SUB AEQUORA

“水面之下”厦门水下海洋科研中心
AN UNDERWATER MARINE SCIENCE HUB BENEATH XIAMEN'S WAVES

厦门岛拥有发达的教育体系和雄厚的科研基础。厦门大学的海洋科学专业在全国排名第二，岛上有第三海洋研究所等著名研究机构。

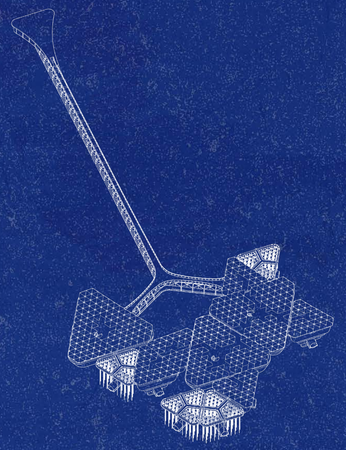
厦门有填海造地的历史，目前正在探索建设水下研究和居住中心的可能性，以扩大城市的生活空间，
巩固其作为领先的海洋科学研究中心的地位。

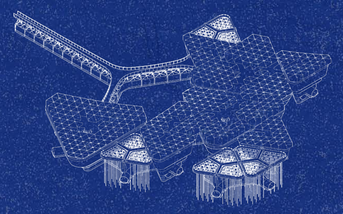
Sub Aequora 在拉丁语中意为“水面之下”旨在创造一个可持续、创新、美观的水下环境，为科学研究、教育和探索海洋生态系统提供场所。

Xiamen Island boasts a well-developed education system and a strong research foundation. Xiamen University's marine science major ranks second in the country, and the island is home to prestigious research institutions like the Third Institute of Oceanography.

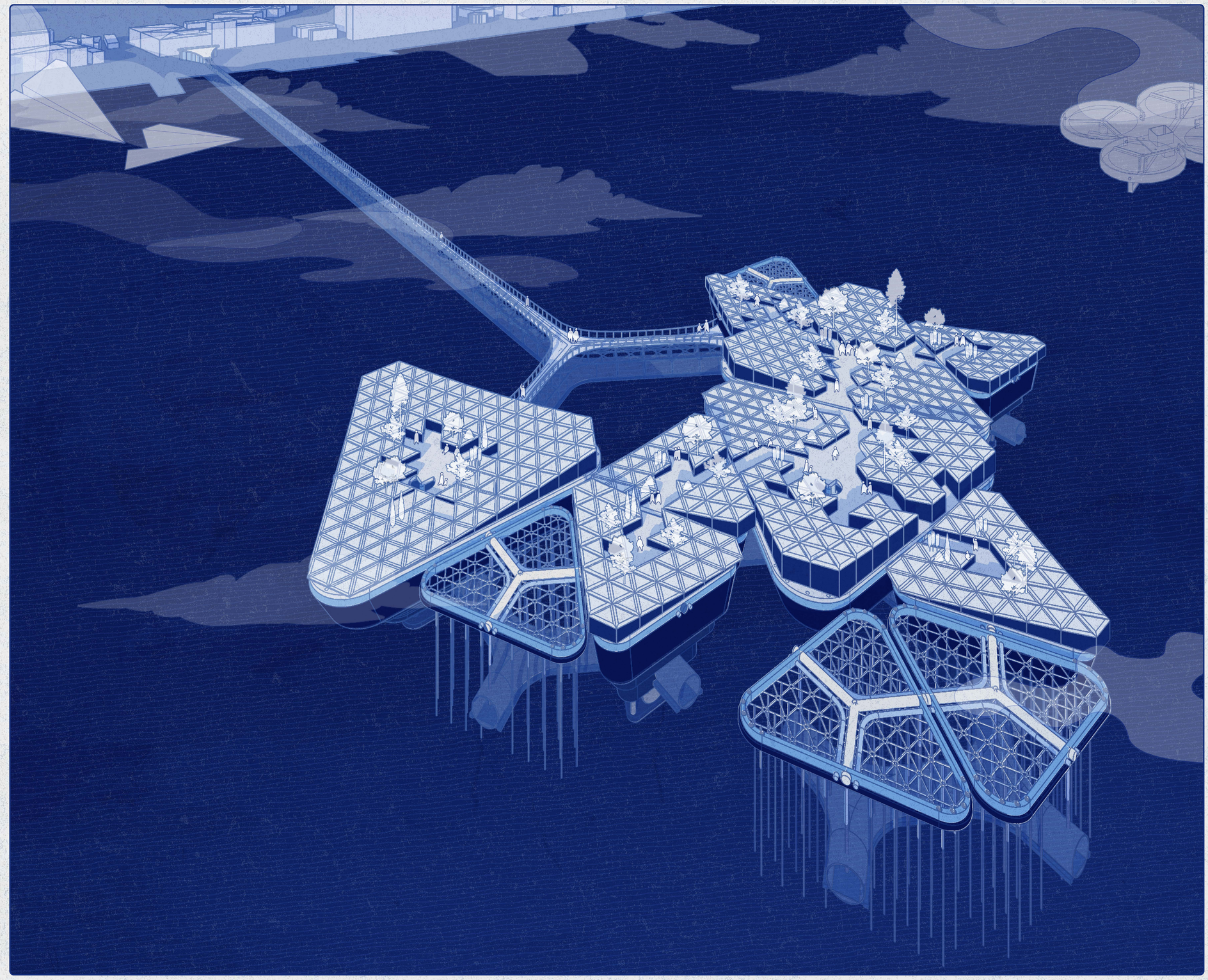
With a history of land reclamation, Xiamen is now exploring the possibility of building an underwater research and residential center to expand the city's living space and solidify its position as a leading marine science research hub.

Sub Aequora, which in Latin means “beneath the sea's surface,” aims to create a sustainable, innovative, and aesthetically pleasing underwater environment that providing a place for scientific research, education and exploration of the marine ecosystem.





