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THE ROLE OF STEEL PILE SHEETS IN BUILDING BASE REINFORCEMENT

ABSTRACT

Structures supporting the slopes of the foundation pit were installed in a densely built-up city area. Geological studies had been carried out, and based on the conclusion, the design of reinforcing the pit was prepared for the first time along the outer perimeter with interlocked steel piles. Due to the insufficient length (12 m) of the steel pile sheets, additional column constructions were used, which created a spatial supporting frame of the pit, ensuring the stability of the pit's slopes.

Keywords: *foundations, sheet pile and cofferdams, interlock, construction*

1. INTRODUCTION

Over the past few decades, many things have changed and improved in Georgia's construction industry. In 2015, a new Georgian company, "Erti" LLC, appeared in Georgia, which, with the help of Dutch and Japanese partners, began to introduce sheet-piling technology.

In 1902, the Chief State Engineer of Bremen, Germany, Tryggve Larssen, developed the first example of a steel U-shaped profile with interlocks, which is now known as the "Larssen interlock". These pile sheets are the most popular type and have been used worldwide.

For 120 years, the production of sheet piles and the equipment used to install and extract sheet piles have been improved [1], [2] [3]. The Netherlands and Japan are advanced countries in the production and use of sheet piles, and the specialists from these countries are helping us to implement the technology in Georgia [4], [5]. In the beginning, there was only a hammer-type impact device, the drawback of which was the impact on the environment and damage to nearby buildings. In the 1930s, the vibratory method was developed. As a result, the friction force is lost, and the pile is placed in the desired location [6] [7]. The negative side of the vibratory method is the impact on the environment; the vibration affects the surrounding structures when the geology is complex, and the deformation modulus is strong. The positive side of the vibratory method is its speed; it is arguably the fastest and most widely spread one among the methods available today. Several piles can be connected and lowered to the design mark at one time. The maximum length of sheets used by the vibratory method can reach 35 meters.

2. BASE STRUCTURE ANALYSIS

When arranging the foundation pit, the construction organization should be guided by the current design, the construction organization design, and the work production design drawn up on their pit, according to construction norms and rules. At the same time, during the dismantling work, special attention should be paid to strictly observing safety rules.

The selection of the type of machinery and means required for the dismantling of existing buildings, the arrangement of the pit and the retaining structures of the retaining wall, and the place and time of their placement are determined according to the construction organization and the work production designs.

The absolute height of the bottom of the pit is 459.80 m. Based on the physicomechanical characteristics of the pit soils, for the drainage work, a compacted gravel pad with a thickness of 0.50 m should be arranged on the bottom of the pit. On top of this pad, a waterproof concrete slab with a thickness of 200 mm (concrete class B 15) will be arranged.

The outline of the pit is an irregular polygon with dimensions of 59.20 x 33.0 (m), the area is 1375 m, the absolute height of the bottom of the pit is 459.80 m, the average depth of excavation is 8.0 m, the approximate volume of soil to be removed from the pit is V=10000 m3. In the present design, the supporting construction of the slope of the pit is a spatial framework. The processing of the pit and the arrangement of its slope-supporting structures should be carried out step by step, according to the scheme given in the design. The production of work can generally be described as follows:

1) Prior to the arrangement of the pit, arrange reinforced concrete drilling-wet hanging beams to which the steel column will be attached;

2) Before processing the pit, the installation of steel pile sheets can be preceded by the arrangement of reinforced concrete piles;

3) After the installation of reinforced concrete and steel beams, the pit should be processed step-by-step (following the scheme given in the design).

According to the design task, a fastening belt should be arranged on the inner perimeter of the retaining wall of the pit slope (steel pile sheets), which will be connected with horizontal bars made of steel coils. Steel pile sheets must be separated by a certain distance (0.8 m-1.0 m) from the basement walls of the building provided for in the design so that it is possible to arrange the carpentry.

The current design has been calculated and processed in compliance with construction norms and rules in force in Georgia. Simultaneously with construction works, permanent geodetic monitoring should be carried out on the surrounding buildings.

Considering the location of the construction site and due to the considerable excavation depth, the stability and reliability of the slope-supporting structures are essential.

