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EXPLORING THE IMPACT OF NATURAL LIGHTING AND VENTILATION FOR SUSTAINABLE ARCHITECTURE IN BOAT TERMINAL DESIGN

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Keywords

Sustainability, Natural Light, Ventilation, Boat Terminal

Abstract

The concept of sustainability has become a rapidly and widely adopted goal in building designs. When developing new buildings and infrastructure, an emphasis is being placed on environmental, energy, and resource use goals for the design, construction, operations and maintenance of these facilities. As intermodal transportation facilities, boat terminals present unique challenges in designing marine structures to accommodate buildings, automobiles, pedestrians, bicyclists and marine vessels. The facilities can be built over land, water or a combination of both. The scope of this study provides a vision for a sustainability system specific to boat terminal buildings. The proposed design is composed of a design guideline that provides the general framework for developing and tracking relevant sustainability metrics and considerations.

1.0.Introduction

The building industry is a vital element of any economy but has a significant impact on the environment. With respect to such significant influence of the building industry, the sustainable building approach has a high potential to make a valuable contribution to sustainable development. Sustainability is a broad and complex concept, which has grown to be one of the major issues in the building industry. The idea of sustainability involves enhancing the quality of life, thus allowing for people to live and work in a healthy environment., with improved social, economic and environmental conditions. For many centuries, natural lighting was the main source of lighting in buildings until the late nineteenth century when artificial lighting was discovered. During the last quarter of the twentieth century and the first years of the twentieth century, building designers and architects have considered the importance of natural lighting within buildings. The main lighting became efficient and cheap enough in the mid 20th century, the major changes in architecture aimed at letting more light in. This was the objective of the Roman and the Gothic groin vault as well as 19th century Crystal palace (Lechner, 1987). Lighting affects the perception of a space as well as the colour and interior finishes. In order to fully replace the electrical lighting with the daylight during daytime, one step must be taken into consideration. How can we do this effectively irrespective of windows and skylights? (Whitehouse, 1999).

Aim of the Study

The aim of the study is to explore the impact of natural lighting and ventilation in boat terminal buildings in order to facilitate sustainable architecture. Climatic factors and the seasonal use of the boat terminals have to be taken into account for technical solutions.

Objectives

i. To provide a unique architectural solution for controlling the indoor climate of boat terminal buildings.
ii. Providing sustainable solutions that are feasible in view of the building's life cycle. \

Research Questions

i. How does natural lighting affect the sustainability and life performance of Boat Terminal buildings?
ii. How can natural lighting and ventilation increase efficiency in Boat Terminal building designs?

2.0.Literature Review

One of the current debates in architecture concerns sustainability and environmental design. The sustainability of the built environment aims to conduct human activities in a way that will preserve natural resources for future generation. Environmental sustainability emphasizes reduction the waste of energy in the environment, reducing the production of agents that harms human health, and using renewable resources. Meanwhile sustainability in architectural fields should encourage using minimum energy resources, using renewable materials, preserving existing buildings, and reusing energy without producing pollution. Among all fossil energy consumers, the building industry can be considered as one of the main energy users (Edwards, 1995). Construction uses almost 40% of the world's energy and is responsible for almost 70% of emitted sulphur oxides and 50% of emitted CO2 (UNCHS, 1993). The amount of energy which has been consumed by the building industry is emitted in any of four stages: firstly, during the process of preparing the materials; secondly, transporting the material, thirdly, building and erecting the buildings and finally the amount of energy required for running and maintaining buildings during their life time. In parallel as a result of increasing family income and population in developed countries, the use of air conditioning systems has also increased which increases the amount of energy being used during the life time of a building (Asimakopoulos and Santamouris, 2005).

2.1.Boat Terminal

Terminals are transportation centres where goods and people are transferred onto and off vehicles. Terminals include ports, airports, bus stations, and train stations. Terminal is defined as the end of a carrier line (such as a railroad, trucking, shipping line or airline, with accompanying dockyard facilities, management office, storage shades freights and stations (Gove, 1976). It goes further to define it differently as a freight or passenger station that is central to a considerable area or serves as a junction at any point with other lines, and as a town or city at the end of a carrier line.

Boat terminal therefore, can be defined as a place where small water- bound passenger vessels and freight are travelling or carried by boat across a body of water and which has dockyard and other ancillary facilities.