厦门大学 2021 级环境设计 宋昕恬
Song Xintian, Environmental Design, Class of 2021, Xiamen University



项目名称：
水面之下

项目目标：
在厦门岛附近建立一个水下研究实验室，缓解厦门的城市拥堵状况，成为海洋环境科学探究、探索和教育的中心。

目标受众：
海洋科学家、访问学者、海洋科学专业学生、游客和教育团体

问题陈述：
*厦门地处沿海，港口、机场和海洋学设施等基础设施发达，具有开展国际研究项目的潜力。
然而，快速的城市化进程和大量游客涌入厦门岛会导致人口密度增加。厦门岛的陆地面积有限。*

解决方案：
作为厦门大学海洋学系的扩建项目，通过开发水下研究空间来扩展厦门城市，应对城市挑战，促进科学教育和研究。

相关理论框架：
受新陈代谢运动（Metabolic Movement）和 建筑电讯派（Archigram）的插件城市（plug-in cities）启发，该项目提出了一种灵活、可调整的结构，可随着时间的推移而演变，允许未来扩展和定制。

此外，水下中心还采用了可再生能源、高效的供水系统和最少的废物产生量，以承担可持续建筑的生态责任。

经济影响：
通过建立拥有先进技术的水下实验室，该项目可创造更多的就业机会，吸引投资、促进厦门的技术发展。

社会和文化影响：
水下研究设施可吸引研究人员、科学家、学生和游客。此外，该结构还具有可扩展性，未来可用于更多目的，如科学教育、居住和旅游。

可持续性和环境影响：
水下结构包括潮汐发电、海水净化和海洋养殖，可减少碳排放，并有可能创造一个自给自足的生态系统。

结论：
*该项目提出了一个水下研究和居住的创新概念，探索海洋生态系统，并鼓励人类更好地了解这一充满挑战的环境。
通过探索建筑和工程方面的可能性，该项目可以彻底改变我们对人类与海洋关系的理解，甚至激励后代。*

Project Title:
Sub Aequora

Project Goal:
Create an underwater research laboratory near Xiamen Island, reduce urban congestion in Xiamen, serve as a hub for scientific inquiry and exploration and education of the marine environment.

Target Audience:
Marine scientists, marine science students, visitors, and educational groups

Problem Statement:
Xiamen's coastal location and well-developed infrastructure, including seaports, airports, and oceanography facilities, has a potential of international research projects.

However, rapid urbanization and the influx of tourists in Xiamen Island could cause increased population density. The island's land area are limited.

Proposed Solution:
Expand the Xiamen City by developing underwater research spaces as an expansion of Xiamen University's Department of Oceanography, addressing urban challenges and promote scientific education and research.

Relevant Theories or Frameworks:
Inspired by Metabolic Movement and Archigram's plug-in cities, the project proposes a flexible and adaptable structure that can evolve over time, allows for future expansion and customization.

Besides, the underwater center incorporates renewable energy sources, efficient water systems, and minimal waste generation to embrace sustainable architecture's ecological responsibility.

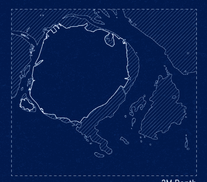
Economic Impact:
By creating underwater laboratories with advanced technology, the project can create more job opportunities, attract investment, and promote technology development in Xiamen.

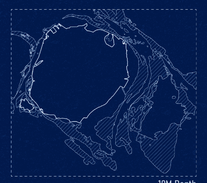
Social and Cultural Impact:
The underwater research facility could attract researchers, scientists, students, and tourists. In addition, the structure is expandable and can be used for more purposes in the future, such as science education, residence, and tourism.

Sustainability and Environmental Impact:
The underwater structure includes tidal power generation, seawater purification, and ocean farming to reduce carbon emissions and has the potential to create a self-sufficient ecosystem.

Conclusion:
The project presents an innovative concept for underwater research and habitation, exploring marine ecosystems, and encouraging humans to have a better understanding of the challenging environment.

By exploring architectural and engineering possibilities, this project could revolutionize our understanding of human's relationship with the ocean, even inspire future generations.





场地分析 + 设计概念
SITE ANALYSIS + CONCEPTUAL DIAGRAM

建筑电讯派

建筑电讯派是 20 世纪 60 年代兴起的建筑运动和团体，以未来主义和前卫的建筑理念著称。
他们是一个由建筑师和设计师组成的集体，旨在挑战传统建筑规范，探索新技术和生活方式。
该团体的特点是强调流行文化、技术以及建筑适应和改变社会需求和愿望的潜力。
建筑电讯派以其“无建筑的建筑”概念而著称，他们认为建筑不应创造固定的空间体量，而应提供“生活”和“存在”的设备(Sadler, 2005)。

Archigram was an architectural movement and group that emerged in the 1960s, known for their futuristic and avant-garde concepts in architecture.
They were a collective of architects and designers who sought to challenge traditional architectural norms and explore new technologies and ways of living.
The group was characterized by their emphasis on pop culture, technology, and the potential for architecture to adapt and change in response to societal needs and desires.
Archigram is noted for their concept of "architecture without architecture," suggesting that architecture should not create fixed volumes of space but provide the equipment for "living," for "being" (Sadler, 2005).

Plug-In City (1964), Peter Cook

新陈代谢派

Plan for Tokyo (1960), Kenzo Tange

A sketch included in the Metabolist manifesto (1960), Kiyonori Kikutake

新陈代谢指的是 20 世纪 60 年代在日本兴起的一场前卫建筑运动。
新陈代谢运动的特点是将城市视为一个有机的过程，新陈代谢主义者设想的城市结构可以随着时间的推移不断适应和演变，就像活的有机体一样。
他们提出了雄心勃勃的设计理念，如人造陆地、海洋文明、新陈代谢循环、巨型结构和群体形式，这些理念体现了他们对社会变革的理想，并对战后日本社会面临的城市和文化危机做出了回应。
新陈代谢运动发起于 1960 年，当时一群年轻的日本建筑师和设计师发表了他们的宣言《新陈代谢：新陈代谢：新城市主义提案”。
这场运动成为日本战后文化复兴的象征，并深深植根于城市作为一个动态实体的概念，它可以像生物过程一样成长和转变(Lin, 2010)。

Metabolism refers to an avant-garde architectural movement that emerged in Japan in the 1960s.
The movement was characterized by its focus on the city as an organic process, with the Metabolists envisioning urban structures that could adapt and evolve over time, much like living organisms.
They proposed ambitious design concepts such as artificial land, marine civilization, metabolic cyclic megastructure, and group form, which embodied their ideals of social change and responded to the urban and cultural crises confronting postwar Japanese society.
The Metabolist movement was launched in 1960 when a group of young Japanese architects and designers published their manifesto, "Metabolism: The Proposals for New Urbanism," at the World Design Conference in Tokyo.
The movement became emblematic of Japan's postwar cultural resurgence and was deeply rooted in the notion of the city as a dynamic entity that could grow and transform, akin to biological processes (Lin, 2010).

