

## THE IMPACT OF ENVIRONMENTAL FACTORS ON CONSTRUCTION BUILDINGS IN LIBYA

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### ABSTRACT

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Libya's construction industry faces significant challenges due to various environmental factors that impact construction practices, sustainability, and project success. This study examines key environmental influences, such as climate, soil conditions, water availability, and natural disasters. Libya's harsh climate, characterized by extreme temperatures, arid landscapes, and sandstorms, complicates construction efforts. High temperatures can hinder concrete hardening, leading to structural weaknesses, while sandstorms can delay projects and damage equipment. Libya's diverse soil conditions, including vast areas of clay and sandy soils, require specialized foundation solutions to ensure stability and prevent structural failure. Water shortages further complicate construction, as water is vital for processes like concrete mixing and dust control. The study emphasizes the need for sustainable water management practices to mitigate impacts on communities and ecosystems. Natural disasters like flash floods and earthquakes, though less frequent, add risks to construction projects. Incorporating resilient design, sustainable materials, and environmentally friendly technologies is essential for building a more resilient and sustainable construction industry in Libya.

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### 1.0 Introduction

The construction industry in Libya faces numerous challenges due to its unique environmental conditions. The harsh climate, characterized by extreme temperatures, dry weather, and frequent sandstorms, has a significant impact on the construction process. These factors complicate concrete curing, delay construction schedules, and increase costs. For example, high temperatures can accelerate the evaporation of water from the concrete mixture, leading to inadequate curing and reduced structural integrity. Sandstorms, common in Libya, not only delay work, but also increase wear and tear on machinery and materials. These conditions require the adoption of special construction techniques and materials that can withstand extreme climates, such as the use of additives in concrete to improve its resistance to high temperatures.

In addition to the climate, Libya's diverse soil conditions present significant challenges to construction projects. The country's terrain includes clay, sandy soils, and areas with high salinity, each of which requires specific foundation solutions to prevent structural failure. For example, clay soils are prone to swelling and shrinking with changes in moisture, which can cause foundations to shift and cracks in buildings. On the other hand, sandy soils have low bearing capacity and require deep foundations or soil stabilization techniques to effectively support structures. These soil-related challenges highlight the importance of conducting thorough geotechnical investigations and using appropriate construction methods to ensure the long-term stability of buildings.

Water shortage is another important environmental factor affecting construction in Libya. The dry climate limits the availability of water, which is essential for various construction activities such as concrete mixing, curing, and dust control. This shortage can lead to delays, increased costs, and poor building quality. Sustainable water management practices are important to mitigate these challenges. These include recycling water on construction sites, using water-efficient technologies, and incorporating materials that require less water. By adopting these practices, the Libyan construction industry can better manage its limited water resources, ensuring project efficiency and sustainability in the face of environmental constraints [1,2].

These environmental factors (harsh climate, diverse soil conditions, and water shortage) collectively shape the Libyan construction environment. Addressing these challenges requires innovative solutions and careful planning to ensure that construction projects are resilient, sustainable, and able to withstand the country's unique environmental pressures.

## **2.0 Problem Statement**

This study examines the environmental challenges the Libyan construction industry faces, which affect construction practices, sustainability, and project outcomes. Key factors include the country's harsh climate, diverse soil conditions, water shortages, and natural disasters. Extreme temperatures and arid terrain complicate construction, affecting concrete hardening and causing delays due to sandstorms. Libya's diverse soil types, particularly clay and sandy soils, require special foundation solutions to prevent structural failure. Water shortages also pose significant challenges, highlighting the need for sustainable water management in the construction process. Less frequent, natural disasters such as flash floods and earthquakes further threaten construction projects. This study highlights the importance of adopting resilient design, sustainable materials, and environmentally friendly technologies to improve the resilience and sustainability of the Libyan construction industry.

## **3.0 Research Objective**

The objectives of the study are:

1. To Evaluate the impact of Libya's harsh climate on construction practices, particularly the impact of extreme temperatures and sandstorms on concrete hardening and project schedules.
2. To Investigate the challenges posed by Libya's diverse soil conditions and focus on the need for special foundation solutions to prevent structural failures.

