

Design Development of Floating Performance Structure for Coastal Areas in the Maltese Islands

Rebecca E. Dalli Gonzi, Joseph Falzon

Abstract—Background: Islands in the Mediterranean region offer opportunities for various industries to take advantage of the facilitation and use of versatile floating structures in coastal areas. In the context of dense land use, marine structures can contribute to ensure both terrestrial and marine resource sustainability. Objective: The aim of this paper is to present and critically discuss an array of issues that characterize the design process of a floating structure for coastal areas and to present the challenges and opportunities of providing such multifunctional and versatile structures around the Maltese coastline. Research Design: A three-tier research design commenced with a systematic literature review. Semi-structured interviews with stakeholders including a naval architect, a marine engineer and civil designers were conducted. A second stage preceded a focus group with stakeholders in design and construction of marine lightweight structures. The three tier research design ensured triangulation of issues. All phases of the study were governed by research ethics. Findings: Findings were grouped into three main themes: excellence, impact and implementation. These included design considerations, applications and potential impacts on local industry. Literature for the design and construction of marine structures in the Maltese Islands presented multiple gaps in the application of marine structures for local industries. Weather conditions, depth of sea bed and wave actions presented limitations on the design capabilities of the structure. Conclusion: Water structures offer great potential and conclusions demonstrate the applicability of such designs for Maltese waters. There is still no such provision within Maltese coastal areas for multi-purpose use. The introduction of such facilities presents a range of benefits for visiting tourists and locals thereby offering wide range of services to tourism and marine industry. Costs for construction and adverse weather conditions were amongst the main limitations that shaped design capacities of the water structures.

Keywords—Coastal areas, lightweight, marine structure, multi-purpose, versatile, floating device.

I. INTRODUCTION

THE scope of this paper is to analyse the design development process for a floating structure which could facilitate performance spaces (dance and acts) as a temporary stage.

Taking into consideration conventional methods of construction of pontoons, this project seeks to create a modular entity with improvements in areas concerning constructability and deconstruct-ability, floor affixes for temporary mounting and initial process development for structure formation. Considering potential of use for tourism and arts, pontoons present versatility in areas of creativity,

architecture and showcasing artistic performances. A floating element is presented as the introduction to alternate use of land mass for providing the option to facilitate entertainment with the option to mount simple construction possibilities.

II. LITERATURE REVIEW

A. Architectural Impact of Floating Structures

Value acquired from the use of floating structures for architectural compositions or habitable spaces has long been sustained by a variety of needs; alternative living spaces and resources [2] moving from a floating living space, towards an increasing definition of architectural space. To this, one might add the increasing challenges faced by unstable climate conditions, and rising environmentalism has added to the appeal of living afloat, as homeowners seek innovative ways to minimize their carbon footprint [5]. Within this context the user shifts from the urban or built environment to the natural environment, specifically to the open seas. A floating structure represents the shift from the land based; a city, a busy urban area, a camp site, a busy waterfront or the coast, to offshore.

The build-up environment for people originating within the 'backbone' of architecture as a floating structure to any type of architecture has grown depending on the needs and requirements of the user [2]. A number of case studies appear in the literature including type of materials used, primary use and structural solutions. In Portugal, a pontoon or floating platform (a redundant barge) was used for a restaurant housed in Miesian steel and glass box on timber decking with a section of the restaurant's full height glass wall pivoted open to extend the dining space with the transparent box acting as a public stage [4]. A spin-off houseboat design company 'Confused Direction', states how contemporary design opens up the appeal of living on water. A pontoon based floating home situated on a lake has two bedrooms on the lower level, an upper common area and two decks, all linked by a frosted-glass stairwell [5]. Potentially innovative floating residences have a more fundamental appeal. Copenhagen's first floating hotel offered a city centre location, with rooms extremely quiet, panoramic views and a sense of calm that comes from being on water. Created in 2003, the 280-sq. meter glass-walled prototype has subsequently become popular for event hire. With its spartan all-white interior, streamlined fixtures and remote-control steering [5]. A float house made from polystyrene foam coated in glass fibre-reinforced concrete, in the aftermath of Hurricane Katrina was constructed as part of a foundation programme.

A number of design developed floating structures are discussed in the literature data collated. The concept of an

Dalli- Gonzi R. is with the University of Malta, Malta (e-mail: rebecca.e.dalli-gonzi@um.edu.mt).