For necessary calculations, the following programs were used:

1. GEO5 reporting program;

2. "Engineering Calculator";

3. LIRA SAPR 2013.

H - the height of the pit slope is 8 m.

A drawing of the retaining structure of the pit wall and a diagram of the interlocks are given in Figure 1.

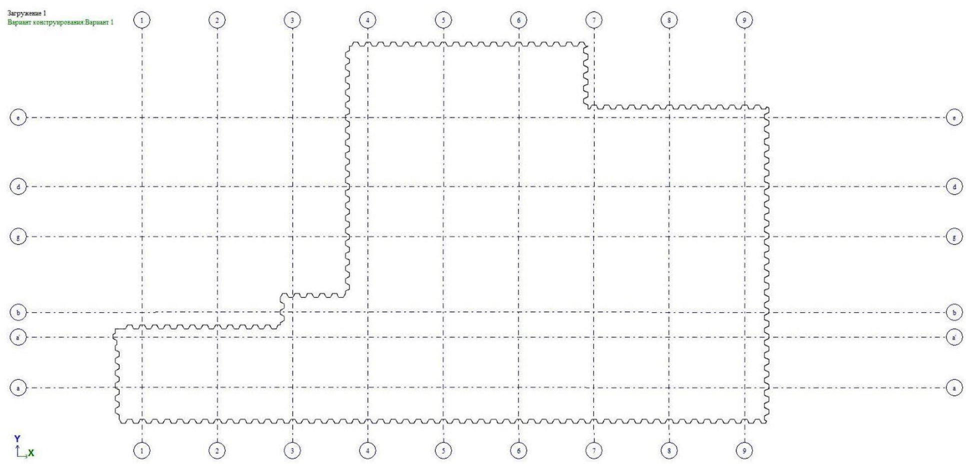

Figure 1. Retaining structure of the pit wall and a diagram of the interlocks

The calculation was carried out considering the gradual removal of the ground.

The results obtained by the calculation imply the determination of deformations, pressures on the wall of the pit, and force factors at a separate stage.

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In the first stage, the pit was processed to a depth of 3.5 m according to the given calculation scheme (Figure 2).

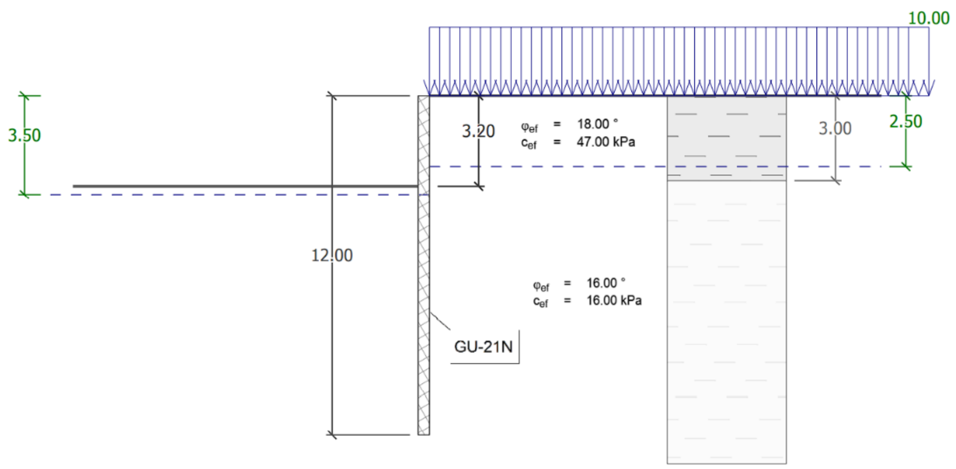


Figure 2. Calculation scheme

The obtained forces, deformations, and pressures, which are caused by the influence of the ground in the slope support structure, are given in Figure 3.

