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Waterproofing Systems in Civil Engineering Structures Located in Coastal Areas: Based on Golem, Albania.

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Abstract: *This paper is focused on the scientific and practical analysis of waterproofing systems for coastal areas in the Golem region of Albania. Waterproofing materials, through their interaction within the structure, constitute integrated waterproofing systems that play a key role in the design and construction of engineering works, particularly civil structures located in coastal environments where high moisture levels, chloride presence, wet-dry cycles, and hydrostatic pressure accelerate the degradation of primary construction materials such as concrete and reinforcement steel, including composite structural materials.*
The Golem area in Kavaje can be characterized as a geomorphologically challenging construction environment, defined by terrestrial and marine sand layers with high permeability, as well as by the presence of shallow groundwater-measured at approximately 3 meters in the specific study zone [6]. These conditions significantly increase the risk of water infiltration and long-term deterioration of structural and construction materials, ultimately reducing the service life of built structures.
This study provides a detailed analysis (referring to both informational sources and practical applications) of the interaction mechanisms of waterproofing systems used in construction projects in Golem (specifically in the selected representative sample area). The systems examined include the crystalline waterproofing system DRACO Hydrobeton [1], PVC and bentonite-based waterstops [2], and supplementary membrane systems.
Based on research findings from 2018-2025, the study concludes that crystalline waterproofing systems significantly reduce concrete permeability to external agents, increase its density, and enhance protection against chloride ingress [3] [4]. DRACO Hydrobeton generates insoluble crystals within the concrete capillaries, enabling the sealing of micro-cracks up to 16bar. Waterstop systems are applied at structural joints where the risk of water infiltration is highest. Bentonite waterstops swell upon contact with water, forming a durable compaction seal, while PVC waterstops provide long-term protection against groundwater flow [2].
This academic work presents a comprehensive and guidance-oriented assessment of the performance and interaction of these materials within a complete structural assembly. The analytical conclusion recommends an integrated, multi-layered waterproofing approach for structures exposed to coastal environments such as the Golem region.

Keywords: *waterproofing system, coastal structure, technical data sheet, waterstop, resistance to external agents, durability, Golem, Kavaje.*

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I. INTRODUCTION

Albania is characterized by two primary typologies of coastal zones relative to its overall land area; however, this study concentrates specifically on the Antarctic coastline, with particular focus on the Golem region of Kavaje. Coastal environments are typically highly aggressive toward civil engineering structures, especially reinforced concrete and composite systems-due to the combined action of external degrading agents such as chlorides, fluctuating moisture cycles, atmospheric salinity, and hydrostatic pressure generated by groundwater dynamics. These factors substantially reduce the durability of concrete and accelerate the onset of reinforcement corrosion and carbonation processes, which, if not adequately mitigated, can lead to structural deterioration with significant implications for the service life of the built asset [3].

Establishing effective conditions for preventing water ingress and protecting construction elements through integrated waterproofing systems represents a critical phase in the study, design, and execution of any structure located in the coastal zones.

Golem, as an administrative unit within the municipality of Kavaje, forms a major entry point along the Adriatic coastline. The rapid growth of construction activity in the area, combined with its unique geotechnical conditions, underscores the need for innovative technologies and enhanced technical controls. According to the geological report of the region, the soil profile consists of four primary strata: aeolian sand, a fill layer, fine gray marine sand, and the groundwater table. The geomorphological composition of these layers-reaching down to the required project depth of 3 meters-facilitates water migration toward structural elements, particularly in the case under study, involving two underground floors. The presence of groundwater generates increased hydrostatic pressure acting directly upon load-bearing structures [6].

Scientific studies and practical references suggest that the implementation of mixed waterproofing systems ensures structural safety, long-term durability, and improved living conditions-especially by addressing indoor moisture problems that have historically affected buildings constructed in Albania before 2016. Such systems are also aligned with environmentally responsible practices. Waterproofing components such as DRACO Hydrobeton, a crystalline admixture that enhances concrete density and reduces groundwater permeability, together with PVC and bentonite waterstops designed to seal and compact structural joints, represent globally recognized and widely applied solutions. Research conducted between 2018-2025 confirms the effectiveness of these technologies in marine environments, demonstrating significant resistance to chloride penetration and hydrostatic pressure [4] [5].

This academic work aims to guide engineering professionals on the proper selection and implementation of waterproofing systems, grounded in technical references and practical construction case studies from the region. Compared to the European countries, the adoption and correct application of a fully integrated waterproofing system-encompassing all necessary stages-remains a topic of ongoing discussion in Albania.

