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STATIC CALCULATION METHODS OF RETAINING WALLS APPLIED ON RIVER BEDS AND STEEP SLOPES

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Annotation: *Making accurate and reliable calculations in the design and construction of retaining walls remains important both from an engineering and economic point of view. This is especially important in hazardous geological conditions and in regions subject to extreme climate changes. Groundwater levels, soil mechanical properties, and other environmental factors must be considered to ensure the stability and functionality of retaining walls. The aim of the research is to improve the existing calculation methods for the design of retaining walls, in particular to increase the accuracy of soil pressure analysis by taking into account the influence of groundwater and the physical properties of the soil more accurately. In addition, the application of new structural materials and construction techniques will be investigated in order to increase the safety and stability of retaining walls in different soil and climate conditions.*

The object of the study is retaining walls located in different geological and climatic conditions. The subject of research is earth pressure calculations, material selection, and design of water management systems to ensure the safety and durability of retaining walls. Scientific innovation is manifested in the development of new analytical and demonstration methods to more accurately model the behavior of retaining walls under static and dynamic loads. These methods will help increase the accuracy of calculations by better including the effects of water pressure and soil engineering properties. Also, these innovations create a scientific basis for optimizing the safety factors of retaining walls and reducing potential failure scenarios. New approaches are especially important to assess the impact of groundwater dynamics and landslides on the durability of walls.

Key words*: retaining walls, river beds, hard slopes, calculation, methods*

Introduction:

The analysis of Soil Mechanics is used to calculate the soil pressure behind the wall. This analysis is a fundamental step in determining the bearing capacity and durability of a wall. Retaining walls are generally designed to resist soil slipping and falling. Therefore, safety factors are very important in the design of the wall. The material selection and dimensions of the retaining walls are carried out in accordance with the calculated loads and safety requirements. A variety of materials can be used, such as concrete, stone, steel, and sometimes Wood. Aesthetic and environmental influences are also taken into account in the design of the wall. Drainage is an essential element for the successful operation of retaining walls. Proper handling of surface and groundwater extends the life of the wall and increases its durability. A well-designed drainage system prevents water from damaging the wall structure, reduces costs and increases safety. They are structural elements used to increase the durability and stability of the soil in areas such as retaining walls, flow beds and hard slopes. Static calculation methods of retaining walls take into account various factors to determine the dimensions and material properties required to ensure the stability of the wall. These calculation methods usually include the following steps: Soil Mechanics and Structural Analysis: Soil Mechanics is an important discipline used to understand soil behaviors that are the cornerstone of engineering projects and how these behaviors affect structural analysis. Soil Mechanics is a branch of science that studies the physical and engineering properties of soils. Its main principles include: 1. The weight of the soil depends on the load multiplied by it, and this load is calculated by multiplying the volume and density of the soil. 2. Soils have two important characteristics called internal friction angle and cohesion. The internal friction angle refers to the shear resistance of the soil particles, while the coupling represents the chemical or physical gravity that holds the soil particles together. 3. The groundwater level is an important factor affecting the water saturation of the soil and the bearing capacity of the Earth [1]. To determine the stability of the wall, the soil pressure behind the wall is calculated. This calculation is based on the principles of Soil Mechanics and includes the following steps: 1. The soil load behind the wall is calculated by correlating the weight of the soil and the height of the wall. 2. The forces of friction and cohesion between the wall and the ground are calculated using the equations of Soil Mechanics. 3. Groundwater levels can significantly affect soil pressure. Therefore, this level must be included in the calculations.

Research results:

The safety of walls and structures depends on the exact calculation of soil pressure. Miscalculations can lead to serious consequences, such as wall collapse or damage to structures. In addition, soil pressure calculations are used in many areas of Civil Engineering, from foundation design to geotechnical engineering. Thus, Soil Mechanics and structural analysis play a key role in the safe and sustainable execution of construction projects. An accurate calculation of the soil pressure behind the walls ensures the safety of structures and interaction with the environment. Therefore, familiarity with these issues is very important for engineers and construction specialists, and attention should be paid to the principles of Soil Mechanics in order to make accurate calculations [2].