The way in which they are designed influences the behavior on, and the perception of the system for both passengers and staff. The quality of Terminal design has the ability to raise the level of confidence in the system as a whole and increase the patronage and revenue.

2.2.Sustainability

Sustainability is an increasingly important aspect in the maritime sector. Boat Terminals all around the world are optimizing their facilities and equipment in a race toward environmental efficiency. Sustainable architecture is architecture that seeks to minimize the negative environmental impact of building by efficiciency and moderation in the use of materials, energy, development space and the ecosystem at large. Sustainable architecture uses a conscious approach to energy and ecological conservation in the built environment.

2.3.Natural Light

In simple terms, natural lighting is light that is generated naturally, the common source of which is the Sun. This is as opposed to artificial light, which is typically produced by electrical appliances such as lamps. Natural light is received during daylight hours and coves the visible spectrum with violet at one end

Natural lighting can play a major role in creating a comfortable environment, helping to regulate your body clock, improve concentration and create a calm, tranquil setting. Lighting has a tangible effect on performance/ productivity. It is an essential element in quality environments that support health and wellness while reducing energy use.

2.3.1.Natural light Provision

The functionality of a building is largely dependent on the quality of its lighting. In order to safely and comfortably perform their tasks, occupants need lighting that provides adequate visibility without causing discomfort or distraction. Adequate provision of natural light allows users to carry out tasks and plays a part in determining the likelihood for the need of artificial lighting at certain times of the day. Daylight factor calculations can be used for assessment of daylight provision within buildings. Optimal use of natural light plays a critical role in sustainable building strategies because it's a free, renewable source. Daylighting, shading and lighting control strategies can help to provide a naturally lit and cost-effective building. The most common design sources of natural light include:

- Windows

- Skylights
- Light shafts
- Atriums
- Translucent Panels

The careful architectural design of Boat Terminals helps maximize natural light while maintaining indoor temperature and light glare reduction. The first step to including extensive daylight features is the building orientation. The building has to be properly oriented to maximize the use of the climatic features in the area (designers orient the structure to maximize daylight potential, taking into account the sun's daily movement).

Assessment of view out of windows

Generally, the overall view to be provided in boat terminal buildings should be clear, undistorted and neutrally coloured. The width and outside distance of the view as well as landscape and skyline should be offered adequately from window view. The width of the view can either be determined using a detailed or simplified approach.

Access to sunlight

Calculating the access, or exposure to sunlight is a health and comfort factor for the end users. Not only does optimal use of sunlight/daylighting require zero electricity, but it can also bring to life other important aspects of a building, such as architecture, colour, and textures. Occupants of buildings with more daylighting than artificial lighting also tend to see health and attitude improvements.

Use of skylight

The skylight is made up of opaque panels that are designed to allow diffused natural light into the main open area. The natural lighting from the skylight reduces the amount of artificial light needed for electrical lighting. Another advantage of the skylight is that since it has opaque panels, the same amount of natural lighting brightens up the terminal whether conditions outside are sunny or cloudy. The use of skylight should be incorporated in open areas such as atrium/ food courts.

2.4.Natural lighting as a tool for sustainable Architecture

A wide variety of sustainability issues intersect with architectural lighting. The design of a daylighting space is both an art and a science. The biggest challenge facing the designer is to admit only as much light as necessary and distribute it evenly throughout the space without introducing glare or heat. In hot/warm climates, it has become a common practice in window spaces to specify blinds and glazing with high shading coefficients to control glare and minimize heat gain. However, this practice reduces the effectiveness of lighting systems that dim automatically.

Improved systems are needed to capture natural daylight and distribute it uniformly throughout a space while controlling heat gain and glare.