II. LOCATION OF THE STUDY AREA AND GEOMORPHOLOGY

The site for the construction of the "7-storey accommodation structure with 2 underground parking floors" is located in the structural unit G1-A41-05, Golem-Kavaja, in Golem. This area is part of the coastal lowland of Albania; therefore, a flat zone of accumulative origin, influenced by neotectonic activity. The coastal lowland has been formed under the continuous influence of the main relief-forming factors, the deposition of river sediments, as well as the action of sea waves. Accumulative sectors and partially abrasive ones characterize the coastline of the Adriatic Sea in the Durres area.

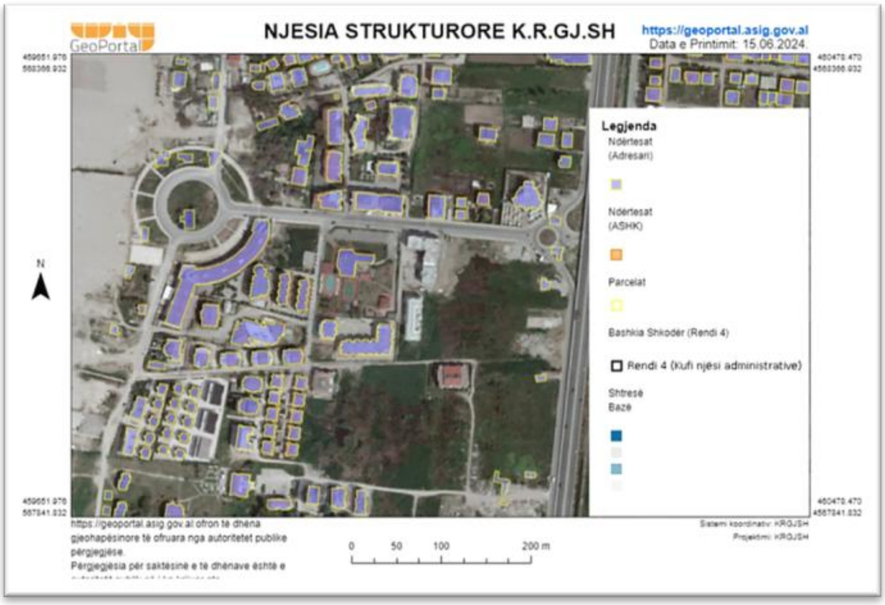

Fig.1 Location of the study. Source [8]

III. HYDROLOGICAL CONDITIONS AND SOME COMMONLY USED WATERPROOFING SYSTEMS

According to the geological report of the construction site, the groundwater level is located at a depth of 3m below the natural ground surface. Therefore, during the excavation of the foundations, the presence of groundwater is encountered in both underground floors (design elevation –6.29 m). For the execution and achievement of the foundation level in accordance with the project, pumping has been used to lower the groundwater level. In this case, care must be taken to ensure that the water pressure curve does not affect the building foundations, as the process of suffusion (washing out and loss of fine material due to groundwater flow) may occur as a result of pumping, which damages the foundations and leads to deterioration of the subfoundation soil structure.

Geological-engineering conditions of the construction site:

Based on the documentation of the samples extracted during the site investigations (the boreholes were drilled using a “UNIMOK” type drilling rig), from six boreholes with a depth of 12.0 m carried out at the construction site, and from the laboratory analyses of these samples, four layers have been identified, which have different lithological compositions and physical-mechanical properties. Their position, both in lateral extent and in depth, is presented through lithological columns and geological–lithological profiles at a vertical scale of 1:100 and a horizontal scale of 1:200.

LAYER 1

Fill material, composed of various construction materials such as: gravel, pebbles, soil, brick fragments, tiles, and plastic debris. Its thickness varies from 2.5 to 3.0 m. This layer will not serve as a foundation for placing the structural footings.

LAYER 2

It is represented by Quaternary eolian deposits composed of fine-grained and medium-grained sand, brown to beige in colour, saturated with water. Thin lenses of silt and coarse-grained sand are encountered, with gravel up to 0.5cm in diameter, with a thickness of up to 20cm, water-saturated and slightly compacted.

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The physico-mechanical properties for this Layer No.2 are:

GRANULOMETRIC COMPOSITION	VALUES
Gravel fraction	0.00%
Sand fraction	75.0%
Slit fraction	23.9%
Clay fraction	1.1%
Natural moisture content	34.8%

Table.1 Source [6]

LAYER 3

It is represented by Quaternary marine deposits, composed of fine-grained, silty sand, gray to ash-colored, saturated with water, and slightly to moderately compacted.