仿生学/生物拟态

仿生学是一种创新的设计方法，它模仿大自然久经考验的解决方案来应对人类面临的挑战。
它也被描述为通过研究和有目的地模仿大自然的形态、过程和生态系统来启动可持续设计解决方案的过程。
它建立在一个前提之上，即大自然已经以可持续的方式解决了人类环境所面临的大多数挑战。
通过在设计过程的各个阶段（从范围界定到创造和评估）模仿自然，生物模拟已成为实现可持续发展的一条颠覆性道路(Oguntona and Aigbavboa, 2024)。

Biomimicry is an innovative design approach that emulates nature's time-tested solutions to human challenges.
It is also described as the process of initiating sustainable design solutions through the study and purposeful emulation of nature's forms, processes, and ecosystems.
It is founded on the premise that nature has sustainably solved challenges like most problems ravaging the human environment.
Biomimicry has become a disruptive path to achieving sustainable developments through nature emulation at all stages (from scoping to creation and evaluation) of the design process (Oguntona and Aigbavboa, 2024).

(Oguntona and Aigbavboa, 2024)

超人类主义

超人类主义是一种探索人类通过技术提高自身能力潜力的哲学，正升始影响建筑领域。
超人类主义设想了一个人类与技术融合的未来，有可能导致一个人类与机器界限模糊的后人类时代(O'connell, 2018)。
采用模块化组件设计建筑的方法，可以随着技术的进步而轻松升级或更换，从而使建筑随着时间的推移而不断发展，就像软件更新可以增强功能和性能一样。

(Hamdani , 2022)

Transhumanism, a philosophy that explores the potential for humans to enhance their capabilities through technology, is starting to influence the field of architecture.
Transhumanism envisions a future where humans integrate with technology, potentially leading to a posthuman era where the distinction between human and machine is blurred (O'connell, 2018).
Approaches like design buildings with modular components that can be easily upgraded or replaced as technology advances allows buildings to evolve over time, much like how software updates enhance functionality and performance.

环保/可持续建筑

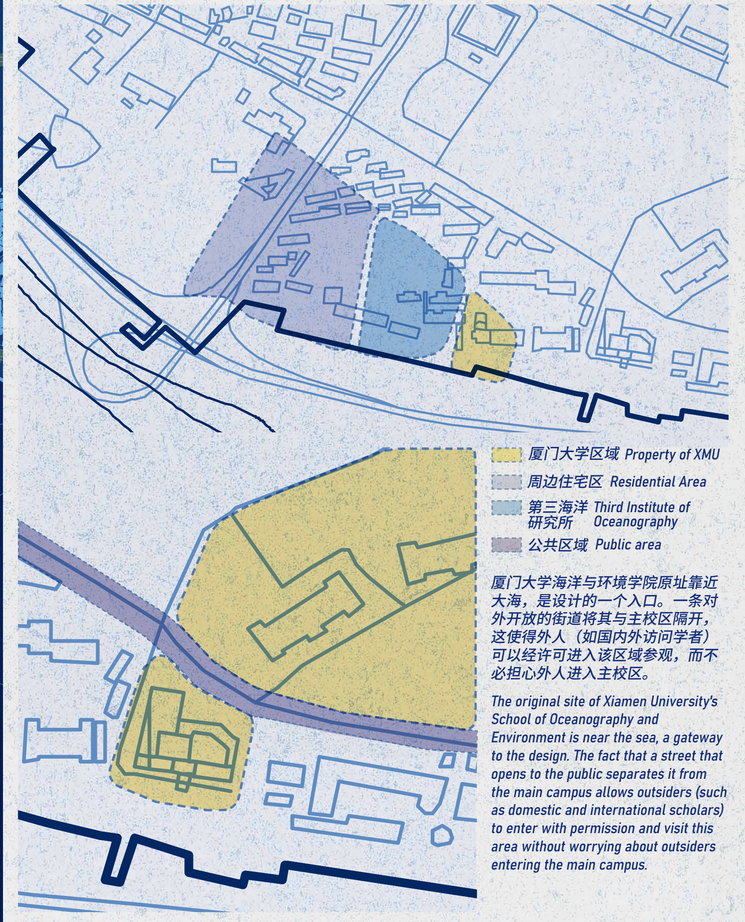
可持续建筑侧重于设计对环境影响最小的建筑，同时最大限度地提高人类的健康和福祉。这种方法考虑了能源效率、节水、材料选择和室内空气质量等因素。

Sustainable architecture focuses on designing buildings that minimize environmental impact while maximizing human health and well-being. This approach considers factors such as energy efficiency, water conservation, material selection, and indoor air quality.

(Tiết Hnin, 2022)

城市边界扩展

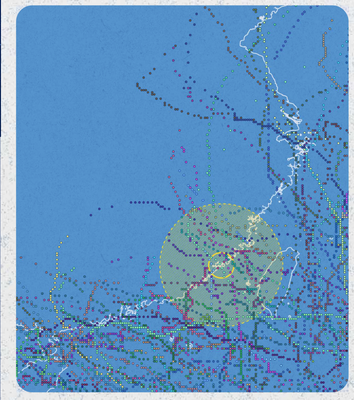
1] Sadler, S. (2005). Archigram : Architecture without Architecture. Cambridge, Ma: Mit. Cop.
2] Lin, Z. (2010). Kenzo Tange and the Metabolist Movement : Urban Utopias of Modern Japan. London: Routledge.
3] Oguntona, O.A. and Aigbavboa, C.O. (2024). Biomimicry and Sustainable Building Performance. Taylor & Francis.
4] O'connell, M. (2018). To Be a Machine : Adventures among cyborgs, utopians, hackers, and the Futurists Solving the Modest Problem of Death. New York: Anchor Books.



