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ENGINEERING MANAGEMENT AND THE DEVELOPMENT OF MARITIME MUSEUM INFRASTRUCTURE: A CASE STUDY OF SABRATHA, LIBYA

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Abstract— This study explores the critical role of engineering management in advancing the infrastructure of maritime museums, with a focus on the coastal city of Sabratha, Libya. Despite its rich maritime heritage and environmental assets, Sabratha currently lacks a dedicated marine science museum. By employing a descriptive-analytical methodology supported by a local case study, this paper illustrates how engineering management tools and principles can transform the concept of a maritime museum into a feasible project that enhances sustainable development, environmental education, and cultural tourism. The study further presents a preliminary integrated museum design, including a 3D spatial model, grounded in contemporary engineering management practices to address local challenges and opportunities.

Keywords— Engineering management, Maritime museums, Sabratha, Maritime heritage, Environmental assets, Descriptive-analytical methodology, Sustainable development.

I. INTRODUCTION

Maritime museums worldwide have witnessed dynamic growth due to their pivotal role in documenting the human relationship with the marine environment and raising awareness of coastal cultural and ecological heritage. Libya, endowed with an extensive Mediterranean coastline exceeding 1900 kilometers, surprisingly lacks museums dedicated to marine sciences, leaving a gap in leveraging this rich maritime legacy for sustainable educational and touristic development. Engineering management emerges as a crucial discipline capable of strategic planning and efficient implementation of cultural infrastructure projects, especially within contexts challenged by limited institutional coordination and resource scarcity. Sabratha, a historic coastal city featuring a unique

maritime legacy and strategic location, offers a compelling case for developing a comprehensive maritime museum managed under modern engineering management frameworks. This paper aims to highlight the integration of engineering management tools in transitioning the vision of a maritime museum into actionable realization in Sabratha, thereby contributing to Libya's cultural infrastructure and sustainable development goals.

II. PROBLEM STATEMENT

Although Libya's coastal environment—particularly in Sabratha—presents substantial natural and historical assets, the absence of specialized maritime museums indicates a significant gap in the management and development of cultural infrastructure. Specifically, engineering management strategies remain underutilized as strategic instruments in museum project development, resulting in a lack of initiatives capable of fostering heritage conservation, tourism, and education. Central to this inquiry is: How can engineering management contribute to developing maritime museum infrastructure in Sabratha?

A. OBJECTIVES

The study pursues the following objectives:

- To articulate the concept of engineering management and its role in planning and executing cultural projects.
- To assess the local potential of Sabratha for establishing a marine science museum.
- To propose a preliminary engineering-based design model for a maritime museum.
- To offer practical recommendations for advancing cultural maritime infrastructure projects in Libya.

B. HYPOTHESES

This research hypothesizes that:

- Applying engineering management principles will enhance the quality and efficiency of maritime museum projects.
- Investing in maritime cultural infrastructure supports sustainable development strategies in Sabratha.

III. METHODOLOGY

The study adopts a descriptive-analytical research design, supplemented with a focused case study of Sabratha. Data sources include scholarly literature, environmental and cultural site analyses, preliminary architectural designs, and employment of project management tools such as SWOT analysis, feasibility studies, and engineering modeling. A 3D spatial model of the proposed maritime museum serves as a visual and technical aid to the design.

IV. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

• Engineering Management

Engineering management combines technical engineering knowledge with managerial competencies to plan, organize, and direct engineering projects aiming for effective, high-quality outcomes (Blank & Tarquin, 2018).

• Cultural Infrastructure

UNESCO defines cultural infrastructure as foundational to sustainable cultural policy, encompassing museums, libraries, theaters, and educational institutions that underpin community identity and cohesion (UNESCO, 2013).

• Project Life Cycle Theory

Project management literature identifies phases—initiation, planning, execution, monitoring, and closure—that ensure resource optimization and goal achievement within defined constraints (PMI, 2021).

• Key Engineering Management Tools

Core tools include quality management, resource allocation, cost estimation, and risk analysis to ensure project viability and resilience (Kerzner, 2017).

• Related Studies

Previous research underscores the role of engineering management in enhancing cultural project outcomes, addressing coastal heritage infrastructure challenges, and promoting sustainable museum development (Abdullah, 2021; Al-Hassani & Woodcock, 2017; Smith & Williams, 2018). Yet, these studies often lack a targeted focus on Libyan maritime museum infrastructure through an engineering management lens, which this study aims to address.

A. FIELD ANALYSIS AND PROPOSED MUSEUM DESIGN IN SABRATHA

• Geographic and Site Analysis

Located on Libya's western coast, Sabratha's strategic Mediterranean frontage and rich historical-cultural fabric provide a potent backdrop for a maritime museum. A preliminary site was identified on an accessible seafront area close to the city core and main transport routes, offering ample space for phased development and expansion.



Fig. 1. Suggested location of the marine museum in Sabratha city

• Needs Assessment and Functional Requirements

Community, educational, and tourism needs necessitate that the museum include permanent and temporary exhibit halls, a marine research center with labs, a specialized scientific library, interactive simulators, visitor amenities such as café and gift shops, environmental awareness training facilities, and integrated administrative and logistical services.

• Engineering Design Concept

The architectural approach melds marine-inspired flowing forms with durable marine-grade materials (treated wood, transparent marine glass). Spatial layout prioritizes smooth visitor flow and accessibility. Sustainability features include solar energy systems, natural ventilation, and adherence to maritime safety and structural standards.