Falzon J. is with the University of Malta, Malta.

extendibility sliding house in Suffolk, by dRMM, comprised three distinct parts - a house, garage, and annexe with an enveloping structure on recessed railway tracks that can be peeled back or rolled over the building, to provide differing combinations of enclosure and open-air living [7]. Shipping containers have been reinvented and stacked on top of each other to create affordable home/office communities. Trinity Buoy Wharf in London's Docklands, was completed in 2001 and provided 12 work studios over three storeys. The same principle is now being applied to schools, community centres, and even a new ecological urban spa in San Francisco [7]. Architects are creating homes that adapt to rising sea levels such as the cedar-clad Floating House by MOS Architects on Lake Huron in Ontario, Canada. Pioneering Copenhagen-based company 'Water living' showcases products with high insulation standards that are constructed of largely recyclable materials with waste water treatment systems. This makes them independent of land-based facilities. Solar panels, accumulation tanks and a specially developed geothermal heat pump - taking its heat from the water rather than land - create the potential for a zero-energy house. It has been noted that

houseboat values are appreciating and investing in one looks like a sound financial move [5]. Proposed typologies based on the spatial relation between water and the structure are illustrated in Fig. 1.

Studies have investigated the relationship between users and space as a key fundamental for architecture and human beings. A primary mission of discipline in architecture and interior architecture is creating comfortable and livable spaces for people giving users greater flexibility in living near nature and experiencing the landscape. With a significant demand for residential moorings, as more people want to live on water and because of their role in tackling the larger issue of housing provision [5] floating pontoons present interesting options for entertainment particularly in seaside locations such as Malta. In most cases however, research is embedded by the formation of space within the context of the built environment. Post-occupancy evaluative studies have been developed with respect to interior spaces of boats and floating vessels. The application of such studies would benefit the design development of this floating pontoon design as part of its detailed technical progress.

	static buildings	elevation buildings	amphibious buildings	waterside buildings	pile buildings	floating buildings, boathouses	houseboats
relation to water	elevation	floating	delimiting	elevated	floating	cruising	
application	flood-prone plane			water banks	water		
context	land						
				water			
legal definitions	real-estate						
						mobility - watercraft	
buoyancy	non-buoyant	buoyant	non-buoyant			buoyant	
supporting substance	ground						
		water				water	
mobility	static	kinetic	static			portable	translent
propulsion	unpowered						self-powered
base type	piles / columns	slits / raft	pontoon / float / waterproof foundation	piles / columns	slits / raft	pontoon / float / raft	hull(s)
discipline	civil architecture						
	naval arch					naval architecture	
							industrial design

Fig. 1 Proposed typologies based on the spatial relation between water and the structure [6]

Key to project success is a structure which can provide a stable platform for human movement to take place and a method for platform constructability and deconstruct-ability. One would need to examine the added value and a floating structure in Maltese waters would present to tourism options and such uses.

B. Regenerating the Maltese Coast

The Mediterranean is a crossroad for cultural, human and economic exchanges and a bridge between civilisations and three continents [3]. The Mediterranean has served its purpose in providing response to a number of changes in the surrounding landscapes, one of which is the recent and ongoing Libya crisis [1] where much action happens on water and requires a substantial amount of management activity to

facilitate assistance.

The direct impact of movement on local seas is enormous, resulting in severely affected shorelines. The Barcelona convention (1976) for the protection of the Mediterranean Sea against pollution is aimed to reduce pollution in the Mediterranean region and to protect and enhance marine habitats. Since the establishment in 2008, the Union of the Mediterranean did not yield the expected results despite a number of initiatives. A call is being made for measures taken to promote the sustainable measures of water resources. In the report entitled 'Preserving the environment in the Mediterranean' [3], combat pollution is linked with urban development, agriculture and industry. Marine litter results from coastal urban centers which is the result of a direct

disposal of waste, waste from touristic venues, flows from landfill sites and waste from maritime traffic [3]. Issues affecting sea water areas include general waste, plastic waste, oil and fuel pollution, unclean water run-off, untreated waste as run-off, and waste from fish farms.

Departing from the shore line, as a prerequisite to this 'floating' concept, a number of challenges are presented on the design capacities of a 'floating' structure. Keeping issue of waste as central to the project, the proposed floating pontoon aims to fit within the ongoing work of the Council of Europe as it incorporates a response towards fulfilling obligations with respect to the preservation of biodiversity as part of tourism sector activities by removal of marine litter. It aims to fit within the Barcelona legal system which includes the 'Protocol for the protection of the Mediterranean Sea against pollution from land-based sources and activities. Phase II of the Mediterranean Action Plan requires the reduction of waste from land-based sources. Within the project development process, a study for the collection of waste is being included. Coastal sites benefit from conducted researches in proper water management and sea clean-up.

The quantitative element provided by the floating structure is data collection and reporting of plastic quantity collected in one unit or units. This is aligned with requests by the United Nations Environment Programme through the reporting of collected plastic waste in weight.