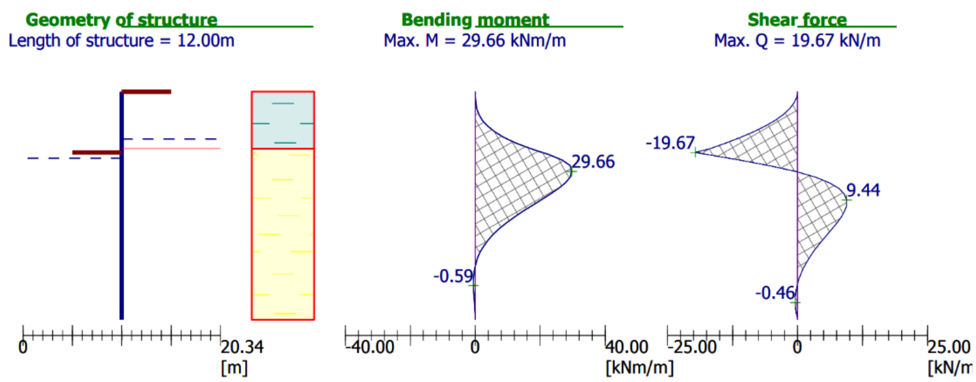


Figure 3. Boundary conditions which structure must withstand.

Maximum shear force = 19.67 kN/m

Maximum bending moment = 29.66 kNm/m

Maximum displacement = 7.3 mm

The pressure on the retaining wall of the pit is shown in Figure 4.

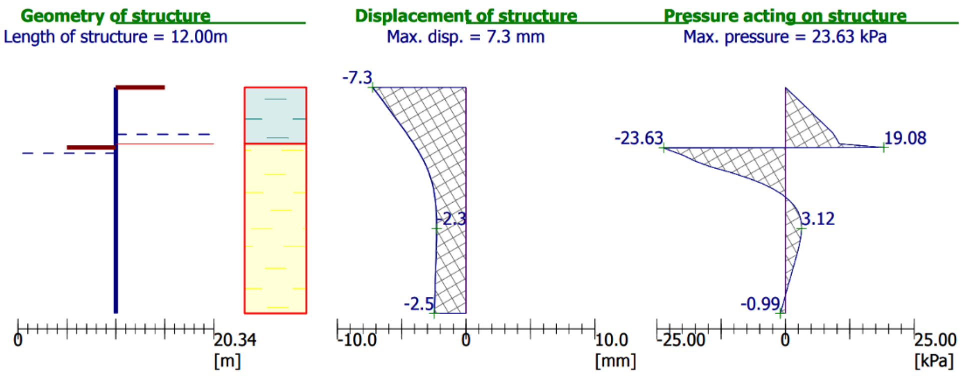


Figure 4. The pressure on the retaining wall of the pit slope.

In the second stage, in the pit with a depth of 3.20 m, we attach interlocks to the columns every 3.6 m (Figure 5).

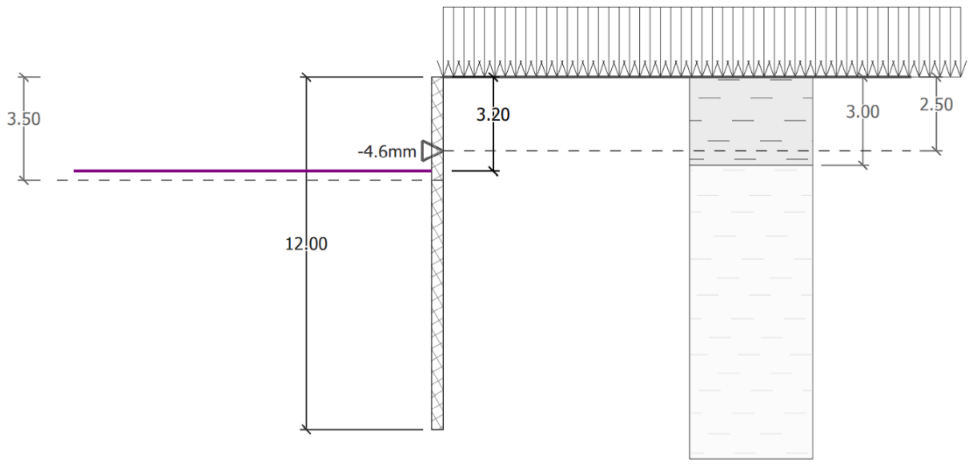


Figure 5. Attachment between interlock and column.

In the third stage, when dividing the pit into sections, we attach 8-m spacers in the depth zone (Figure 6).