3. To evaluate the importance of water scarcity in the construction process and explore sustainable water management practices to mitigate these challenges.
4. Discussion

### 3.1 Impact of Mitigating Avalanche and Ice Risks in Construction on Steep Slopes

Construction sites on steep slopes or in narrow valleys are particularly vulnerable to avalanches, requiring careful design of temporary and permanent structures to mitigate the risk. For infrastructure projects such as pipelines, railways, and highways that cover large areas, addressing avalanche hazards is critical to prevent damage from direct impact or blast effects. Heavy snowfall can cause snow accumulation on large construction sites, making it essential to remove snow and ice to keep them safe and access routes open. Snow and ice storms also pose a risk to construction equipment such as crane booms and wind turbine blades due to ice build-up. Ice storms and ice storms are particularly destructive to transmission and distribution (T&D) lines, with ice overload potentially causing collapse and extensive damage. When building on frozen ground, it is important to consider permafrost and specific geological conditions, as cyclical temperature changes can cause soil settlement or jacking, distorting structures and potentially causing collapse.

#### The real example the dran dam in Libya

The Darna Dam disaster in Libya is a stark example of the catastrophic consequences of inadequate infrastructure design and maintenance in a region prone to natural disasters. Located near the coastal city of Derna, the Darna Dam was built to manage seasonal water flows and protect the surrounding area from flooding. However, the design and construction of the dam failed to adequately account for the environmental challenges of the area, including steep terrain, heavy rainfall, and the risk of burst floods, all of which are prevalent in this part of Libya.



Figure 1 . Image of the city, (Source: Wikipédia, visit on 12/12/2023 [3]).

In 2023, the Darna Dam tragically collapsed following a severe storm that brought unprecedented rainfall to the region. Already weakened by years of neglect and lack of proper maintenance, the dam was unable to withstand the pressure of the accumulating water. The resulting collapse devastated the city of Derna and surrounding areas, causing numerous casualties and extensive property damage.



Figure 2 . Image of the city, (Source: Wikipédia, visit on 12/12/2023 [3]).

This disaster highlighted several important factors that must be considered when building and maintaining infrastructure in areas with challenging environmental conditions. First, the design of the Darna Dam did not adequately account for the potential severity of natural phenomena, such as the risk of burst floods associated with extreme rainfall. Failure to incorporate resilient engineering practices into the dam design to withstand such events was a major factor in the disaster.

Second, the dam was severely under-maintained. Warnings that the dam was deteriorating over the years were largely ignored. The lack of regular inspections, repairs, and updates to the dam infrastructure meant that by the time the storm hit, the dam was already damaged and collapse was almost inevitable.

The Darna Dam disaster also highlights the importance of integrating environmental assessment into the planning and construction of infrastructure projects. Understanding local climate, topography, and hydrological patterns is essential to designing structures that can withstand the forces of nature. In Libya, the combination of steep slopes, narrow valleys, and the risk of explosive flooding requires serious consideration of these factors.

Furthermore, this tragedy demonstrates the need for continued investment in infrastructure maintenance and the implementation of early warning systems. Better monitoring and maintenance of the Darna Dam, and effective emergency response plans, could have significantly reduced the scale of the disaster.

In conclusion, the Darna Dam disaster is an important lesson in the importance of resilient design, regular maintenance, and environmental awareness in infrastructure development. This highlights the need for a proactive approach to managing natural disasters to prevent such devastating outcomes in the future .

### **3.2 The challenges posed by Libya's diverse soil conditions.**

Cracks are one of the global problems affecting concrete structures, not only affecting the exterior appearance of the building, but also compromising its structural integrity and reducing its durability. Due to certain mistakes and unavoidable factors that occur during construction, various types of cracks start to appear in various parts of the building. Therefore, it is essential to identify these cracks in time and take preventive measures.

### 3.3 Types of cracks

Cracks can be divided into two main categories based on their cause:

#### Structural Cracks:

These cracks are caused by improper design, incorrect execution, or overloading, and can endanger the safety of the building. Cracks can also be caused by poor bonding between large diameter reinforcing bars and concrete, especially if the concrete cover over the reinforcing bars is thinner than the allowable thickness.

If these cracks are within acceptable limits and represent normal structural behavior, they are not dangerous. However, in some cases, they become noticeable and cause concern and pose the following hazards:

Cracks that continue to widen progressively.