2.5.Natural Ventilation

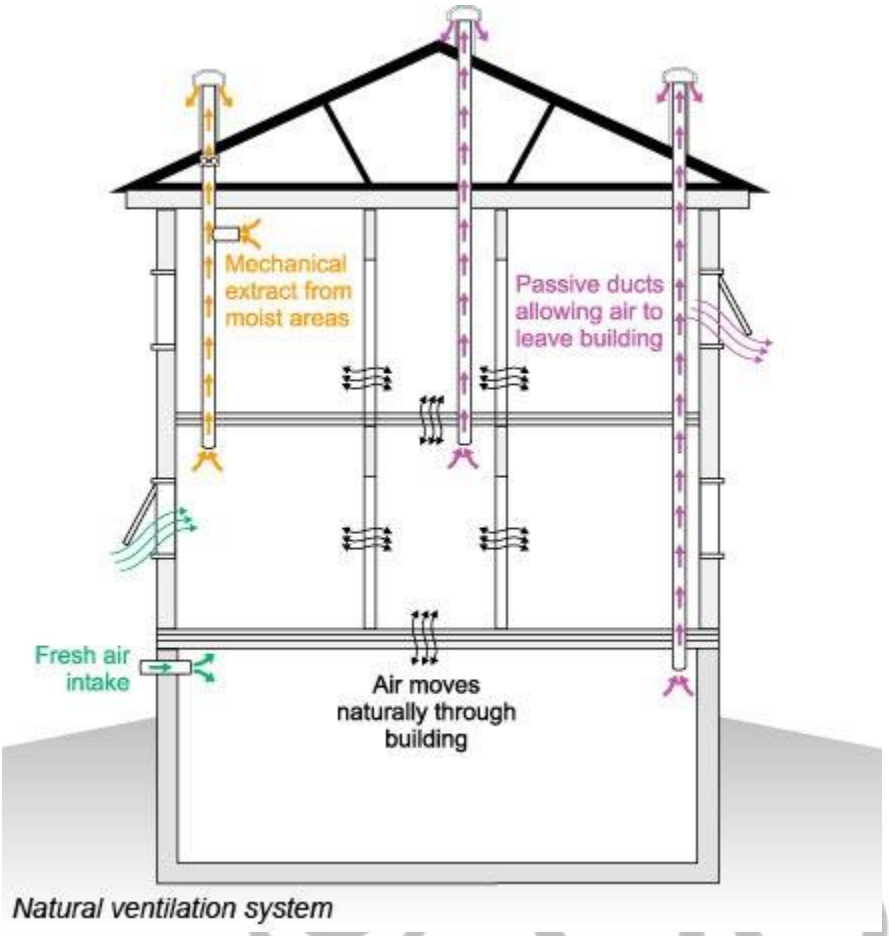
When designing a sustainable building, it is very important to control indoor climate as efficiently as possible, which is why minimal use of demand-based ventilation in the main zone of the terminal is advisable. In reducing carbon emissions. Considerate importance is attached to the roles of natural ventilation and lighting. Natural ventilation is always the preferred solution for a space, provided that the quantity and quality of air required, and the consistency of control to meet the requirements of the spaces are achievable.

Natural ventilation uses the natural forces of wind and buoyancy to introduce fresh air and distribute it effectively in buildings for the benefit of the occupants. Fresh air is required to achieve a healthy, fresh and comfortable indoor environment for people to work in. Natural ventilation can ensure or support the supply of adequate breathing air, adequate ventilation of contaminants, adequate thermal conditioning and moisture dissipation, and contribute to well-being through a connection to the dynamics of nature. For natural ventilation to be effective, there has to be a close relationship between the architecture and the air circulation system. This includes the relationship between the built form, the site environment in a particular location, and layout within the building.

Natural ventilation is a healthy and cost effective way to save energy and provide fresh air for building occupants. It is defined as using passive strategies to supply outdoor air to a building's interior for ventilation and cooling without using mechanical systems. Natural ventilation has become a key component of green building today and is required in order to be certified by LEED and the Living Building Challenge (LBC).

How it works

During the preconstruction phase of a project, research is done to determine the best positioning of the building to allow adequate ventilation from prevailing winds. There are also design elements that have to be incorporated into a building to allow for the free air access. For example, the installation of upper clerestory windows in order to provide free air access to the workspaces is shown in the figure below.



Natural ventilation system

2.6 General considerations to be taken in the course of the design to solve the problems of climatic factors

(a) Emphasis should be on the orientation of the building on the North and South direction i.e. the longest axis facing North and South with minimum opening on the east-west direction.

(b) Use of sun shading devices (horizontal and vertical) like canopies, pergolas and fins to prevent direct sunshine from entering the building.

(c) Use of reflective materials and choice of colour of material. Bright colours reflect heat while dark colours absorb heat.

(d) Use of adequate over-hanging eaves.

(e) Use of shading device like, trees, shrubs, and hedges to protect building from direct sunshine.