Table 1. Basic soil parameters and typical ranges used in the design of retaining walls

Soil type	Internal friction angle (degree)	Cohezia (kPa)	Unit Weight (Kn / m3)
Sand	30-45	0-5	15-19
sediment	25-35	0-10	14-18
Clay	15-30	10-25	17-20
Organic Soil	0-20	0-5	10-15
Mixed granular soil	20-40	5-15	16-20

Source:https://arxkom.gov.az/index.php/en/qanunvericilik/normativler/insaat-konstruksiyalar-sistemi/

Safety factors: safety factors to consider in the design of retaining walls are an important part of civil engineering and structural design. These walls are built to resist soil pressure and optimize soil use. However, for the safe and effective operation of retaining walls, it is very important to ensure an adequate margin of safety against various failure modes, such as slipping and falling. Sliding is a type of failure that retaining walls can experience. This means that the wall acts against the loss of soil behind it. The slip safety coefficient is calculated by dividing the slip resistance of the wall by the maximum shear force acting on it. In general, this factor must be kept above a certain minimum value, which means that the wall is sufficiently safe from the risk of slipping. Demolition is another risk factor to consider, especially with high retaining walls. This is when the top of the wall collapses outward or inward due to the repulsive force of the soil behind it. The overturning safety coefficient makes the resistance of the wall to the overturning moment relative to the maximum transformation moment acting on it. If this factor is high enough, it means that the wall is safe from the risk of overturning. In the design of retaining walls, the type and pressure of the soil behind them should also be taken into account. Different types of soil can create different repulsive forces that can directly affect the design of the wall. In addition, soil conditions, especially the presence of water, can significantly affect the performance of the wall. Water can increase the weight and density of the soil, which may require additional safety measures. Load calculations: the design and safety of retaining walls depends on the correct calculation of the loads affecting them. These loads consist of soil stress, water stress, live loads, and various environmental factors. In particular, water-related loads such as hydrostatic and hydrodynamic stresses can directly affect the performance and safety of retaining walls. The main function of retaining walls is to resist the pushing of the soil behind them. This repulsive force varies depending on the type of soil, its density, moisture and the slope of the soil behind it. Analytical techniques such as Coulomb or Rankine theories are usually used in calculating ground pressure. These calculations are important to ensure that the wall is designed with sufficient thickness and strength [3].

Water pressure is an important load factor for retaining walls, especially in creek beds or areas with high groundwater levels. Hydrostatic pressure is effective when the water is stagnant, that is, it does not move. The higher the water level, the higher the hydrostatic pressure acting on the wall. Hydrodynamic tension, on the other hand, occurs under moving water conditions, for example, during floods, applying additional dynamic forces to the wall. Such stresses should be taken into account when determining the design of the wall and its safety margin. Live loads are temporary loads such as people, vehicles and mechanisms and are especially important on retaining walls near roads. These loads are usually calculated based on standard traffic load models. In addition, other environmental factors such as snow load, wind pressure and earthquake forces must be taken into account in the design of retaining walls. Material selection and determination of dimensions: in the design of retaining walls, material selection and dimensions are very important for the safety and effectiveness of the wall.

These decisions are made on the basis of calculated loads and established safety factors. Materials such as concrete, stone, steel and, in some cases, even wood are used in different types of retaining walls. Each material has its own characteristics and advantages, which means that the choice of material must be carefully considered in accordance with the project. Concrete is one of the most used materials in retaining walls. With their high strength, longevity and relatively low cost, concrete walls are particularly dominant in large-scale projects. Concrete cast iron can be used in various forms, such as concrete walls, precast concrete panel walls, and concrete block walls. Concrete also has good waterproof properties, making it an ideal choice in flood-prone areas.