• 3D Museum Model

A detailed 3D map/model visualizes the spatial organization: main entrance plaza, central exhibition halls, educational labs, library, service zones, outdoor maritime walkway, and educational garden. This model facilitates stakeholder engagement and supports iterative design refinement.

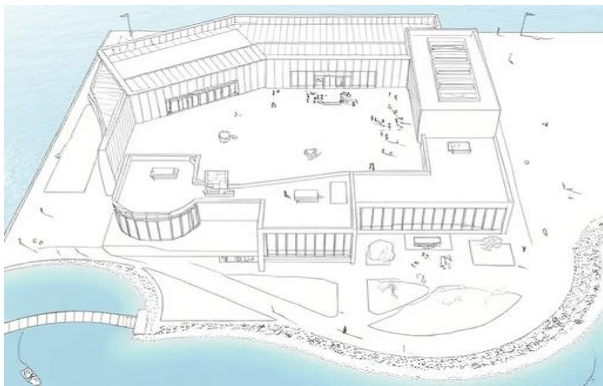


Fig. 2. A Sketch of the marin museum in Sabratha city

- **Preliminary Architectural Layout for the Maritime Museum**

- 1. Main Entrance and Reception Plaza**

A grand, inviting entrance leads visitors into a spacious open plaza. This reception area acts as a social hub with seating zones and clear signage. The plaza is designed to accommodate visitor flow smoothly, featuring transparent canopy structures blending with the marine-inspired exterior.

- 2. Main Exhibition Hall and Auxiliary Galleries**

Directly accessible from the reception plaza, the primary exhibition hall serves as the museum's centerpiece—large enough for immersive permanent displays about maritime history and ecology. Surrounding this central hall are several smaller subsidiary galleries for temporary exhibits and specialized themes, arranged in a circular or semi-circular layout to facilitate natural visitor progression.

- 3. Laboratory and Educational Center**

Adjacent to the exhibition spaces, a dedicated zone houses the marine science laboratory and classrooms. The lab is outfitted with modern research equipment and flexible classroom setups to support workshops, hands-on experiments, and lectures. Large windows overlook the sea, creating an inspiring educational environment.

- 4. Multimedia Library**

A quiet, tech-enhanced library area is designed for research and digital learning. It includes multimedia stations, interactive archives, and ergonomically-designed reading spaces, supporting both scholars and casual visitors interested in deeper knowledge.

- 5. Service Area: Restrooms, Café, and Retail Shops**

This functional zone contains all visitor amenities, including accessible restrooms, a café offering light refreshments, and gift shops selling maritime-themed souvenirs. These services are located near the entrance and exit points for convenience without disrupting circulation.

- 6. Management and Research Offices**

A cluster of offices occupies a strategic position overlooking the main atrium, encouraging openness and communication. These include spaces for museum administration, project management, event planning, and research staff. Offices are designed for flexibility, equipped with smart systems for efficient operation.

- 7. Outdoor Zone: Marine Promenade and Educational Garden**

The surrounding outdoor area features a scenic seaside walkway with interpretive signage and resting spots. An educational garden showcases native coastal flora and interactive exhibits related to marine ecosystems, offering an engaging outdoor learning experience.



Fig. 3. A, B 3D concept of the marin museum in Sabratha city

V. FIELD RESULTS AND SWOT ANALYSIS.

- 1. Findings**

Interviews and surveys highlight the absence of maritime cultural infrastructure in Libya broadly and Sabratha specifically, despite stakeholder enthusiasm. Suitable sites exist, but there's a shortage of specialized managerial expertise locally.



2. SWOT Analysis Overview

Strengths: Strong cultural identity, strategic location, local enthusiasm
Weaknesses: Limited institutional support, resource scarcity, lack of trained personnel

Opportunities: International funding, cultural tourism growth, educational outreach
Threats: Political instability, economic constraints, environmental risks.

3. Feasibility Indicators

Economic feasibility may be supported through public-private partnerships and international cultural funding. Technical feasibility leverages existing regional engineering competencies. Social demand enhances the chance of sustained museum operation.

VI. CONCLUSION

The study confirms engineering management as vital for cultural infrastructure development, ensuring integration of functional design, sustainability, and technological innovation. Sabratha, with its untapped maritime heritage, represents an ideal context for a pioneering maritime museum project anchored in strategic management. Comprehensive multi-phase planning, continuous stakeholder engagement, and capacity building are essential to translate this vision into reality.

VII. RECOMMENDATIONS

- Launch a national awareness campaign to mobilize support and funding.
- Establish a national multidisciplinary committee with engineers, museum experts, and environmentalists.
- Seek collaborations with UNESCO and global marine research centers.
- Incorporate environmental education through interactive exhibits targeting youth.
- Develop local training programs for cultural infrastructure management.
- Ensure museum design emphasizes renewable energy and environmental compatibility.
- Allocate space within the museum for marine innovation and entrepreneurship initiatives.

VIII. CLOSING REMARKS

Sabratha's maritime science museum project embodies a rare synergy of scientific knowledge, cultural identity, and environmental stewardship. Through engineering management's lens, this initiative can transform from concept to catalyst for sustainable cultural and economic growth in Libya's coastal regions.

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