(f) Proper location and size of openings to influence wind flow and through the building. Preferably opening shutters should be flexible enough to ward off unfavourable wind movement.

(g) Proper bracing and rigidity of the building structure to withstand extreme winds.

(h) Use of wind-breakers to reduce devastating effect of winds.

(i) The use of reflective roofing materials to minimize the amount of solar radiation emitted.

(j) The introduction of expansion joints to cope with the differences in temperature.

(k) There should be adequate provision for surface water drainage to avoid flooding and marshy environment.

3. Case Study

Case Study 1

Project Name: Alcudia Marine Station

Location: Puerto de Alcudia, Spain

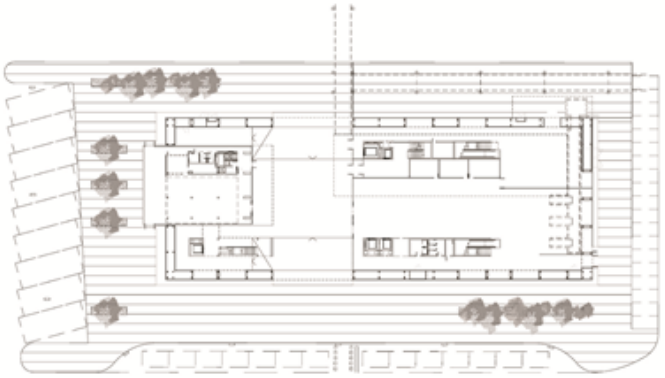
Architect: SCT estudio de arquitectura

Project Information

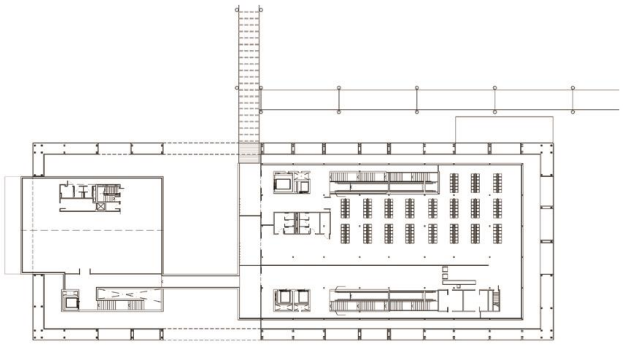
The Alcudia marine station, Spain was completed in 2009. It was designed by architect SCT estudio de arquitectura. The generative idea behind the project consists of the creation of a large volume by way of a container which through its segregation, gives rise to a situation where access to the different resulting volumes is gained via a main marquee like a large covered space. this segregation allows for the functioning of the different programmes regardless of the others.

In this way, the ferry terminal, the offices and the cafeteria/ restaurant, comprise the three distinct zones of the project and they are accessed from the ground floor. moreover, whereas from one side of this large side is connected to the car and lorry embarking areas thus allowing for access to the ticket office on the one hand, and to the cafeteria/restaurant on the other.

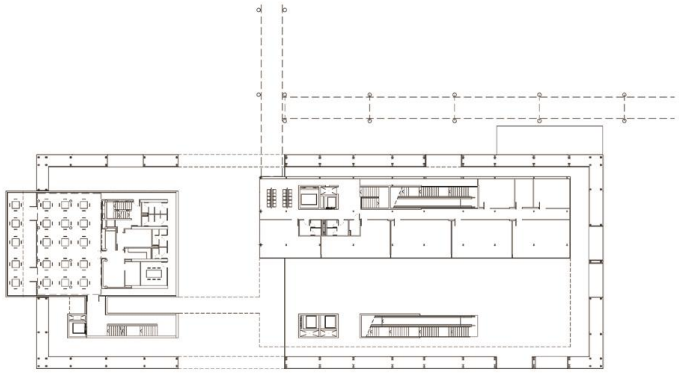
With the aim of promoting the image of a large container, whilst on the façade a strict modulation is organized based on Aluco bond panels measuring 5 meters in length and glazed elements, inside the structure and in the main lobby we have envisaged that the slabs at a level of + 3.50 and + 6.50 be suspended from the roof, creating a large hanging element, that is the offices and departure lounges, which cannot enter into perimeter contact with the building at any point. Thus, from level +- 0.00 a passenger can see that the Ferry Terminal has been developed in a single interior space.