厦门大学区域 Property of XMU
周边住宅区 Residential Area
第三海洋研究所 Third Institute of Oceanography
公共区域 Public area

厦门大学海洋与环境学院原址靠近大海，是设计的一个入口。一条对外开放的街道将其与主校区隔开，这使得外人（如国内外访问学者）可以经许可进入该区域参观，而不必担心外人进入主校区。

The original site of Xiamen University's School of Oceanography and Environment is near the sea, a gateway to the design. The fact that a street that opens to the public separates it from the main campus allows outsiders (such as domestic and international scholars) to enter with permission and visit this area without worrying about outsiders entering the main campus.



过去十年台风路径图
Typhoon track map for the past decade

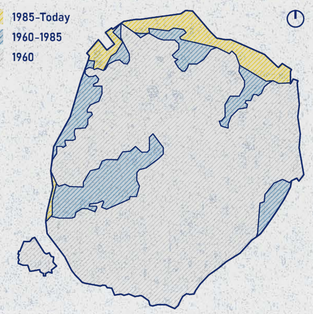
数据显示，厦门位于福建省东南部，是台风最容易袭击的地区之一。水下建筑可以有效避免台风造成的破坏，并为居民提供紧急避难所。

Located in southeastern Fujian Province, Xiamen is one of the areas most prone to typhoon strikes, as data has shown. Underwater structures can effectively avoid typhoon damage and provide emergency shelters for residents.

数据采集自中国科学院海洋研究所海洋大数据中心海洋科学数据中心门户网站 (http:// msdc.qdio.ac.cn)。

Data collected from The portal of Marine Science Data Center, Marine Big Data Center, Institute of Oceanology, the Chinese Academy of Sciences (CAS), China (http:// msdc.qdio.ac.cn)

厦门岛通过填海造陆实现城市扩张的历史
History of Xiamen Island's Urban Expansion Through Land Reclamation



作为第三海洋研究所和厦门大学海洋科学项目的延伸，海上实验室的建立将加强厦门的海洋科学研究。由于第三海洋研究所附近住宅密集，实验室选址在海边，作为厦门岛延伸的一部分 -- 这与厦门岛过去的填海造陆遥相呼应。

The establishment of an offshore laboratory as an extension of the Marine Science program of the Third Institute of Oceanography and Xiamen University will enhance marine science research in Xiamen.

Due to the density of housing in the vicinity of the Third Institute of Oceanography, the location of the laboratory was chosen to be on the sea as part of the extension of Xiamen Island - an echoing to the past of Xiamen Island's land reclamation.

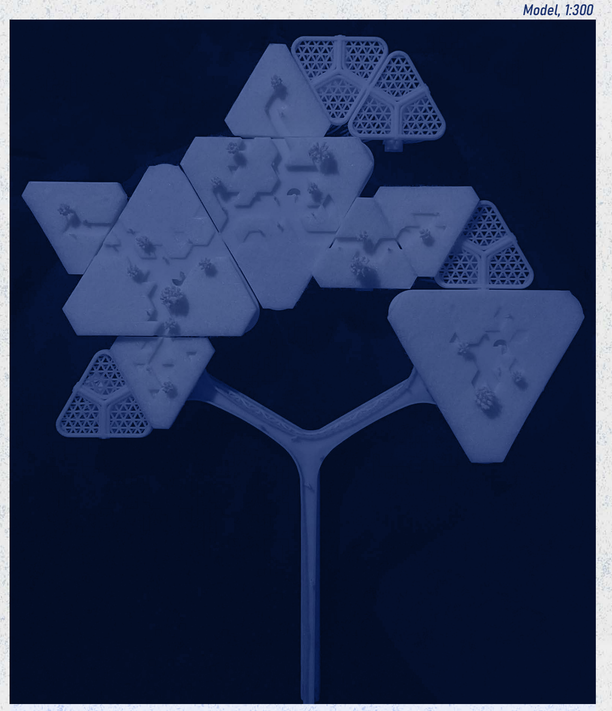
项目选址
PROGRAM LOCATION

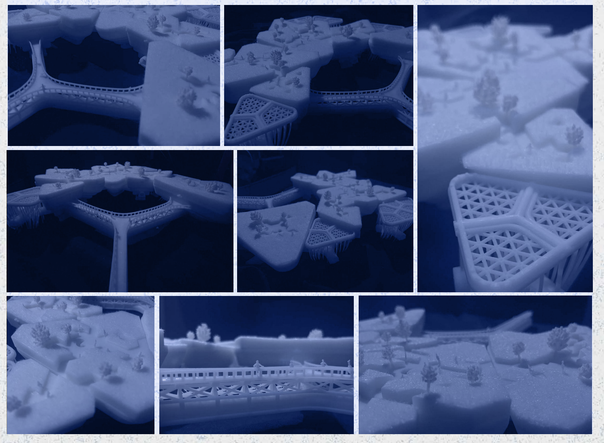
Model, 1:1500

Site Model, 1:4000

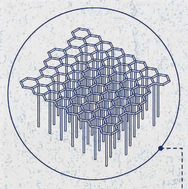
模型展示
PHYSICAL MODEL

Model, 1:300





设计过程
DESIGN DEVELOPMENT

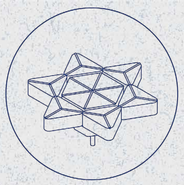


这一版设计采用了优雅、轻巧的外形，易于复制和更改。
其结构由玻璃纤维增强塑料制成，这是一种常用的水下材料，具有高强度和耐腐蚀性。

This design applied an elegant, lightweight shape that can be easily duplicated and altered. The structure is made of glass fiber-reinforced plastic, a commonly used underwater material with high strength and corrosion resistance.

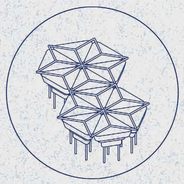
这一版设计更加紧凑和稳定，中间是一个钢筋混凝土圆柱体，用于支撑和运输。圆筒周围建有聚合物复合材料平台，为人们创造一个生活空间。

This design is more condensed and stable, with a reinforced concrete cylinder in the middle for support and transportation. Polymer composite platforms are constructed around the cylinder, to create a living space for people.