Fig.2 Photo of layer no.3 Source [6]

The physico-mechanical properties for this Layer are:

GRANULOMETRIC COMPOSITION	VALUES
Gravel fraction	0.00%
Sand fraction	51.7%
Silt fraction	43.2%
Clay fraction	5.1%
Natural moisture content	34.0%

Tab.2 Source [6]

LAYER 4
It is represented by Eluvial deposits of the Neogene base formation, highly compacted, composed of clay interbedded with layers of siltstone and sandstone, brown in color, with streaks and white patches, slightly moist, and compacted.

Fig.3 Photo of the sample from layer no.4 Source [6]

The physico-mechanical properties for this Layer are:

GRANULOMETRIC COMPOSITION	VALUES
Sand fraction	30.9%
Slit fraction	45.2%
Clay fraction	23.9%
Liquid limit	45.5%
Plastic limit	27.3%
Plasticity index	18.2%
Natural moisture content	14.5%
Porosity coefficient	0.54
Porosity	36.0%
Cohesion	0.8 kg/cm²

Tab.3 Source [6]

Photos during the drilling process

Fig.4 Photo during the drilling of borehole no. 1. Source [6]

Fig.5 Photo of the sample from depth 0.0–5.0 m. Source [6]

Fig.6 Photo of the sample from depth 5.0–12.0 m Source [6]

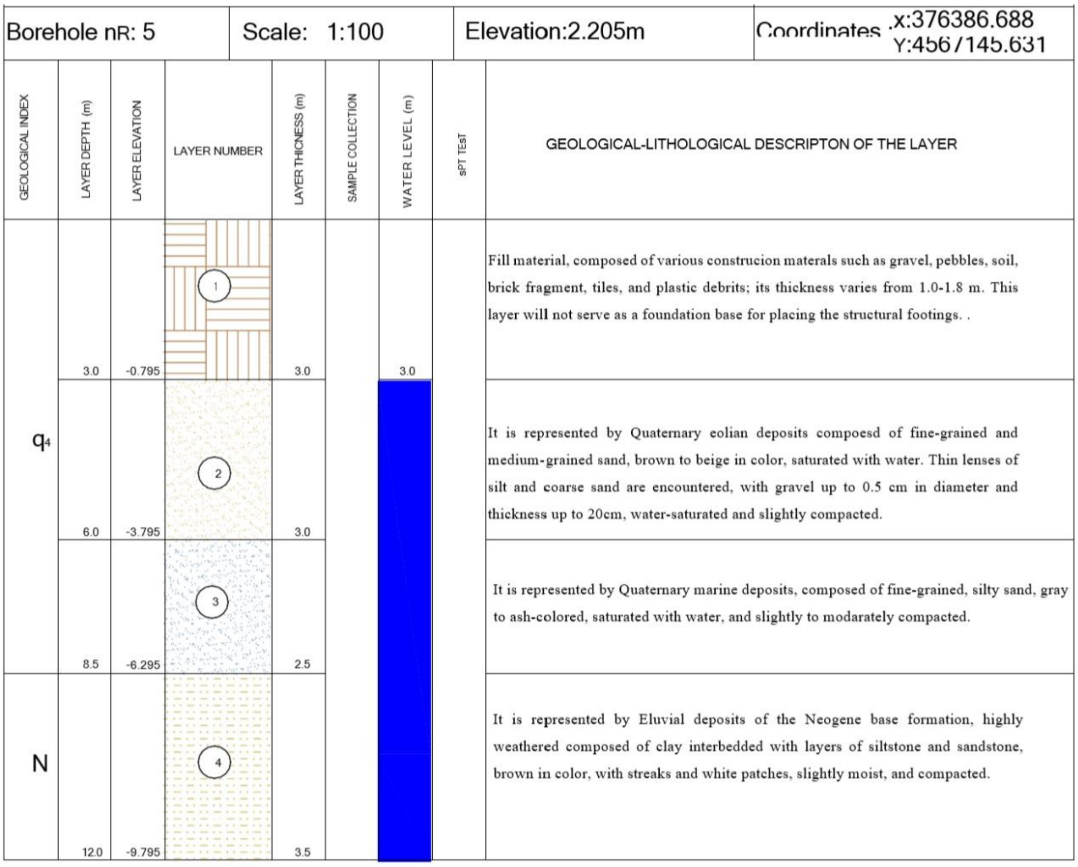

Fig.7 Geological-lithological profiles Source [6]

Draco hydrobeton

Draco hydrobeton is a powdered crystalline admixture that, through its formulation, interacts with the internal structures and capillary pores of concrete, providing a waterproofing system that becomes a permanent and integral part of the concrete matrix.

