ISSN 1846-6168
UDK 624.15

# ISTRAŽIVANJE ANIZOTROPNIH SVOJSTAVA BIOKLASTIČNOG VAPNENCA NA MODELIMA PILOTA U LABORATORIJSKIM UVJETIMA

# INVESTIGATION OF ANISOTROPIC PROPERTIES OF SHELL LIMESTONE BY MODELS OF BORED PILE IN LABORATORY-LIKE ENVIROMENTS

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*Pregledni rad*

***Sažetak:*** *U članku su opisani metodologija i rezultati istraživanja anizotropnih svojstava bioklastičnih vapnenaca na modelima bušenih pilota u laboratorijskim uvjetima.*

***Ključne riječi:*** *bioklastični vapnenac, anizotropija, slojevitost, posmična čvrstoća, strukturna čvrstoća.*

Review article

***Abstract:*** *The methods and results of the investigation of anisotropic behavior of shell limestone by models of bored pile in laboratory-like environments are described.*

***Keywords:*** *shell limestone, anisotropy, lamination, shear strength, structural strength.*

## 1. INTRODUCTION

The widespread use of shell limestone as the base of foundations, including bored pile, allows new task for researchers, which solutions will allow to investigate subsoil with special characteristics.

Shell limestone is organogenic rock, which has anistropic properties. Its stratum consisting of mussels – skeleton remainders of shellfishes, which placed horizontal and cemented on their contacts with strong crystallization bonding. Compressive strength capacity depends on the direction of stress. The value of maximum load applied vertically to the area of their accumulation (across/perpendicular to lamination) is lower than in horizontal direction (alongside the lamination). This may explain the different values of deformation and strength parameter properties in horizontal and vertical directions.

In the normative literature for evaluation criterion for anisotropic properties of rock and half-rock solids is adopted anisotropy coefficient $k_a$, and it's value is determined by the ratio of parameter of maximum strength on unixial compression in horizontal direction $R_{ca}$, to its value at the vertical vector of the load application $R_c$.[1,2].

It should be noted that a similar relation between another ratios of mechanical characteristic of shell limestone (structural strength, shear strength) is considerably different from the coefficient of anisotropy by amount of strength on uniaxial compression, and because of that corresponding coefficients of anisotropy must be used in the calculations that use the structural strength and shear strength, including alongside the lateral surface of bored piles.

The aim of research, the results of which are presented in this paper, is further definition of anisotropic properties of shell limestone of Odessa region determining the shear strength alongside the lateral surface of models of bored piles, which are located perpendicular, alongside and at an angle of 45° to the lamination.

## 2. THE RESULTS OF THE INVESTIGATION

The shell limestone has a high porosity (60%) with many interstices of large size. Drilled formation wall of bored pile has a high porosity. Cement slurry at concrete pouring of pile is permeating to the large blowing spaces of interstices and forming a rough blending surface between the pile body and the surrounding rock. In this case the shear resistance is determined not by friction, but strength of limestone, which is located outside surface of pile shaft, impregnated with hardened cement grout. Consequently, the failure at "disruption" occurs on limestone.

The investigation of shell limestone by piles of minor diameter in a laboratory environment are made in compliance with the basic requirements of ДСТУ Б В.2.1-1-95 "Soils. Field testing methods by piles". Investigations were carried out to determine shear strength at lateral surface of bored piles. For this, their production was carried out with preservation of hollow below toe of pile that which allowed load transfer on the shell limestone to internal contact surface of borehole.

The borehole with diameter 21 mm was bored to the full height of the sample. It's bottom part was filled with sand on the required height, whereupon, the down hole was filed by grout. We performed shaft equipment by cane of iron wire of Ø3 mm, and the head top we strengthened by snipping of the pipe Ø1/2 inches by a height of 6 cm. The space below the toe of bored pile was out of sand after achieving the design strength.

Investigations were carried out on a laboratory bench, which is a hand-power press, its circuit design and configuration are showed on the picture 1.