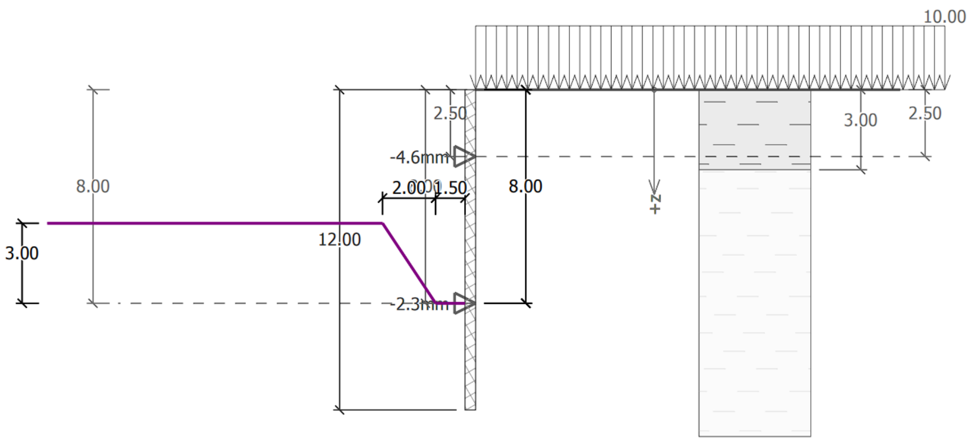


Figure 6. Column attachment scheme.

The obtained forces, deformations, and pressures, which are generated by the geophysical situation in the base structure, are presented in Figure 7.

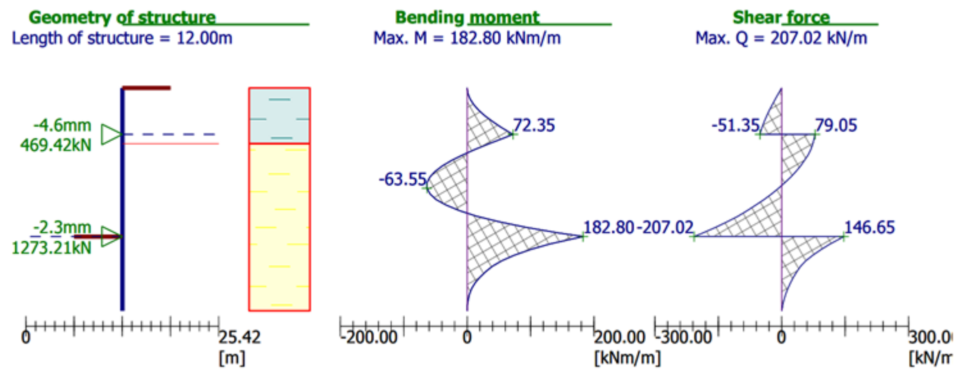


Figure 7. Boundary conditions from the ground

Maximum pressure = 207.02 kN/m

Maximum bending moment = 182.8 kNm/m

Maximum displacement = 7.8 mm

The pressure on the retaining wall of the pit slope is shown in Figure 8.

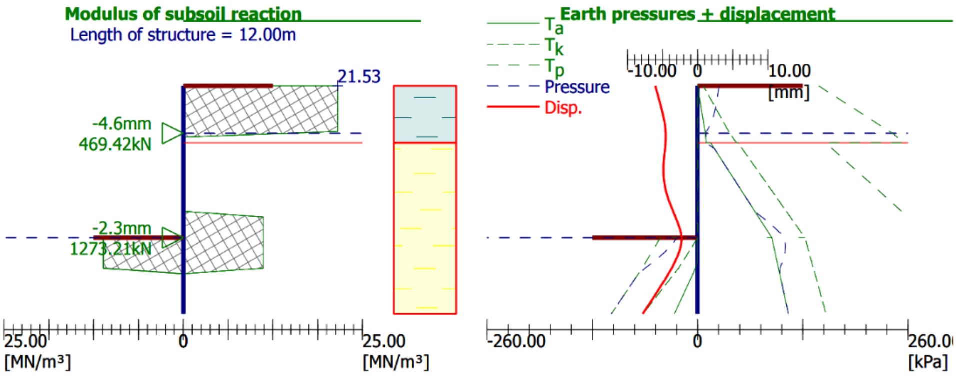


Figure 8. The pressure on the retaining wall of the foundation pit slope.