The constituent components of Draco Hydrobeton are a blend of chemical compounds that combine and react with the free lime present within the capillary pores of the concrete, under conditions of moisture, to form a crystalline complex that is insoluble in water.

This crystalline system also blocks the capillary pores and reduces micro-cracks that may occur in the concrete, to prevent any further ingress of water (even under hydrostatic pressure). It is also important to note that the concrete retains its ability to allow vapor diffusion through the structure. [1]

Technical Specifications

Appearance	Powder
Colour	Grey
Specific weight of mixture (g/cm^3)	0.450-0.650g/cm^3
Alkali Content	Max.0.1% by mass

Tab.4 Source [2]

Let us discuss some of the key features of this system:

1-As a permanent system that becomes part of the molecular bond of the concrete structure, one of the principal advantages offered by the crystalline technology is the improvement of the concrete´s mechanical strength, which consequently contributes to a significant increase in the structure´s service life.

2- Another important characteristic of the crystalline system is its active nature. This means that the system reactivates whenever it comes into contact with water, thereby reinitiating the crystallization process within the concrete matrix. Studies and various laboratory tests confirm that after 56 days, the crystals are capable of filling voids and capillaries to a depth of up to 30cm.

3-The system also demonstrates resistance to hydrostatic pressures of up to 16 bar. (equivalent to the pressure exerted by a 160-meter water column)

4-Another significant feature is its ability to provide permanent and comprehensive sealing of cracks, with an effective sealing capacity for crack widths of up to 4mm, including those that may form during the long-term service life of the concrete structure.

5-The crystalline system withstands freeze-thaw cycles exceeding 50 repetitions and is resistant to aggressive atmospheric agents (such as water containing carbonates, sulfates, chlorides, and nitrates). This contributes positively to the protection of the reinforcing steel embedded in the concrete by preventing corrosion. [1]

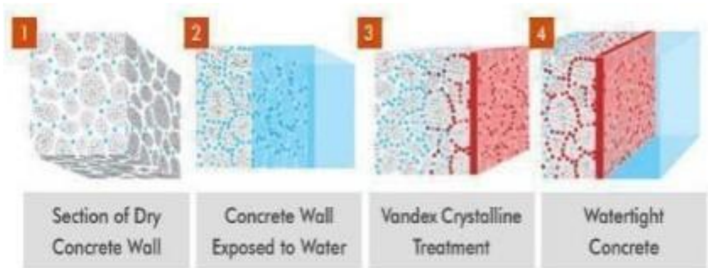

Fig.9 Crystallization process in a concrete sample Source: [2]

Expansive waterstop 20x25

This is a waterproofing element used at construction joints where concrete is cast at different times.

Typical applications of this type of waterstop include:

a. Between the foundation slab and the perimeter wall.
b. Between the perimeter wall and the perimeter beam of the intermediate floor slab.
c. At vertical construction joints of the perimeter wall. [2]

Fig.10 Expansive waterstop 20x25 Source: Authors

Waterstop for targeted crack stimulation

The installation orientation of these waterstops is vertical, positioned in predetermined locations for controlled crack induction in basement walls or other surfaces that may be exposed to groundwater presence. [2]

Fig.11 Waterstop for targeted crack stimulation Source: Authors

Fig.12 Waterstop for targeted crack stimulation Source: Authors

Additionally, a PVC waterstop (a waterproof, impermeable plastic material) may be installed to interrupt the wall section, accompanied by two expansive waterstops positioned on both sides to prevent penetration. [2] Waterstops when concreting is embedded in the body of each slab. All the waterstops have anchors (or anchor ribs) (Fig.2). Due to these protrusions, the waterstop is firmly retained in the body of the concrete elements. These concrete elements are interconnected through an elastic material - a waterstop, which plays the role of a barrier and prevents the penetration of water into the structure.