Stone retaining walls are used, especially in places where natural appearance is preferred or has historical or aesthetic value. Stone walls can be built in various structural forms, such as engineering stone walls and gravity stone walls. Natural stone is preferred because of its strength and natural drainage properties, but it usually costs more than concrete. Steel is used in applications that require particularly high strength and flexibility. Steel is often used as pile walls or support beams and adapts well to harsh soil conditions or high load requirements. Steel requires protective measures against the risk of corrosion, but with proper protection it can offer a long-term solution. The dimensions of the retaining wall are determined based on the calculated loads and safety factors. The height, width and thickness of the wall must be designed to withstand the loss of soil behind it, water pressure and other environmental influences. In addition, the depth and width of the foundation must correspond to the bearing capacity of the Earth and the distribution of the weight of the wall. So in the design of retaining walls, the choice of material and its dimensions are very important. Materials such as concrete, stone and steel each offer advantages for specific projects and conditions. The correct selection and dimensions of these materials optimize both the structural integrity and efficiency of the wall. Each project is unique and requires a thorough engineering assessment of material selection and dimensions and an individual approach [4].

Drainage and water management: drainage and water management: the design and functionality of retaining walls are not limited to material selection and structural dimensions; an effective drainage and water management system is also of great importance. The formation of standing water behind retaining walls can seriously impair the stability and structural integrity of the wall. Therefore, engineers should carefully consider drainage solutions at the design stage of retaining walls. When puddles form behind retaining walls, they can significantly increase the pushing force of the soil. This happens due to an increase in the hydrostatic pressure of the soil and the saturation of the weight of the soil with water. In addition, water can weaken the structure of the soil and reduce its shear resistance, increasing the risk of landslides and landslides. An effective drainage system is designed to prevent waterlogging and keep the soil behind the retaining wall dry. This both reduces the pushing force of the soil and maintains the strength of the soil. Drainage systems typically include drainage pipes, drainage stones, and seepage Wells. These elements provide quick and effective removal of water, preventing it from accumulating behind the wall. The design of the drainage system must be individualized based on local soil conditions, water level, rainfall and other environmental factors. The correct placement and slope of the drainage pipes ensures effective water collection and removal. In addition, drainage stones and filter fragments prevent soil from seeping into the drainage system, preventing clogging of pipes. Water management around retaining walls includes not only drainage behind the wall, but also surface water runoff and puddles in front of the wall. To prevent water from diverting and accumulating on the foundation of the wall, gutters and channels are used for surface drainage. In addition, the design of the wall must ensure that the water does not obstruct the natural flow paths. An effective drainage and water management system is very important for the longevity and durability of retaining walls. Standing water can seriously disrupt the structural integrity of the wall, so drainage solutions must be taken into account from the very beginning of the design. Since each project is unique, the drainage system and water management strategies must be customized based on specific location conditions and environmental factors. This approach ensures the safe and effective operation of the retaining walls.

Discussion:

Geotechnical reports and soil surveys: the design and construction of retaining walls requires a thorough understanding of the soil characteristics of the area to be built. This understanding is provided through geotechnical reports and location surveys. These reports and studies assess the physical and mechanical properties of the ground, the level of groundwater, the bearing capacity of the Earth and potential ground movements. This information is the basis of the design of the retaining wall and directly affects its structural integrity and safety. Geotechnical reports determine soil bearing capacity, compaction capacity, erosion potential and other critical factors. These reports are produced through laboratory analysis and field tests of soil samples. The reports provide critical information to engineers to understand soil behavior and its potential effects on the retaining wall [5]. Soil surveys are surveys carried out in the field to understand the specific conditions of the project area. These studies determine the type, layers, humidity and other physical characteristics of the soil. In addition, studies assess groundwater levels and drainage conditions. This information helps to make the right decisions in the design of the retaining wall and in the choice of material. The bearing capacity of the Earth is a factor that directly affects the safety and durability of the retaining wall. Geotechnical reports and soil surveys determine how well the soil can bear the weight of the retaining wall and the repulsion force of the soil behind it. If the bearing capacity is insufficient, soil improvement or the application of supporting methods may be required. Understanding the groundwater level is important for the design of a wall drain. High groundwater levels can increase hydrostatic stress and reduce the stability of the Earth. Therefore, geotechnical reports play a key role in developing water management and drainage strategies. In the process of designing and building retaining walls, geotechnical reports and ground surveys are very important. These reports and studies play an important role in understanding the physical and mechanical properties of the soil and designing it accordingly. Using this data, engineers can design retaining walls that are both safe and economical. Each project is unique and detailed soil analysis is the cornerstone of a successful retaining wall project [3].