At this stage, the pit is completely arranged, and the soil is completely removed. The obtained forces, deformations, and pressures, which are generated by the influence of the ground on the support structure of the slope, are given in Figure 9.

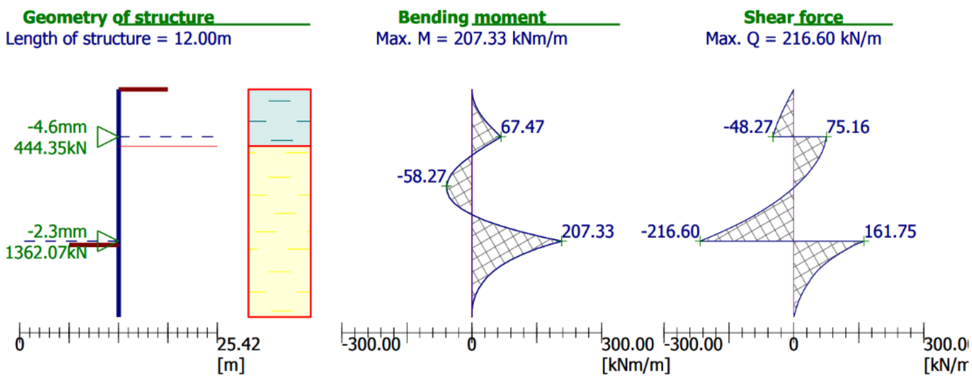


Figure 9. Boundary conditions from the ground.

Maximum shift force = 216.6 kN/m

Maximum bending moment = 207.33 kNm/m

Maximum displacement = 10.2 mm Figure 10.

The pressure on the retaining wall of the pit slope is shown in Figures 10 - 11.

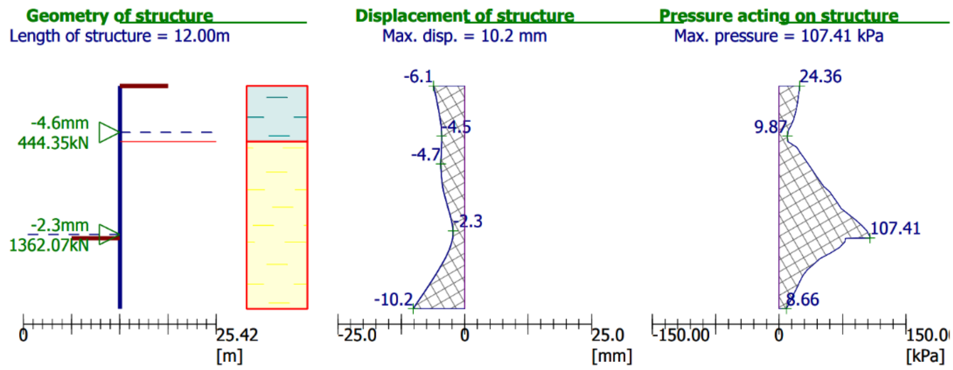


Figure 10. Boundary conditions from the ground

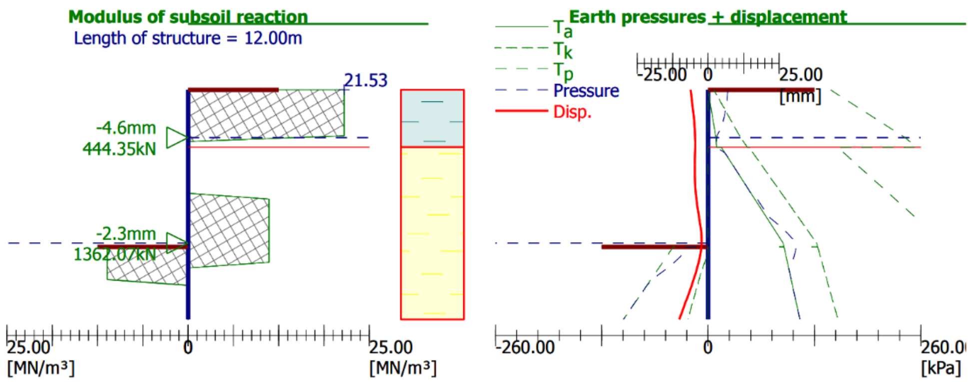


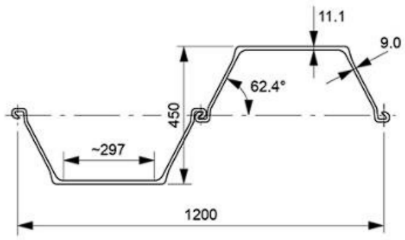
Figure 11. Boundary conditions from the ground

Let us check if the selected section GU 21N meets the requirements according to the calculation results.