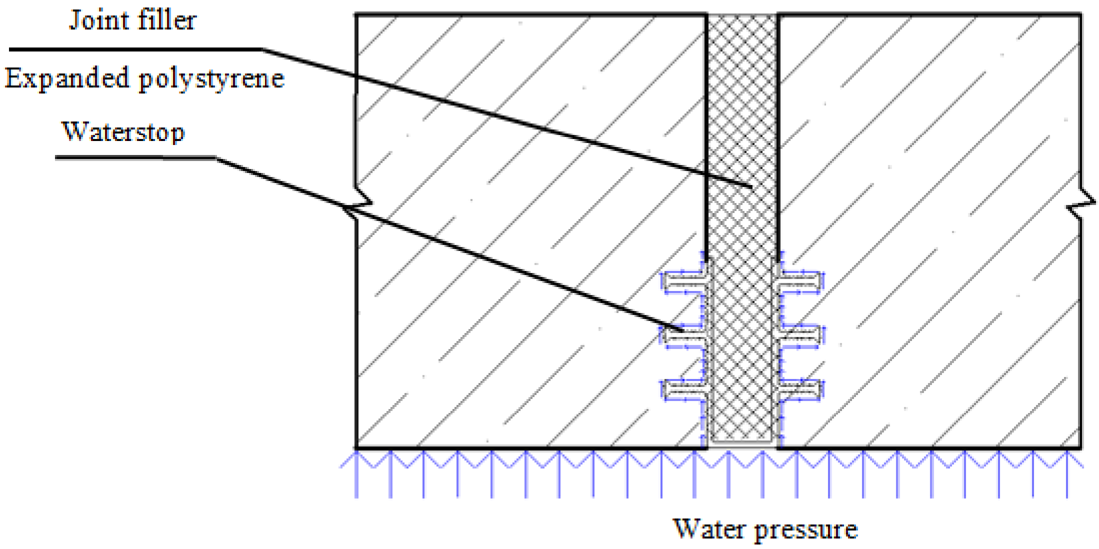

Fig.13 Waterstop in the concrete Source: [9]

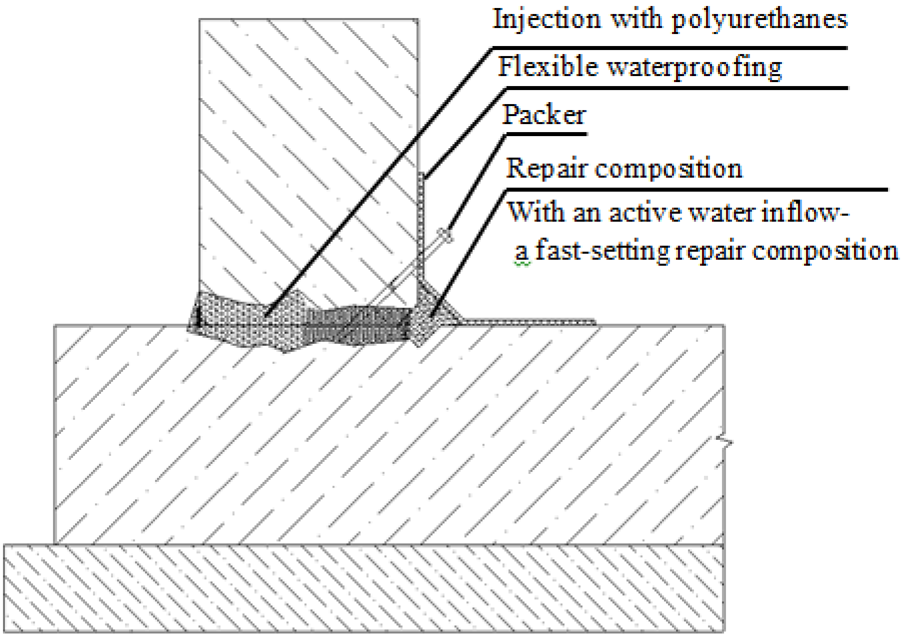

Fig.13 Waterstop in the concrete Source: [9]

Joint movements are compensated:

- for technological joints - due to the elasticity of the material of the waterstop;
- for expansion joints - due to deformation of the central element of the waterstops (compensator) and the inherent elasticity of the material.

The principle of operation is very simple: due to the different anchors and ribs, these materials lengthen the path of water.

Now consider the practical part related to finance for waterproofing buildings and structures.

At the beginning examining at the cost of waterproofing of technological joint mating base plate-wall with using a waterstop.
This waterstop is mounted using special staples (3 pieces per 1 meter), which are attached with a binding wire to the transverse reinforcing bars of the upper belt of the reinforcing cage of the foundation plate or slab. Staples prevent the movement of the waterstop from the design position. The reinforcement frame in the upper part of the outer walls should allow unobstructed placement of the waterstop. [9]

IV. CONCLUSION

After the geological survey was carried out, we noticed that the presence of groundwater is reached at a level of 3 m below the ground surface. Based on the geological investigation conducted, several of the aforementioned waterproofing materials and systems were selected for application in the structure. These systems are technologically available and economically feasible in the coastal regions of Albania. However, newer technologies, which are more environmentally friendly, safer for human health, and more advantageous in terms of building durability and service life, are not yet widely adopted. This is mainly due to the lack of appropriate application technology and their relatively high cost.

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