Table 2. Design and analysis of retaining walls

Parameter	Definition	Importance
Soil type	Type of soil behind and under the wall	The type of soil affects the engineering properties of the soil and the loads applied to the wall
Groundwater level	Depth of groundwater in the area where the wall will be built	High groundwater levels can create hydrostatic pressure and increase drainage reserves.
Ground pressure	The horizontal pressure exerted by the soil on the wall.	Ground pressure is a key parameter for wall measurements and strength calculations.
Safety factors	Factors used against various failure modes such as skidding, overturning and carrying capacity	Adequate safety factors ensure that the wall is long-lasting and durable.
Material selection	Materials to be used in the construction of the retaining wall.	The choice of Material affects the price, appearance and durability of the wall.
Drainage option	System designed to control water inside and around the wall.	Effective drainage prevents water from damaging the wall and increases the durability of the wall.
Download calculations	Live loads acting on the wall, soil pressure, water pressure, etc.	Accurate load calculations are important for determining the size of the wall and determining safety factors.
Soil science	Survey of the soil in the area where the wall will be built.	Soil properties directly affect the design and safety of the wall.

Several basic formulas for statistical calculations of retaining walls applied in river beds and on hard slopes are: Coulomb's law:used to calculate the horizontal pressure exerted by the ground on the empty box inside:

$$P = \frac{1}{2} \times \gamma \times H \times H \sin(\varphi)$$

Here: P-horizontal ground pressure acting on the retaining wall,

γ unitweight of soil,

H soil height,

ϕ is the internal friction angle.

Coulomb Qanunu (Twenty Up Formula):

This formula can be applied in a wider spectrum. In more complex and real situations, it is used to calculate the horizontal ground pressure acting on the retaining wall:

$$P = \frac{1}{2} \times \gamma \times H \times H \times \sin(\varphi) \times K_a$$

Here: Ka is the active soil pressure coefficient. This coefficient may depend on the characteristics of the soil, the geometry of the retaining wall and other factors.

1. Bishop method: This method is used to assess soil pressure on sloping soil surfaces. This formula is widely used to assess the stability of slopes.

$$F_{total} = \int_0^H \gamma H \sin(\beta - \alpha)\, dH$$

F_totalgeneral horizontal ground pressure force,

γ unit weight of soil,

H soil height,

β is the slope of the slope,

α is the angle of internal friction.

These formulas are the main approaches used in the design and analysis of retaining walls. However, in actual applications, local soil characteristics, geological conditions and other factors must be taken into account. In addition, when performing professional engineering calculations, in general, local standards and recommendations of existing guidelines should be followed.

Conclusions: From the article we concluded that retaining walls are vital for engineering and infrastructure projects; however, difficulties in their calculations and design can threaten the safety and effectiveness of structures. Calculations of retaining walls are often not accurate enough, as variables such as groundwater levels and soil characteristics are not taken into account. The development of new analytical models and more comprehensive testing methods can improve the accuracy of these calculations. Material and design decisions for retaining walls are usually based on local standards and empirical experience. Modern research and technological advances can offer more effective material options and design approaches. An effective drainage system is very important for the integrity of the retaining walls. Improving water management and drainage systems can increase the durability of walls by keeping water pressure under control. Adopting more dynamic and adaptable approaches in designing retaining walls can strengthen the resistance of walls, especially against changing environmental conditions.

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