Site plan of the Alcudia marine station



Ground floor plan of the Alcudia Marine Station



First Floor Plan of the Alcudia Marine Station

Design Program

- Administration
- International Collaboration
- Strategic Planning
- Communications and Marketing
- Finance
- Education
- Exhibition & Design
- Fine Arts
- Membership & Development
- Museum Operations
- Visitor Services

- Human Resources

Perspective view showing the Alcudia Marine Station

Case Study 2

Project Name: Yokohama International Cruise Terminal

Location: Japan

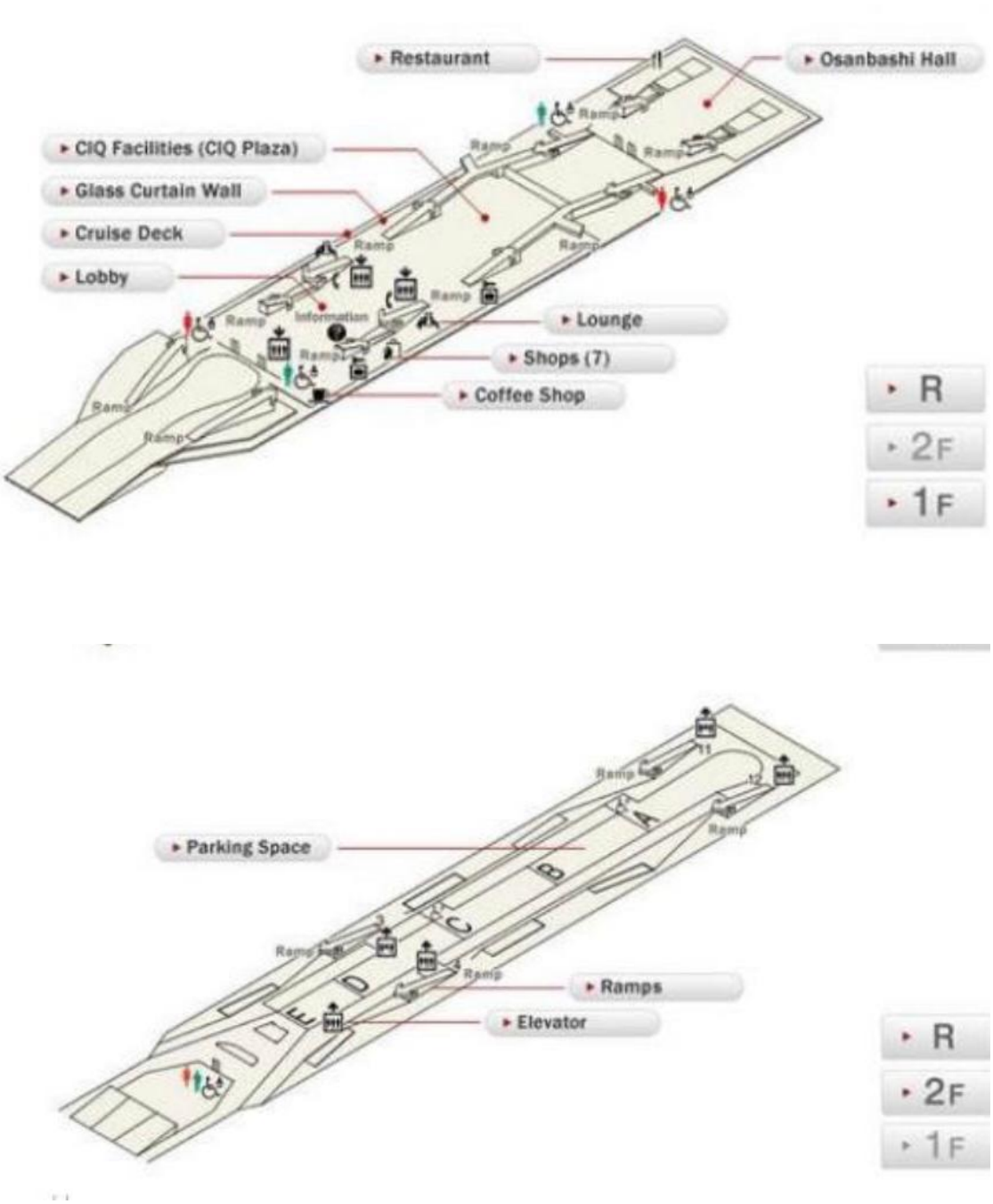
Architects: Foreign Office Architects (FOA)
Area: 48000m^2