Cracks that appear in the concrete section under compression, indicating abnormal behavior of the structure.

Concrete disintegration in compression areas (such as columns, ceilings, or beams on the compression side) is one of the most critical dangers to a structure. When such cracks occur, it may be necessary to reinforce the structure and immediately remove the loads. Afterward, the cause and source of the defect in the structure should be studied, and solutions for strengthening the structure and addressing the cracks should be implemented. The cause of the defect may be due to an increase in the loads on the structure, insufficient reinforcement, poor quality of concrete, or soil settlement, etc.

The significant effects of these cracks can be minimized and controlled by paying close attention to design details, such as the distribution of reinforcement and construction techniques. If the reinforcement is appropriately distributed and the concrete is of good quality, these cracks will be fine enough to prevent corrosion of the reinforcement. Generally, these cracks are acceptable if their width is 0.2 mm. Studies have shown that corrosion and rust increase rapidly only when the crack width exceeds 0.4 mm.

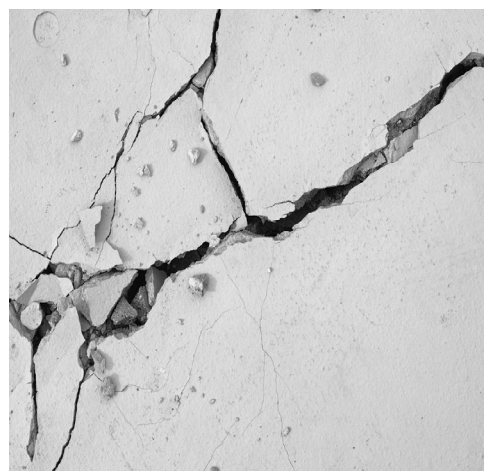




Figure 3. Types of Cracks in Houses in Libya ( Tripoli City ) due to diverse soil conditions

### 3.4 Non-structural cracks:

These cracks occur due to internal forces that develop within the concrete. Non-structural cracks are influenced by the materials used in the concrete, as well as other factors such as ambient temperature, humidity, and general exposure conditions, whether internal or external. The effects of one type of crack can be exacerbated by the presence of another type. Some types of cracks allow aggressive chemical agents to penetrate the reinforcement, leading to corrosion of the reinforcement and the potential for cracking and the falling of parts of the structure.

An example of non-structural cracking in Libya can be seen in older residential buildings, especially in areas exposed to extreme temperature changes such as desert areas. In these areas, concrete structures experience significant expansion and contraction due to high daytime temperatures and low nighttime temperatures. Over time, this thermal cycling can cause non-structural cracking in the concrete.

For example, some houses in the Sahara region of Libya experience intense heat during the day and rapid cooling at night, which can cause cracks in the walls and ceilings. These cracks are usually not caused by structural problems, but rather by internal stresses within the concrete material. While they do not immediately compromise the structural integrity of the building, they can allow moisture and other aggressive substances to penetrate, which can lead to more serious damage over time if not properly addressed.



Figure 4. Non-Structural Cracks [5].

### The Importance of Water Scarcity in the Construction Process and Sustainable Water Management Practices

Water scarcity is an increasingly critical issue worldwide, impacting various industries, including construction. In the construction sector, water is a fundamental resource required for numerous activities, such as concrete mixing, dust control, curing processes, and general site maintenance. As global water resources become more constrained due to factors like climate change, population growth, and industrial demands, the construction industry faces significant challenges in maintaining efficient and sustainable operations. This paper evaluates the importance of water scarcity in the construction process and explores sustainable water management practices to mitigate these challenges.

### 3.5 The importance of water in construction

Water plays an indispensable role in construction, particularly in processes like concrete production and curing. Concrete, one of the most widely used building materials globally, requires water to mix with cement, aggregate, and sand to form the final product. The water-cement ratio is crucial for determining the strength and durability of concrete; therefore, consistent and adequate water supply is essential. Insufficient water can compromise the quality of concrete, leading to structural weaknesses that may affect the safety and longevity of buildings and infrastructure.