Maximum bending moment M_{max} = 207.33 kNm/m

Elastic section modulus Wx = 2000 cm3/m

Steel grade S235GP



$$\sigma_{exis} = \frac{M_{max}}{W_x} \leq \sigma_{allow} = \frac{f_y}{y_m}$$

$$\sigma_{exis} = \frac{207}{2000} 10^3 = 103.67 \leq \frac{235}{1.5} = 156.0N/m^2$$

The report of the pile sheet led to the arrangement of additional constructions. The use of the mentioned construction limits the occurrence of large deformations in the pile sheet and ensures the stability of the base.

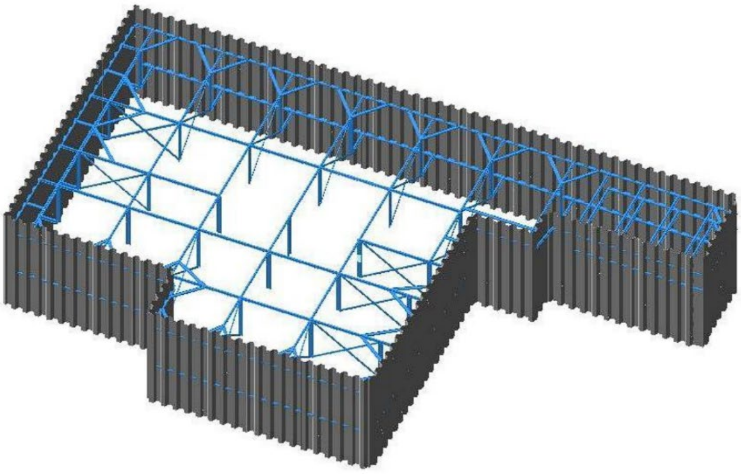


Figure 12. Base construction.

A spatial report of the retaining structure of the pit slope was carried out using the application LIRA SAPT 2013. Based on the obtained results, the type of steel sections was selected. The deformations caused by the load applied to the pit slope were determined. Figure 13 - Figure 15 shows the deformations obtained by moving the steel frame structure along the "6" axis:

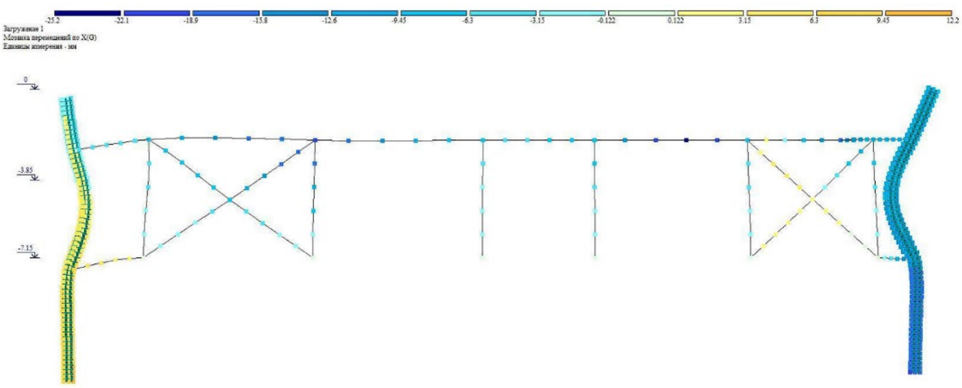


Figure 13. Displacement on the X-axis.