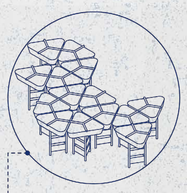
该设计显示了结构各部分之间的层次关系。建造了两种类型的聚合物复合浮动平台，同时在主平台中心下方建造了一个水下能量转换系统。

This design shows the hierarchy between different parts of the structure. Two types of polymer composite floating platforms are constructed, while an underwater energy-transforming system is built under the center of the main platform.



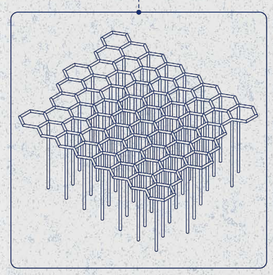
该设计由多个三角形浮动平台组成，平台之间由钛合金钢管连接，并组合成一个六边形集群。下面是玻璃纤维增强塑料，用于收集低温海水并将其转化为能源。

This design consists of multiple floating triangular platforms, interconnected by titanium alloy steel pipes, and combined into a hexagonal cluster. Below it is a glass fiber reinforced plastic used to collect low-temperature seawater and convert it into energy.



该设计是上一版设计的衍生品，改进了钛合金管道的形状，使其能够更自由地相互组合。浮动平台下方是三角形的聚合物复合材料单元，作为生活空间。

This design is a derivative of the previous design, improving the shape of titanium alloy pipes and allowing them to be more freely combined with each other. Below the floating platform, triangular polymer composites units have been established as living spaces.

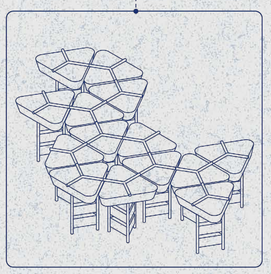


优点：
+ 易于相互组合
+ 易于复制
+ 轻质材料可使结构漂浮在海面上
+ 适用于海洋养殖

缺点：
- 可能无法承受重物
- 不能用于支撑水下结构
- 钛合金管的成本相对较高

Advantages:
+ Can be easily combined with each other
+ Easy to duplicate
+ The light weight material enable the structure to float on the sea surface
+ Suitable for underwater farms

Disadvantages:
- May not be able to bear heavy weight
- It cannot be used to support underwater structures
- The cost of titanium alloy tubes is relatively high

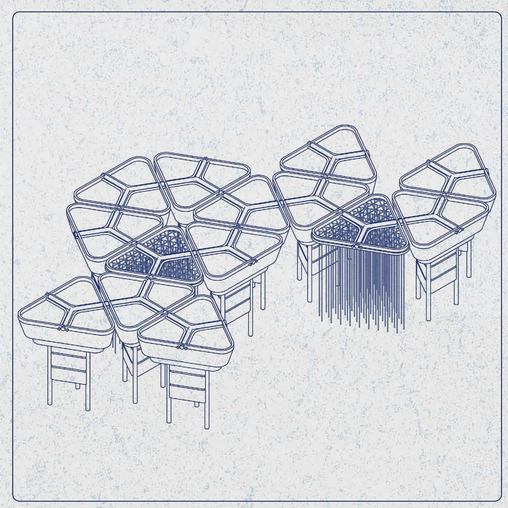


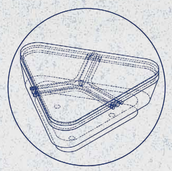
优点：
+ 易于相互组合
+ 能够承受重型结构
+ 浮动平台还可用于其他功能
+ 为平台下方的居住单元提供空间

缺点：
- 由多种不同材料的部件组成
- 占用大量空间

Advantages:
+ Can be easily combined with each other
+ Be able to bear heavy weight structure
+ The floating platform can serve for other functions
+ Provide the space for living units below the platform

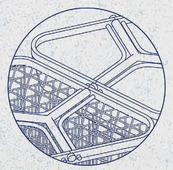
Disadvantages:
- Composed of components made of different materials
- Occupying a lot of space





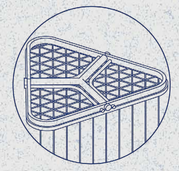
浮动建筑平台由高性能混凝土表层、聚合物复合材料主体、钛合金加固钢结构和玻璃纤维增强塑料管道组成。

The floating building platform consists of a top layer of high-performance concrete, a main body of polymer composites, a reinforced steel structure of titanium alloy, and pipes made of glass fiber reinforced plastic.



通过管道和结构系统的连接，这些浮动平台可以很容易地相互连接，以扩大平台并适合平台，满足不同的要求。

Connected by a system of pipes and structures, those floating platforms can be easily attached to each other, in order to expand the platform and suit different requirements.



这一版设计结合了前两者的优点，采用模块化框架，可与其他平台连接。它还采用了轻质钛合金管道，可以收集海水和进行海洋养殖。

This version of design combines the advantages of the previous two, using a modular framework which connects with other platforms. It also has lightweight titanium alloy pipes, allowing for the collection of seawater and ocean farming.