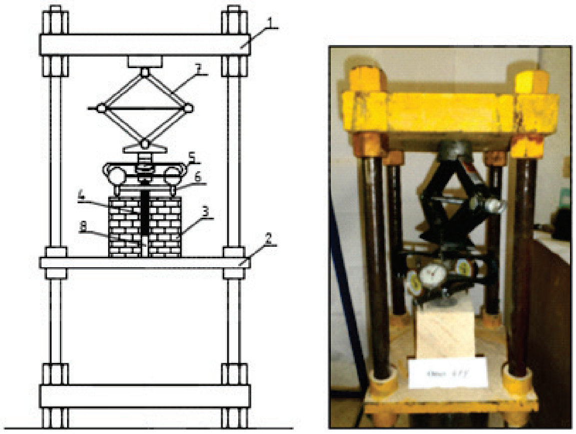

**Figure 1** Scheme and appearance of test shell limestone with models of bored piles inside, 1-2 - fixed plates; 3 – Sample of shell limestone; 4 – model of bored pile; 5 – Dynamometer; 6 - dial test indicator; 7 - adjustable jack; 8 – hollow space under the pile toe.

The loading of pile was carried out in stages at 0,5 kN. Each stage of load was hold until the increase of displacement was 0.01 mm in the last 10 minutes of observation. For maximum load taken the value when displacement of the pile does not fade out. After the "disruption" repeated investigations of piles were carried out to determine the shearing resistance alongside the side face after the destruction of the structural bonds.

Amount of the load at each stage was determined by a dynamometer, which was installed at the pile's head, with support on the upper stationary plate. The dynamometer's extension is measured with scale sensitivity of 0.01 mm. Vertical displacement of piles during investigations was measured by two dial gauge with a measuring sensitivity of 0.01 mm, which were fixed by the clamping console (reference system) on the metal head of pile. According to sample results the pile's dependency displacement diagrams from load were plotted.

**Table 1** The ratio of the shear resistance of shell limestone on the lateral surface of bored piles across and along lamination

| № ser, | Number of tests | Parameters value, MPa | | Factor of anisotropy $k_{af}$ |
|---|---|---|---|---|
| | | across lamination $f_c$ | along lamination $f_{c,a}$ | |
| 1 | 4 | 0,78 | 0,83 | 1,06 |
| 2 | 4 | 0,45 | 0,37 | 0,92 |
| 3 | 4 | 0,38 | 0,24 | 0,63 |
| 4 | 4 | 0,41 | 0,40 | 0,98 |
| 5 | 4 | 0,44 | 0,31 | 0,70 |
| 6 | 4 | 0,52 | 0,46 | 0,88 |
| Average | | **0,50** | **0,43** | **0,86** |

The above-described method of determining the shearing resistance at the contact lateral surface of bored piles and shell limestone was used in the investigations of shell limestone by piles across, alongside and at an angle 45° to the lamination, which allowed establishing the variation of this characteristic with the anisotropic properties of the rock.

The limit value of shearing resistance was determined by the results of the investigations of shell limestone by simulative piles across, alongside and at an angle 45° to the lamination. The results are shown in Table. 1 and 2.

**Table 2** The ratio of the shearing resistance of shell limestone on the lateral surface of bored piles across, alongside and at an angle 45° to the lamination.

| № ser. | Number of tests | Parameters value, MPa | | Factor of anisotropy $k_{af}$ |
|---|---|---|---|---|
| | | across lamination $f_c$ | under 45□ to lamination $f_{c,45}$ | |
| 1 | 4 | 0,83 | 1,02 | 1,23 |
| 2 | 4 | 0,55 | 0,60 | 1,09 |
| 3 | 4 | 0,50 | 0,48 | 0,96 |
| 4 | 4 | 0,43 | 0,40 | 0,93 |
| 5 | 4 | 0,46 | 0,54 | 1,17 |
| 6 | 4 | 0,55 | 0,60 | 1,09 |
| Average | | **0,56** | **0,61** | **1,08** |

## 3. CONCLUSION

Thus, the results of research showed that the shearing resistance alongside the side surface of bored piles is lower than shearing resistance across while at an angle 45° to the lamination is slightly higher. The coefficients of anisotropy are respectively equal 0,86 and 1,08.

## 4. REFERENCES


[1] Новский, А.В.; Новский, В.А.; Тугаенко, Ю.Ф.: Известняк-ракушечник. Исследование и использование в качестве основания фундаментов, Астропринт, Одесса, 2014., 92 с.

[2] Тугаенко Ю.Ф.; Ткалич, А.П.; Паламарчук, А.А.; Гевондян, А.Р.: Прочность и сжимаемость понтических известняков, Вісник державної академії будівництва та архітектури, Одесса, Випуск 16., (2004.), 206-211



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