Year: 2002

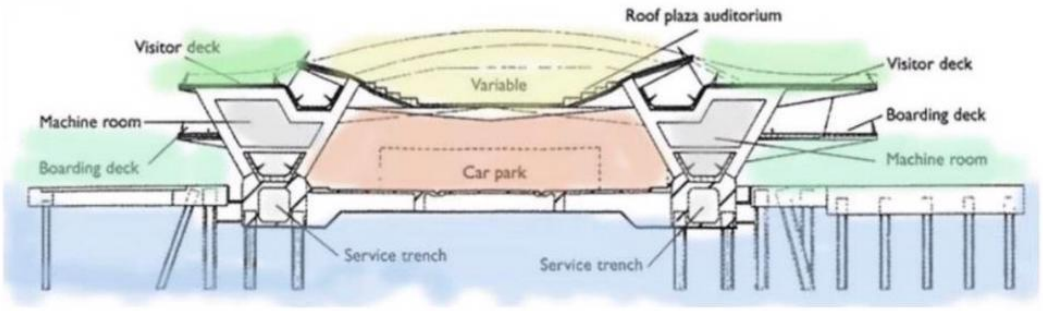
Project Information

The Yokohama Cruise Terminal covers an area of 48000m2. The terminal is designed based on the concept of "No Return Pier'. The terminal is unique for its no return pier concept, where you can never retrace your steps. The terminal has focused more on structuring and circulation and created spaces that are architecturally and aesthetically pleasing. In addition, to promote barrier free movement inside the terminal there are no staircases and the movement is only possible through ramps. The ground floor is dedicated for parking areas and can be used for a flea market. To conclude, the terminal not only attracts the passengers in the terminal but also the public outside. The event plaza and observatory desks are interesting features of the terminal. The rooftop plaza is used for gatherings, car shows, beer festivals, New Year fireworks, weddings and outdoor concerts. This case study is a good example on how it provides various programs that attracts the public to the terminal.

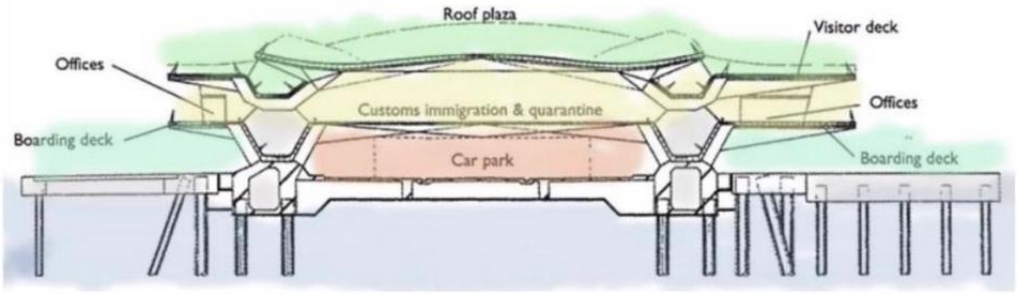
Graphical Analysis



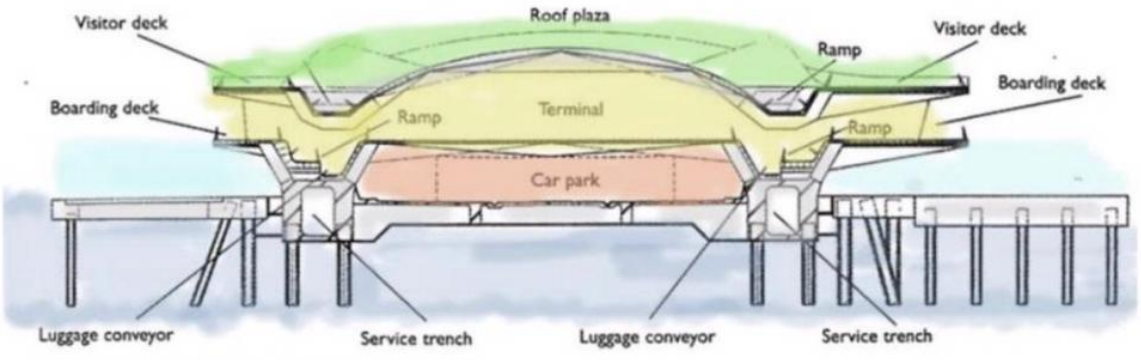
In the barrier free environment ramps are used as vertical circulation between the levels. Ramps built along the girders serve both as the structural framework and passageways. The ground floor is dedicated for around 400 standard-sized cars. The parking areas can be used for a flea market. The first floor consists of the lobby, cruise decks and plaza. The terrace floor is dedicated for rooftop plaza, observatory deck and outdoor event plaza. The terrace floor is the main attraction for the public. Various events such as car shows, beer festivals, New Year fireworks, weddings and other outdoor concerts are hosted in the terrace floor.