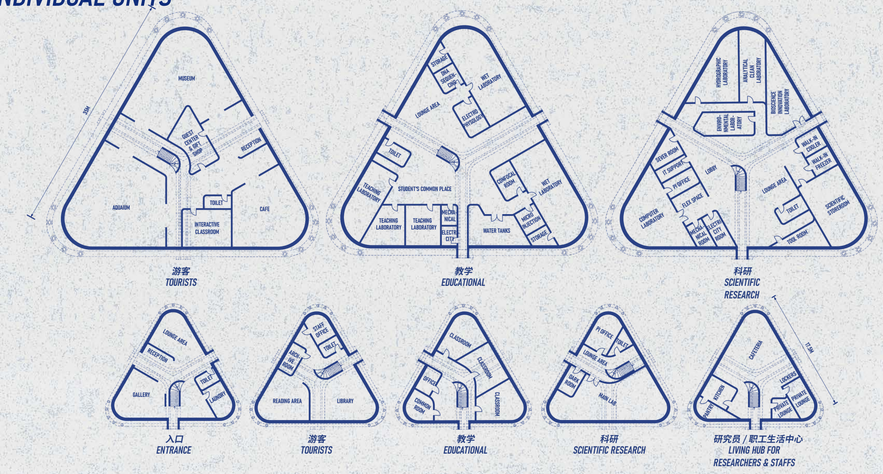
功能分区
FUNCTIONAL ZONING

- 实验室 Laboratories
  - 主实验室 Main Lab
  - 湿实验室 Wet Lab
  - 水域实验室 Hydro Lab
  - 电脑实验室 Computer Lab
  - 生物实验室 Biolohical Lab
  - 分析实验室 Analytical Lab
- 其他设施 Other Facilities
  - 会议室 Conference
  - 首席研究员办公室 PI Office
  - 暗室 Dark Room
  - 储藏室 Store Room
  - 冷冻库 Walk-in Freezer
  - 冷藏库 Walk-in Cooler
  - 储水罐 Water Tanks
  - 机械间 Mechnical Room
  - 电力室 Electricity Room
- 教学设施 Educational Facilities
  - 教学实验室 Teaching Lab
  - 教室 Classroom
  - 助教办公室 T.A. Office
  - 图书馆 Library
- 生活中心 Living Hub
  - 办公室 Office
  - 休息室 Lounge
  - 洗手间 Restroom
  - 储物柜 Lockers
  - 厨房 Kitchen
  - 餐厅 Cafeteria
  - 洗衣房 Laundry
- 对公众开放 Open to Public
  - 接待处 Reception
  - 博物馆 Museum
  - 水族馆 Aquarium
  - 咖啡厅 Cafe

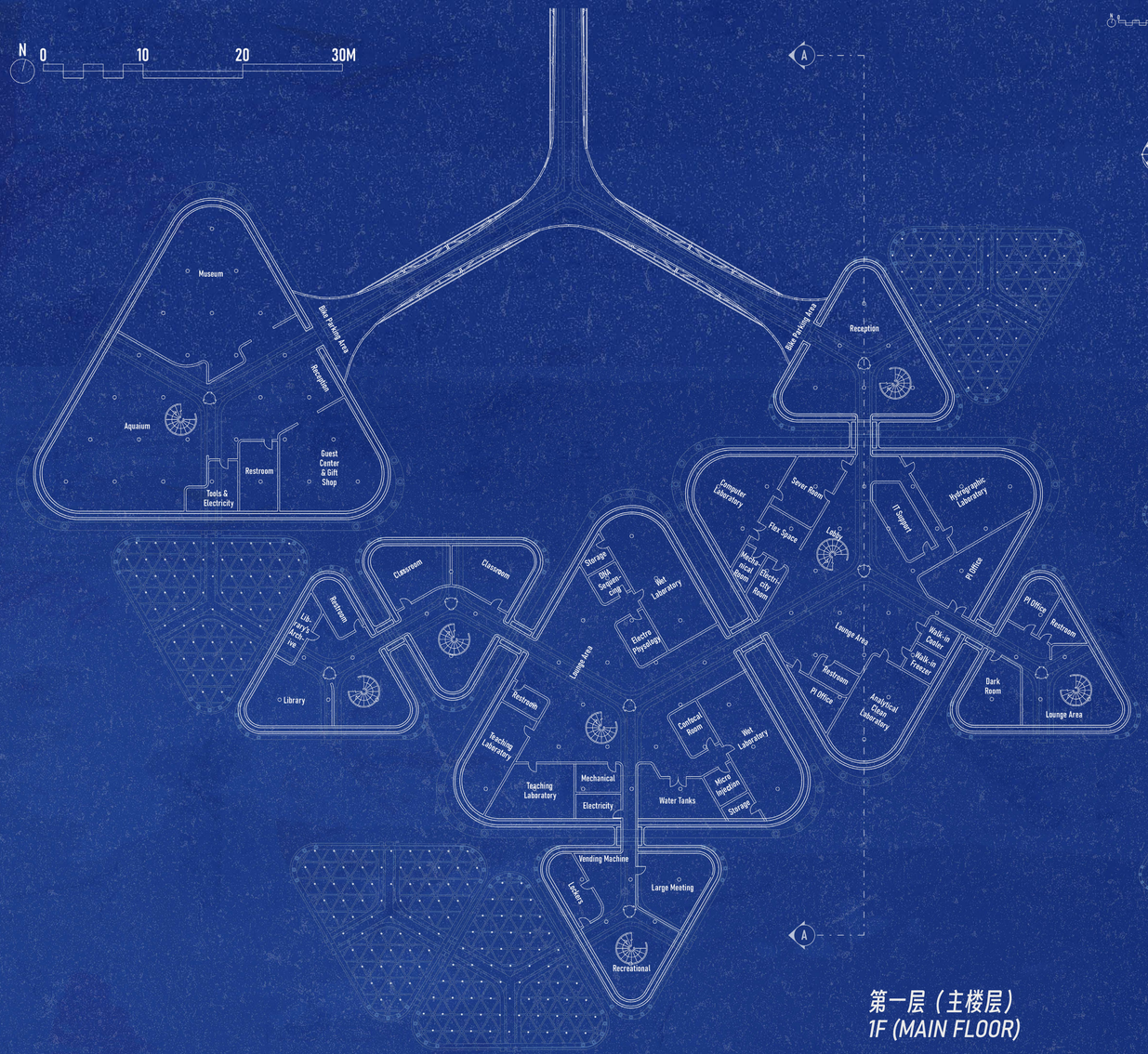
目标群体
TARGET AUDIENCE

- 研究者 Researchers
- 相关领域学生 Students in Relevant Fields
- 访问学者 Visiting Scholars
- 居民与游客 Residents & Visitors