The Ports & Yachting Directorate based at Transport Malta has a regulatory role in monitoring the maritime activities which take place within the internal and territorial [8] waters of Malta and also manages port facilities which are under the control of the Authority, including yachting and mooring facilities. The directorate ensures the right management for use of waters in terms of leisure and other commercial operations. Data retrieved from the floating pontoon will be fed to the Directorate for processing and up keeping of Malta's shores.

III. METHOD

The floating structure project design process was developed by adopting a sequence. The sequence was based on a 6-step identification process which included the following:

1. Consideration of size of elements for transportation and handling due to street size limitation
2. Cost of production for marketability
3. Easily constructed and deconstructed for efficiency
4. Traffic in grand harbour for optimum siting
5. Closed waters siting, wave action impact
6. Visually acceptable and in vicinity of pedestrian coastal areas

A. Intent of Interviews and Intent of Focus Group

Initial discovery phase is commenced with literature review, research and analysis of floating water structures for the marine environment. Information was thoroughly gathered in a series of goal setting workshops to develop the intent including adaptations and applications of the research.

The following are the events that led to a focus group

intended as goal setting workshop:

- a) Initial meeting arising from the authors to establish project goals;
- b) Interview with marine engineering contractors with the aim to determine main limitations of the manufacturing process, available materials, available plant and machinery within the production sequence, mould fabrication techniques, cost issues and simulation techniques;
- c) Interview with logistics contractor to determine handling and transport limitations - the intent was to understand and hereby establish practical parameters.
- d) Interview with naval architect to discuss and develop technical design parameters and requirements within the marine environment,
- e) Interview with structural engineer to discuss scoring of criteria
- f) Interview with marine engineer specialised in wave action to discuss procedural and testing required of the prototype - projected simulation of the prototype, design of the model, 3D printing of model, laboratory testing in water tank, collection of data, analysis of data.
- g) Interview with Health & Safety Officer
- h) Interview with Transport Malta as entity responsible for maritime activities.

IV. FINDINGS FROM THE INTERVIEWS AND FOCUS GROUPS

Authors (architects): A clear intent outlining the scope of works was developed. Design requirements included a floating structure for multi-purpose use, mainly for attractive and eye catching architectural design, versatile, easy to transport and assemble, low cost and easy to store. Design drawings were prepared using CAD software and engineering simulation.

Fibreglass as the preferred material for a marine environment is key to the product. For production costs to be minimized, the mould will utilize a standard prototype, and each mould will be utilised for twenty casts, (easy to cast) additional units if required. Connection detail is of great consideration. Magnetic action (technical word) was thoroughly considered. Other options discussed were utilisation of steel frame that will hold individual units.

Logistics Contractor: Transport restrictions limit the width of each particular unit to fit in container size of 2.4 m. Therefore, units are to be not more than 2250 mm wide. Shape of units to be in a way that individual units can be stacked within least possible space occupied. Storage methods are to be considered in conjunction with handling practices. This is a very important consideration as transport is one of the major cost elements both in the initial product delivery as well as for the ongoing displacement of the floating structure from one location to another. This will in addition ease shipment of structures to locations abroad.

Naval Architect: Connection between the different units pose one of the key challenges for the overall design. The stability of the overall structure both during assembly of the units as well as during the functional activities on the floating structure directly impact on the stresses on the jointed

connections. Assembly of the structure could be either carried out directly on water or land based and tugged on waters. Mooring of the structure to be designed in consideration of wave action on floating structure.

A. Floating Structure Design Development

Initial Project Scope: The proposed floating design aims to fulfill the following three criteria: floatation device to receive varying degrees of live or fixed loads, fully deconstruct-able with potential for re-use, and plastic clean-up capacity. A floating system is a terminology proposed by architects and naval, engineers which an example of architectural equivalent for the marine hull resulting in merging civil and naval building rules [7]. The context that this project aims to address includes the following points:

- This sector is under-researched
- Potential applicability i) Malta is surrounded by water ii) local and touristic aspects iii) will benefit from waste clean-up
- Cultural dimensions very much suit Maltese climatic conditions and heritage trails
- Marine lifestyle
- Similar to promoted tourism in mountain areas and tourism in coastal areas
- Source for tourism attraction with added value

B. Discussion

The applications of floating architecture in Maltese coastal areas are grossly underutilized for a variety of reasons. Stakeholders argued that there could be several reasons why unlocking the potential of floating architecture has yet not materialized. Data from the Transport Authority reveal that maritime activity in relation to registration of yachts and super yachts increased steadily throughout the last decade and a number of marinas were developed. Notwithstanding, the developments of such facilities for yachts and super yachts still do not cater for the ever increasing demands. In parallel, several land based coastal areas have been developed and several land based historical areas were regenerated predominantly within the grand harbour region to cater for tourism and leisure industry. A major step forward for commercial and leisure activity was the development plan of Malta's vision for the Regeneration of the Grand Harbour (Ministry for Infrastructure, Transport and Information Technology) in 2008 that featured both land based and sea based regeneration. Despite this, the consideration of floating architecture did not gain pace. Several reasons were elicited during focus group discussions on which factors are hindering the unlocking of potential of Malta's coastal areas.