Additionally, water is used in the curing process to ensure that concrete reaches its intended strength and durability. Proper curing involves maintaining adequate moisture levels in the concrete to allow the hydration process to continue, which is necessary for the development of the material's strength. Water is also vital for controlling dust on construction sites, which is necessary for worker safety and environmental protection. Dust control measures often involve spraying water on roads, excavation sites, and other dusty areas to reduce airborne particles that could pose health risks or disrupt nearby communities.

However, with increasing water scarcity, the construction industry is challenged to balance its water needs with the limited availability of this resource. Water scarcity can lead to delays in construction projects, increased costs, and compromised building quality. For example, in arid regions or areas experiencing drought, accessing sufficient water for construction activities can be difficult, leading to significant operational challenges. Furthermore, the environmental impact of excessive water use in construction, such as the depletion of local water sources and the degradation of ecosystems, has become a growing concern.

### Sustainable Water Management Practices

Given the critical importance of water in construction and the challenges posed by water scarcity, the industry must adopt sustainable water management practices to mitigate these challenges. Several strategies can be employed to reduce water consumption and promote the efficient use of water resources on construction sites.

**Water Recycling and Reuse:** One of the most effective strategies for reducing water consumption in construction is recycling and reusing water. Construction sites can implement systems to capture and treat wastewater for reuse in activities such as dust control, equipment cleaning, and even concrete mixing. For instance, water used for washing equipment can be collected, filtered, and reused instead of relying on fresh water. Additionally, rainwater harvesting systems can be installed to capture and store rainwater for use in non-potable applications, reducing the demand for potable water.

**Use of Alternative Materials and Techniques:** To minimize water use in construction, alternative materials and techniques that require less water should be considered. For example, self-curing concrete is a type of concrete that contains water-retaining agents, reducing the need for external curing. Additionally, prefabrication and modular construction techniques, which involve constructing components off-site in controlled environments, can reduce water usage by minimizing on-site activities that require water.

**Efficient Water Use Practices:** Implementing efficient water use practices on construction sites is essential for reducing water consumption. This includes regular maintenance of water systems to prevent leaks, using water-efficient equipment, and optimizing water use in processes like concrete mixing. Workers should be trained in water conservation practices, and water usage should be monitored to identify areas where savings can be achieved. Additionally, scheduling water-intensive activities during periods of low evaporation, such as early morning or late afternoon, can reduce water loss due to evaporation [5].

**Environmental Impact Assessments and Regulatory Compliance:** Conducting environmental impact assessments (EIAs) before the start of construction projects can help identify potential water-related challenges and guide the implementation of sustainable water management practices. Compliance with local regulations and guidelines on water use is also essential to ensure that construction activities do not negatively impact local water resources or ecosystems.



Figure 5. Artificial river in Libya to bring water from desert aquifers to the coast [6].

#### 4.0 Conclusion

This study highlights the significant impact of Libya's harsh climate on construction practices, with a particular focus on extreme temperatures and sandstorms. Intense heat accelerates the evaporation of water from concrete mixtures, negatively affecting the curing process and compromising the structural integrity of buildings. Sandstorms not only disrupt construction schedules, but also contribute to the deterioration of materials and equipment. Addressing these challenges requires the adoption of climate-resilient construction techniques, such as the use of advanced concrete additives and the implementation of protective measures to protect construction sites from environmental extremes.

In addition to climatic factors, Libya's diverse soil conditions present significant challenges to construction projects. The diverse topography, including clay and sandy soils, requires specialized foundation solutions to prevent structural failure. Clay soils, which expand and contract with moisture fluctuations, can cause significant foundation movement and cracks in buildings. Sandy soils with low bearing capacity require deep foundations or soil stabilization techniques. Recognizing these challenges, it is essential that construction projects in Libya conduct thorough geotechnical investigations and implement tailored foundation solutions to ensure long-term stability and safety.

Water shortage is another major issue affecting construction in Libya. The dry climate limits the availability of water, which is essential for various construction activities such as mixing, curing and dust control of concrete. This shortage can lead to delays, increased costs and poor building quality. To alleviate these challenges, the Libyan construction industry must adopt sustainable water management practices such as recycling water on construction sites and using efficient technologies. By implementing these strategies, the industry can better manage limited water resources, not only ensuring that construction projects are completed efficiently, but also contributing to the sustainability of Libyan infrastructure development.

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