THE ROLE AND IMPORTANCE OF SURFACE WATER MANAGEMENT IN ROAD INFRASTRUCTURE ENGINEERING WORKS IN ALBANIA

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ABSTRACT

This paper examines the role and significance of surface water management in road infrastructure engineering works in Albania. Effective surface water management is essential at every stage—design, construction, operation, and maintenance—for ensuring road safety, stability, and longevity. Therefore, each phase of road infrastructure projects, including planning, design, construction, and maintenance, must properly consider terrain characteristics, such as geological, hydrogeological, and meteorological factors. Well-planned projects integrate morphological, meteorological, geological, and environmental factors, along with the use of suitable materials and technologies, to improve the durability and efficiency of infrastructure. Several negative geological and geotechnical phenomena observed in recently constructed road infrastructure in Albania are here analyzed. The discussion addresses the issues arising from inadequate surface water management and evaluates the causes and consequences impacting road infrastructure performance. Proper management of surface water is crucial not only for road infrastructure safety but also for its users. Furthermore, effective water management enhances the stability, functionality, and long-term maintenance of roads. Given the increasing attention to environmental and climatic changes, the importance of surface water management in Albania's road engineering projects has become even more pronounced. The primary focus of this paper is to highlight the adverse effects that inadequate surface water management has had on Albania's road infrastructure network.

Keywords: surface water, management, road infrastructure, engineering

1. INTRODUCTION

In Albania's road infrastructure, effective surface water management is of paramount importance. As urbanization and traffic volumes increase,

managing surface water presents an escalating challenge for designers, engineers, and planners. Slow water discharge into road infrastructure can lead to severe damage and degrade road quality. To address these issues, adequate road surface paving and well-planned drainage systems are essential. The use of appropriate paving materials and a robust drainage design ensures safe and efficient removal of water from road surfaces. Drainage systems should be designed to capture all surface water, directing it away to minimize negative impacts on the road and nearby infrastructure. In terms of road infrastructure sustainability, surface water management is critical. Water accumulating on road surfaces can cause structural damage, erosion, slope instability, and increased maintenance costs. To enhance sustainability, it is important to implement suitable techniques and materials to mitigate these negative effects. Investing in innovative technology and sound engineering practices is vital for effectively managing these challenges and building a sustainable road infrastructure for the future.

2. MATERIALS AND METHODS

In recent years, Albania's road infrastructure has seen rapid development, marked by the construction of new roads and improvements to the existing network. However, these investments have frequently encountered various problems and uncertainties. Compared to other types of projects, road infrastructure projects face more risks and uncertainties due to the diverse and challenging terrain (Stille, 1998). The data used in this paper are drawn from events that have occurred over the years across different parts of Albania’s road infrastructure and are supplemented by relevant literature and documents related to road infrastructure. The negative geotechnical phenomena analyzed in this paper were selected based on their impact on road stability and safety. The study considers reports and documents from the Albanian Road Authority (ARA), the World Bank (WB), press articles, dissertations, and other sources, including the Albanian Development Fund (ADF) and local municipalities. The methodology involves examining recent geotechnical phenomena occurring along some of Albania’s major road axes, directly tied to surface water management issues. These events were inadequately managed, resulting in unexpected negative outcomes, including environmental impact, revenue loss, reputational damage, increased construction or maintenance costs, and project delays (Clayton 2001a;b). Significant

investments, such as the Tirana-Elbasan Highway and the Nation's Road (Rruga e Kombit), have already encountered these issues. Roads under construction, like Qukës-Qafë Plloçë, Arbri Road, and the Vlora Bypass, have faced similar challenges. Globally, many infrastructure projects report geotechnical problems due to improper management during the design and execution phases (Clayton 2001 a;b) a trend also evident in Albania. Each infrastructure project is unique, with varying conditions and requirements, which implies that risks differ significantly from project to project (Sturk, 1988). Several recent geotechnical events highlight the critical role of surface water management in road infrastructure. On the Nation's Road (Rruga e Kombit), a landslide on May 26, 2015, at km 7+000, blocked three lanes, while heavy rainfall triggered further landslides on November 24, 2015, and February 9, 2019, near Rubik. Photo 1 illustrates the landslide that occurred on March 24, 2018, near Reps. Landslides are an ongoing issue on the Nation's Road, frequently obstructing traffic along this segment. On the Tirana-Elbasan Road, a landslide on September 7, 2014, after heavy rainfall, blocked the road (Photo 2). Additional landslides occurred in the Ibë area on December 13, 2014, and on December 10, 2017. The ARA's official Facebook page documents many such events along the national road network, and these incidents are frequently reported in the media. Heavy rainfall often results in road blockages, affecting not only national roads but also those managed by local municipalities.

Photo. 1: The landslide of March 24, 2018.

Photo.2: The landslide of September 07, 2014.