Section through Open Air auditorium

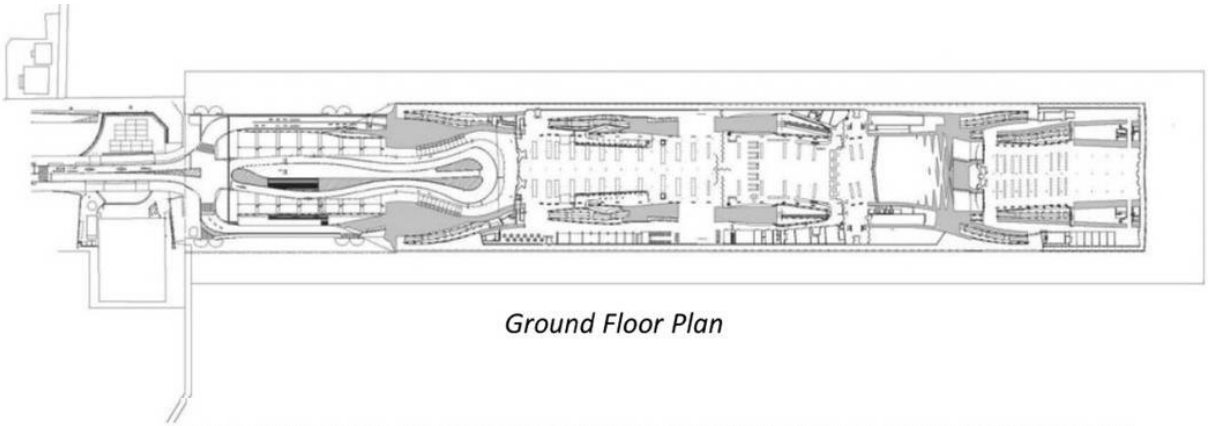


Section through Customs Immigration and Customs

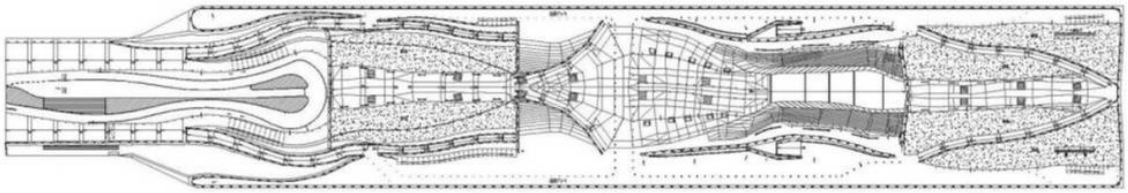


Section through the Departure and Arrival Hall

The sections indicate the innovative geometry of the structure of the terminal. These geometries expose the abstract bands of space that are used by the architects, along with the folds in the ground that are translated into the enveloping structure in one big operating platform working in an active and efficient system.



Ground Floor Plan



First Floor Plan

Merits:

- It is composed of a complex series of surfaces that gently curve and fold into a navigable, inhabitable architectural geography.
- It has a unique roof garden and an observation deck.

4.Conclusions

We can draw the conclusions below:

- There is a considerable awareness of the importance of adjacency with nature in boat terminal designs from the case study. It is possible to have an appropriate environment that enhances efficiency of the occupants and lack of such principles would weaken the percentage of the building quality.
- The natural lighting and ventilation within the Boat terminal buildings has a significant impact on users comfort satisfaction and efficiency.
- The using of modern techniques and architecture processing that would increase the daylight rate in the space are very important. To reduce the energy consumptions with the use of natural ventilation reducing thermal loads transmitted through openings.
- The more awareness of the architect is important as sustainability concepts in the design processes which contributes to a strong continuous architecture for many years.

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