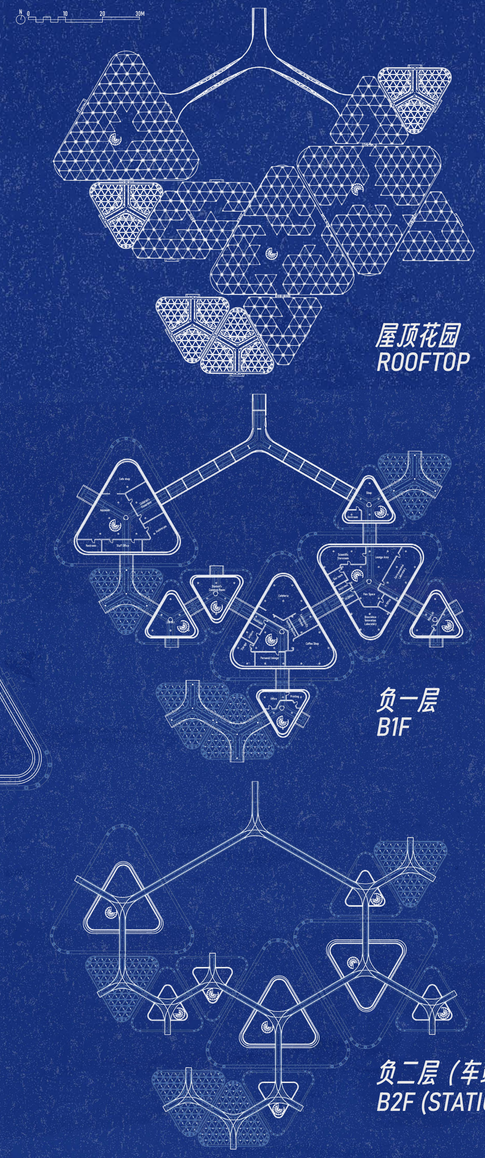
建筑单元
INDIVIDUAL UNITS

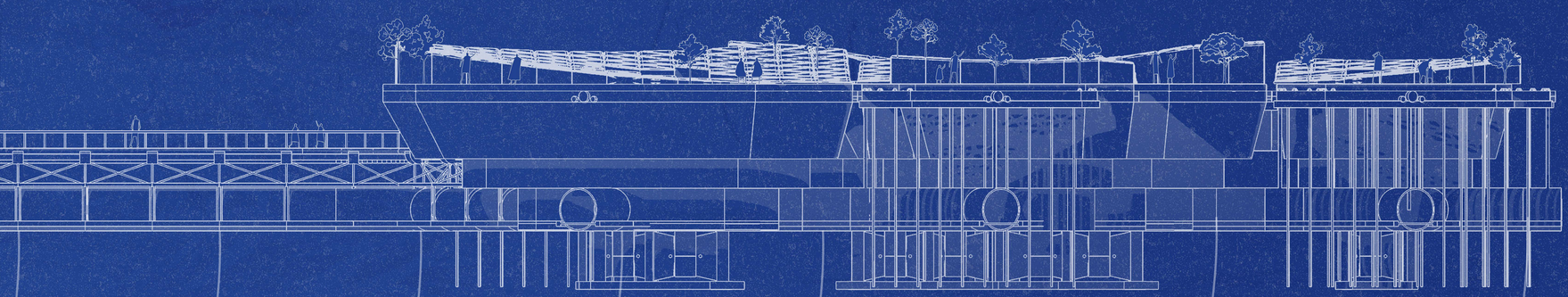


平面 + 立面图
SITE PLAN + ELEVATION

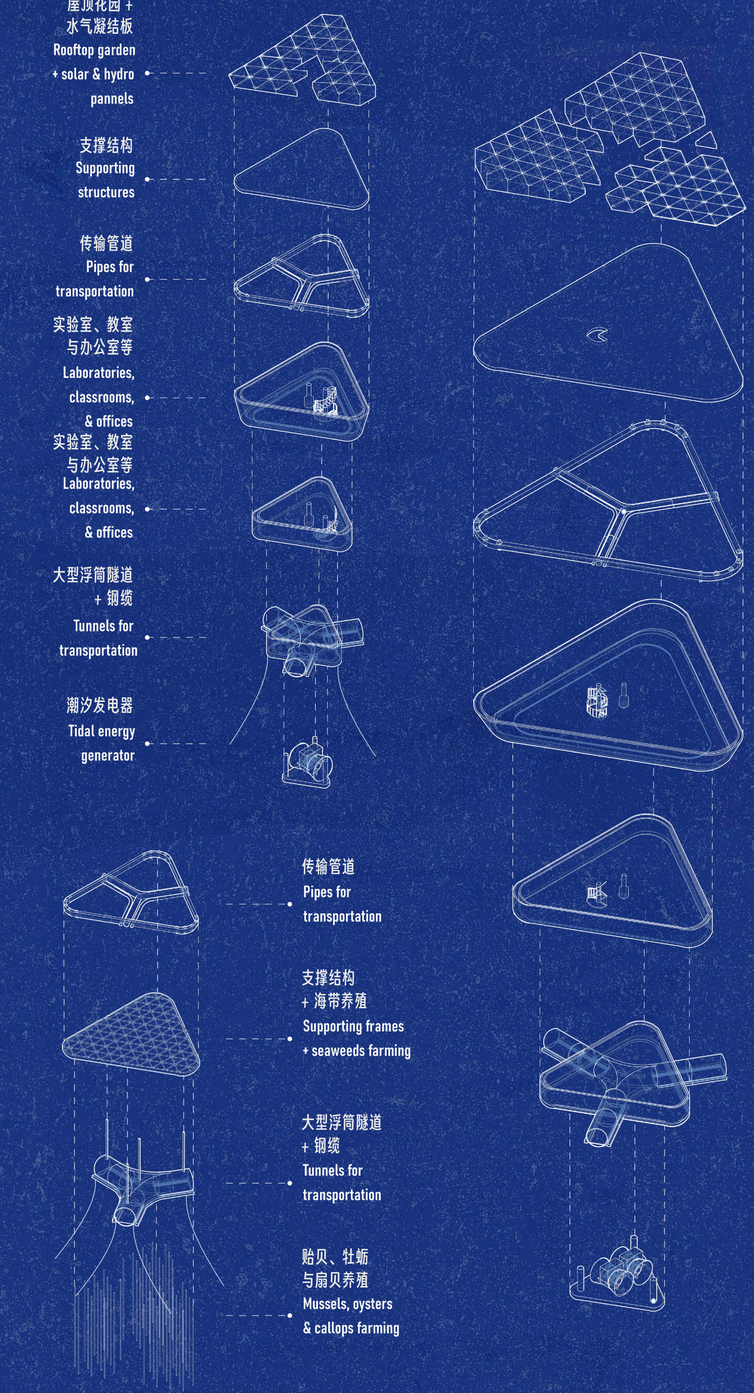


第一层（主楼层）
1F (MAIN FLOOR)



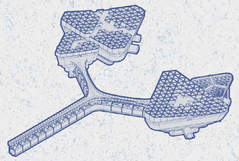


轴测爆炸图
EXPLODED ISOMETRIC

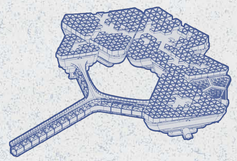


实施阶段图
PHASING DIAGRAM

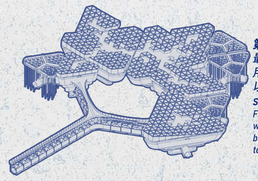
第 1 步：
首先要建造的是通往场址的桥梁和第一批面向公众的建筑单元；施工采用浮吊与驳船设备作业。
STEP 1:
The bridge to the site location and the first public-facing building units are the first to be constructed. Floating cranes and barge equipment were used for surface operations during construction.