3. RESULTS AND DISCUSSION

An analysis of last year's geotechnical phenomena in Albania's road infrastructure, along with relevant literature on terrain stability, reveals two

primary factor categories: passive (influencing) and active (initiating) factors. Passive factors include geological structures, tectonics, relief, and weathering, while active factors encompass surface and groundwater activity, hydrometeorological events (such as snow, frost, rain, and wind), earthquakes, vegetation, plant cover, and human activities. These factors must all be carefully considered throughout each phase of road infrastructure project design. From 2011 to 2015, the Albanian Geological Survey developed the "Compilation of Landslide and Landslide Susceptibility Maps" (at the scale 1: 200,000 for the entire country and the scale 1: 50,000 for municipal territories). This project analyzed six elements—lithology, slope gradient, land cover, rainfall, and seismicity (Albanian Geological Survey, 2015). Such information, alongside geological-engineering and hydrogeological reports, forms the foundational data needed for designing infrastructure projects, particularly for roads that span large areas with significant terrain variability. Technical reports frequently reveal substantial deficiencies in execution per the Council of Ministers' Decision No. 628, dated July 15, 2015, "On the Approval of Technical Design and Construction Rules for Roads." These deficiencies affect project design from the outset, leading to issues that carry over into construction and, subsequently, into operation and maintenance. During the operational phase, the importance of surface water management becomes especially clear. Problems across all phases incur additional financial costs and project delays. For example, the World Bank withdrew financing from the Tirana-Elbasan road project due to such complications. A significant portion of cost overruns and delays in infrastructure projects stems from unanticipated geotechnical terrain conditions (Hintze *et al*., 2000). The World Bank's 2019 report, Climate-Resilient Road Assets in Albania, provides comprehensive data on annual repair costs by road axis and a map of expected annual landslide costs per corridor (Figure 1). Risk is quantified as annual damage costs (in euros) per kilometer of road (Xiong *et al*., 2019). Reports and periodicals, as well as our construction-phase observations, reveal frequent neglect in project implementation, with some designs lacking essential geological-engineering data. In several road projects considered in this study, the absence of these reports—and the resulting negative consequences—has been acknowledged by leading officials in road infrastructure. Low-quality materials and workmanship, especially in designing drainage systems, installing drainage pipes, culverts, channels, and gabion walls, and failing to implement terrain stabilization measures to mitigate water impact, have

contributed to increased costs, extended timelines beyond projected deadlines, and issues with infrastructure durability and safety. In many instances, project supervision, particularly regarding work methodology, falls short of required standards.

Landslides Annual Expected Damages	Repairs (1,000 €)	Interuption (1,000 €)	Total (1,000 €)
01 Milot - Morine New	287	38	**324**
02 Shkoder - Puke - Kolsh	110	3	**113**
03 Milot - Shkoder - Muriqan	38	52	**90**
04 Tirana - Durres	45	72	**116**
05 Durres - Vlore	150	363	**513**
06 Tirana - Elbasan - Pogradec	200	256	**457**
07 Fier - Gjirokaster - Kakavi	61	45	**106**
08 Gjirokaster - Sarande - Ksamil	39	0	**40**
09 Elbasan - Gramsh	25	2	**26**
10 Lushnje - Berat - Çorovode	64	30	**93**
11 Rrogozhine - Elbasan	17	12	**29**
12 Shkoder - Hani i Hotit - Vermosh	76	21	**97**
13 Milot - Peshkopi	124	74	**198**
14 Vlore - Sarande	146	32	**178**
15 Pogradec - Korce - Kapshtice	22	45	**67**

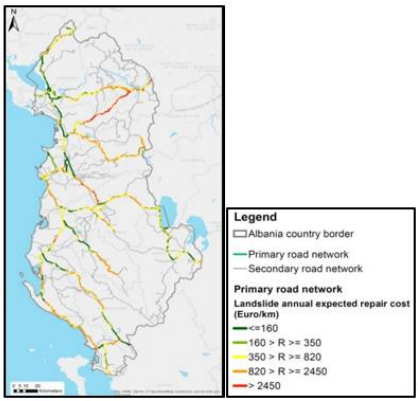

Fig. 1: AED from expected repair costs and damages from interruption of services due to landslide (Xiong *et al*., 2019).

Short deadlines in road project work often lead to higher maintenance costs. Performance-based Road maintenance contracts have increased contractors' awareness of the importance of routine and periodic maintenance, yet these tasks are often only addressed when conditions have significantly deteriorated. Tasks such as cleaning channels, unclogging culverts, clearing vegetation, removing surface water, and filling even small potholes should be carried out according to well-defined contract standards. Timely, quality maintenance interventions not only minimize costs but also enhance road durability and safety. It is essential to remember that surface water poses a considerable threat to road infrastructure. This study documents, with evidence and photos, the processes essential to managing surface water, focusing on two key examples (Photos 4 and 5). For instance, cleaning channels and unclogging culverts are critical actions for effective surface water management. Blocked channels or culverts can lead to water accumulation, causing significant drainage problems during heavy rainfall. Such issues contribute to road erosion and increase the risk of landslides and structural damage. Additionally, clearing vegetation and removing water from the road surface are essential measures for maintaining road durability and safety.

Overgrown vegetation or accumulated water on the road surface can increase slip hazards and significantly impact road traffic. The documented evidence in this study highlights the importance of routine actions in managing surface water, emphasizing the role of good engineering practices and adherence to contract standards. These measures support timely, quality interventions that reduce costs and improve road durability and safety.

Photo 2. Blockage of the channel leading to water. overflow onto the road

Photo 1. The collapse of surface water channels.

4. CONCLUSIONS

Managing surface water in road infrastructure is essential for ensuring road safety and longevity. Effective planning and design must prioritize understanding the terrain and using suitable materials and technologies to mitigate surface water impact. Investing in innovative technology and sound engineering practices is crucial for tackling the challenges of surface water management. Geological, hydrogeological, and meteorological factors should be integrated into all phases—design, construction, and maintenance—to ensure resilient road infrastructure. The numerous issues observed in road projects within our country underscore the need for effective surface water management. Failing to implement these measures leads to higher costs, project delays, and increased risks to road safety and durability.

Road-owning and managing agencies, such as the Albanian Road Authority (ARA), the Albanian Development Fund (ADF), and local municipalities, in collaboration with the Ministry of Infrastructure and Energy (MIE), should reassess the importance of oversight and consider

strengthening the legal framework to ensure that these standards are upheld.

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