1) Geographical and Climate Conditions

The marine environment presents considerable challenges to floating architecture mainly due to the fact that the Maltese islands are exposed to sea conditions of the Mediterranean with very limited sheltered areas and deep waters just off the coast. One other consideration is the maritime traffic within sheltered coastal areas. Though the grand harbour is one of the naturally formed, several ongoing operations render the

harbour very difficult to accommodate additional architectural floating structures. With the exception of coastal areas facing north which are featured predominantly by sandy beaches, the remaining coastal zones are exposed to open seas.

2) Technical Capabilities of the Floating Structure

Floating architecture, despite certain limitations, and thus presents an interesting medium as an expression of art, and can provide exciting challenges for designers and its users. However, it presents challenges as it is set on uneven base, which unlike land it is subject to the characteristics of liquids and therefore 'floating'. It is therefore set within the context of open waters which however can be set amongst a land based backdrop or the open sea. The design and construction technology still however remain dependent by anthropology, its function or purpose and the environment in which it is to be built, in this case sea water. 'You can't have a space which can be badly affected and become uncomfortable for its users' was the ultimate debate.

3) Consideration of Available Products and Materials

Participants discussed the use of floating structures that are available on the market internationally. Available products and construction modules for floating architecture are predominantly for use within lakes, where environmental conditions are much different from coastal areas in the Mediterranean island region. Most of the structures are built on stilts, supported from the ground where pillars protrude from water to support the structure. In this case the underside of the structure is not in direct contact with water as this is raised on the stilts. Other types of structures are of a modular type that are in direct contact with water and floats on water and is partially submerged. The main difference is therefore that stability of the partially submerged structure is more subject to any degree of wave action than those on stilt supports. While the stilts structure is more stable as it is not in contact with water, the partially submerged structure is not limited to a fixed position. Another important consideration in the design consideration is to provide a floating structure that is more resistant to wave action which however is not barred to a permanent location. A third consideration is thus to have a floating structure that is raised on vertical stilts supported on a fully submerged foundation structure which is not permanently anchored to the sea bed.

TABLE I
CRITERIA SET INTERNALLY FOR THE PROJECT SCOPE AND DEVELOPED
THROUGHOUT THE FOCUS MEETINGS

Excellence	<i>Human comfort for movement, entertainment with application, environmental friendly on the local market, for leisure, tourism and the visual arts, cleaning element for sea water (sea-clean up incorporated), reduction of land impact and use as activity is transferred from land to sea, potential in meeting market gap, possible boat or yacht services</i>
Impact Factor	<i>an iterative process, design and construction, assembled product, client interface will allow to choose the multi-purpose structure according to what his needs are,</i>
Implementation	<i>various parameters the client can opt for</i>

4) Selecting the Type of Structure (Through a Scoring Chart) and Setting the Design Parameters

A set of criteria were identified from the three themes selected from the focus group as follows: a) Excellence, b) Impact factor and c) Implementation.

TABLE II
SCORING MARKS USED INTERNALLY WITHIN THE PROJECT TEAM ON A SCALE OF 1 TO 3 (1 LOWEST, 3 HIGHEST) DEVELOPED THROUGH THE FOCUS MEETINGS

	Honey-comb	Rectangular	Submerged Foundation
Versatility	3	1	2
Ease of Manufacture	2	3	1
Ease of Production	3	2	1
Manufacturing Costs	3	2	1
Transport	3	1	2
Hoisting	3	2	1
Cost to Assemble components	3	2	1
Loading Capacity	3	3	3
Resistance to Wave action	2	2	3
Ease of Shipping	3	1	2

V. CONCLUSION

In the present paper, the design development for a floating structure is presented. Floating structures for coastal areas in the Mediterranean region clearly merit further investigation, as their potential to various applications for sectorial industries together will spur further attention for the development of niche markets. Themes focusing on excellence, impact on the markets and implementation process emerged as key themes within this research. Another area of focus is that a wide stakeholder base should be encouraged to actively participate in research and development programmes within the remit of a sustainable approach in the development of floating structures. Product cost and life cycle is fundamental in providing versatile, efficient, cost effective and environmentally sustainable floating structures. Authorities should also encourage the introduction of floating structures focusing on the architectural and cultural dimensions. The development of floating performance structures further adds to the integration of culture within the Mediterranean region in particular the Maltese coastal areas.

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