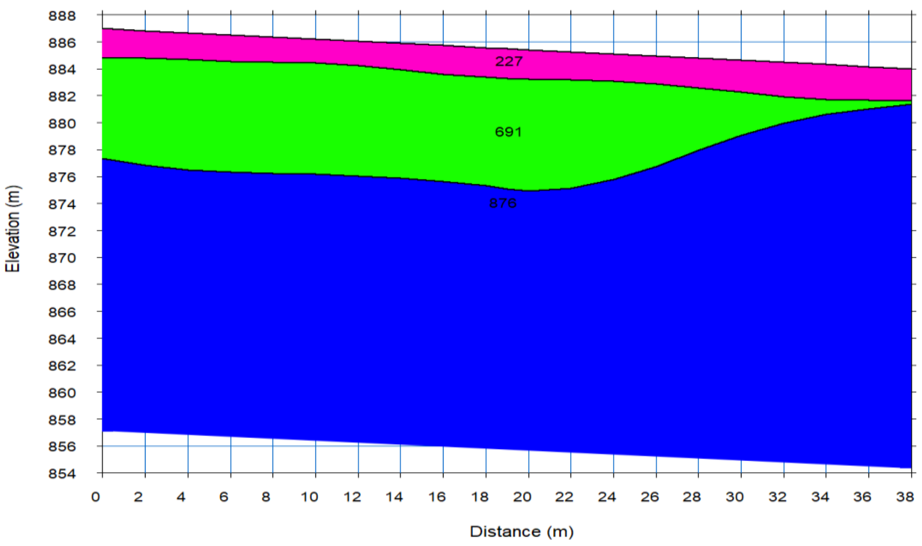

Fig. 2. Seismic section №1.

Layer N	Parameter	Parameter description	Values	Capacity, m
1	**Vp m/sec**	Longitudinal wave velocity	227	2
	Vs m/sec	Transverse wave velocity	142	
	Vs/Vp	Velocity ratio	0.63	
	ρ gr/cm^3	Density	1.25	
	μ	Poisson's ratio	0.18	
	Ed Mpa	Young's dynamic modulus	60	
	Gd MPa	Shear dynamic modulus	25	
	Kd Mpa	Dynamic modulus of universal compression	308.01	
	D Mpa	Total deformation modulus	0.37	
	τ Mpa	Tensile strength limit	-	
2	**Vp m/sec**	Longitudinal wave velocity	691	4
	Vs m/sec	Transverse wave velocity	322	
	Vs/Vp	Velocity ratio	0.47	
	ρ gr/cm^3	Density	1.65	
	μ	Poisson's ratio	0.36	
	Ed Mpa	Young's dynamic modulus	470	
	Gd MPa	Shear dynamic modulus	171	
	Kd Mpa	Dynamic modulus of universal compression	5600.50	
	D Mpa	Total deformation modulus	10.09	
	τ Mpa	Tensile strength limit	2.45	
3	**Vp m/sec**	Longitudinal wave velocity	876	24
	Vs m/sec	Transverse wave velocity	438	
	Vs/Vp	Velocity ratio	0.50	
	ρ gr/cm^3	Density	1.75	
	μ	Poisson's ratio	0.33	
	Ed Mpa	Young's dynamic modulus	900	
	Gd MPa	Shear dynamic modulus	336	
	Kd Mpa	Dynamic modulus of universal compression	8961.87	
	D Mpa	Total deformation modulus	28.56	
	τ Mpa	Tensile strength limit	4.80	
Vs30, m/sec		Average transverse wave velocity up to 30 m depth	36	9

Conclusion

Based on geophysical surveys and the average shear-wave velocity in the upper 30 meters of soil (VS30, which was determined to be 369 m/s for the construction site), the soil categories were determined according to both Georgian standards and international standards (IBC 2006, Eurocode 8, ASCE 7). It should be noted that, according to Georgian standards, the soil corresponds to Category II, while according to international standards, it was classified as follows: Eurocode 8 – Type B, IBC 2006 and ASCE 7 – Class C.

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ქ. დუშეთში, ილია ჭავჭავაძის ქუჩის სარეკონსტრუქციო ობიექტის ტერიტორიაზე სეისმური პროფილების აგება, სეისმურობის დაზუსტება ლოკალური პარამეტრების გათვალისწინებით

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რეზიუმე

ქანების კლდოვანი მასივების სანჟინრო-გეოლოგიური თვისებების შესახებ ობიექტური ინფორმაციის მისაღებად საჭიროა კვლევების ფართო კომპლექსის ჩატარება, რომელშიც შედის გეოლოგიური, გეოტექნიკური, ჰიდროგეოლოგიური და გეოფიზიკური კვლევები. საინჟინრო სეისმოაკუსტიკის ფიზიკურ საფუძველს წარმოადგენს დრეკადი ტალღების პარამეტრების მჭიდრო დამოკიდებულება საკვლევი კლდოვანი მასივების აგებულების, თვისებებისა და მდგომარეობის თავისებურებებთან.

ეს ნაშრომი შეეხება საინჟინრო გეოფიზიკის როლს მნიშვნელოვანი ნაგებობების მშენებლობაში. მაგალითის სახით მოვიყვანთ კონკრეტულ პროექტებს და მათი განხორციელებისათვის გამოყენებულ მეთოდებს.

საკვანძო სიტყვები: საინჟინრო გეოფიზიკა, სეისმურობა, კლდოვანი მასივები.

Сейсмические исследования и уточнение сейсмичности с учетом локальных параметров в селе Квибиси, Боржомский район

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Резюме

Для получения объективной информации об инженерно-геологических свойствах скальных массивов необходимо проведение широкого комплекса исследований, включая геологические, геотехнические, гидрогеологические и геофизические. Физической основой инженерной сейсмоакустики является тесная связь параметров упругих волн с особенностями строения, свойств и состояния изучаемых скальных массивов.

В данной статье рассматривается роль инженерной геофизики в строительстве ответственных сооружений. В качестве примера приведем конкретные проекты и методы их реализации.

Ключевые слова: инженерная геофизика, сейсмичность, скальные массивы.