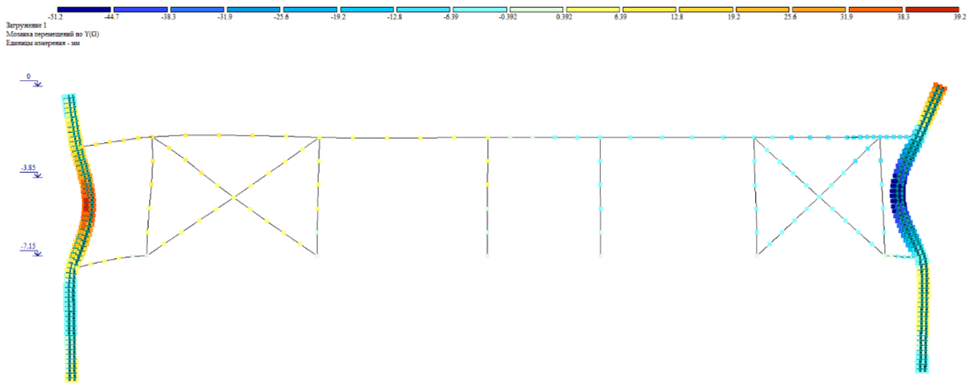


Figure 14. Displacement on the Y-axis.

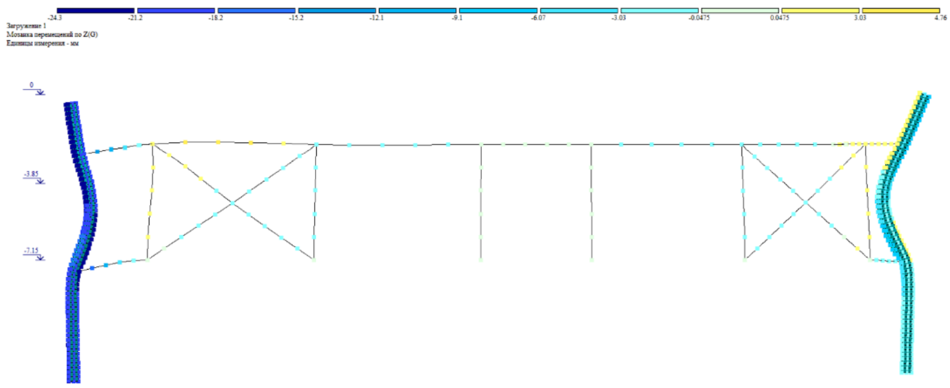


Figure 15. Displacement on the Z-axis

3. CONCLUSION

Steel retaining walls based on the Larssen interlock are technically wholly safe and economically feasible compared to other methods of strengthening the foundation pit, and they also provide the quickest solution. When these criteria are profitable in construction compared to other methods, this is already a sign of great success.

Steel pile sheets and the machines needed for their consumption were refined. European interlocks may be relatively costly compared to their counterparts, yet their economic viability is underscored by the exceptional quality of European technology. The data integrity of these interlocks surpasses that of interlocks manufactured in other countries, exhibiting a strength that is often double or even multiple times greater.

In European countries, machines with more vibratory methods are developing; in Japan, pressing machines without noise and vibration have been developed. In these countries, science has advanced to a level where new and increasingly modernized devices are introduced every year. In 2022, the production of fully electric vehicles began, and this direction will be improved in the following years.

4. ACKNOWLEDGEMENTS

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Beka Gurgenidze holds a Ph.D. degree in engineering, and he is a founder of "ERTI" LLC in Georgia with Dutch and Japanese partners. He has been working in the field of civil engineering for more than two decades. Under his leadership in Tbilisi, Georgia, numerous tower buildings have been constructed as part of a special case study.

Ioseb Giorgobiani

Ioseb Giorgobiani is a PhD student at Georgian Technical University. He graduated from Brno University of Technology and received the title of engineer. For the last two years, he has been working on thin-walled spatial structures in different companies like T.S Georgia and Tam Management.

УЛОГА ЧЕЛИЧНИХ ТАЛПИ У ЗАШТИТИ ТЕМЕЉНИХ ЈАМА

Сажетак: У раду су описане потпорне контрукције за осигурање темељних јама које се користе у густо играђеним подручјима. Извршена су геолошка истраживања, и на основу закључка први пут је израђен пројекат заштите јаме по спољним нивицама са међусобно повезаним челичним талпама. Због недовољне дужине (12 м) челичних талпи кориштене су додатне конструкције стубова, чинећи носиви рам јаме и обезбјеђујући стабилност косина јаме.

Кључне ријечи: темељи, прибоји и загати, талпа, конструкција.