第 2 步：
桥梁和隧道可加快材料运输，紧接着，为科学家和研究人员建造的建筑单元被用作海洋实验室。
STEP 2:
Immediately after the bridges and tunnels, which allowed for faster transportation of materials, the building units for scientists and researchers were constructed to serve as marine laboratories.

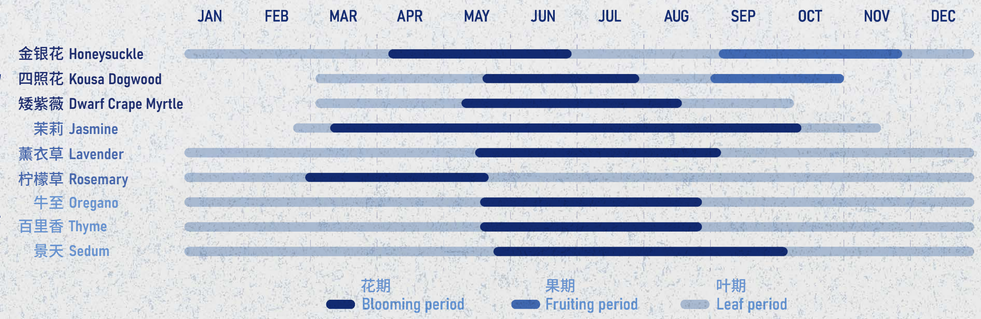


第 3 步：
建造了更多的实验室和辅助设施。其中一些实验室向大学生开放，用于教学目的。
STEP 3:
More laboratories and ancillary facilities are built. Some of these are open to university students for teaching purposes.



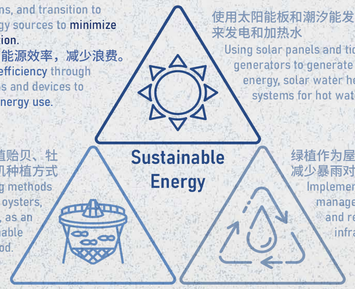
第 4 步：
最后，还建造了一些海洋养殖设施，用于生态养殖。建筑本身将来还可以扩建，连接更多的单元。
STEP 4:
Finally, a number of ocean farming facilities were built for ecological cultivation. The building itself can be expanded in the future to connect more units.

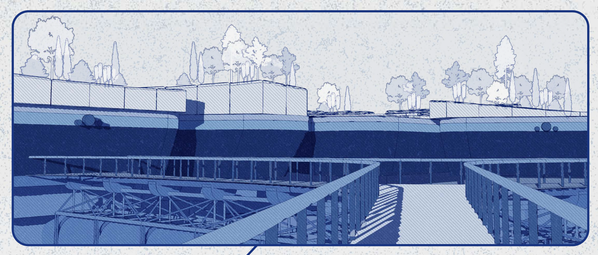
屋顶植物覆盖图
PLANTATION DIAGRAM (FOR ROOFTOPGARDEN)

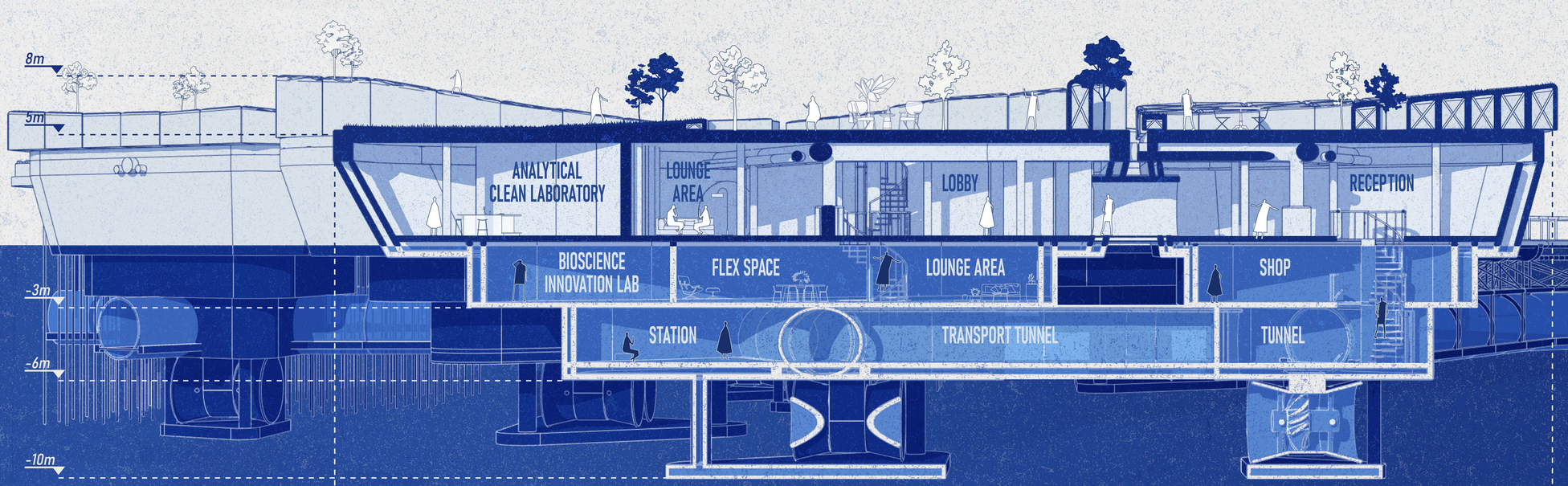


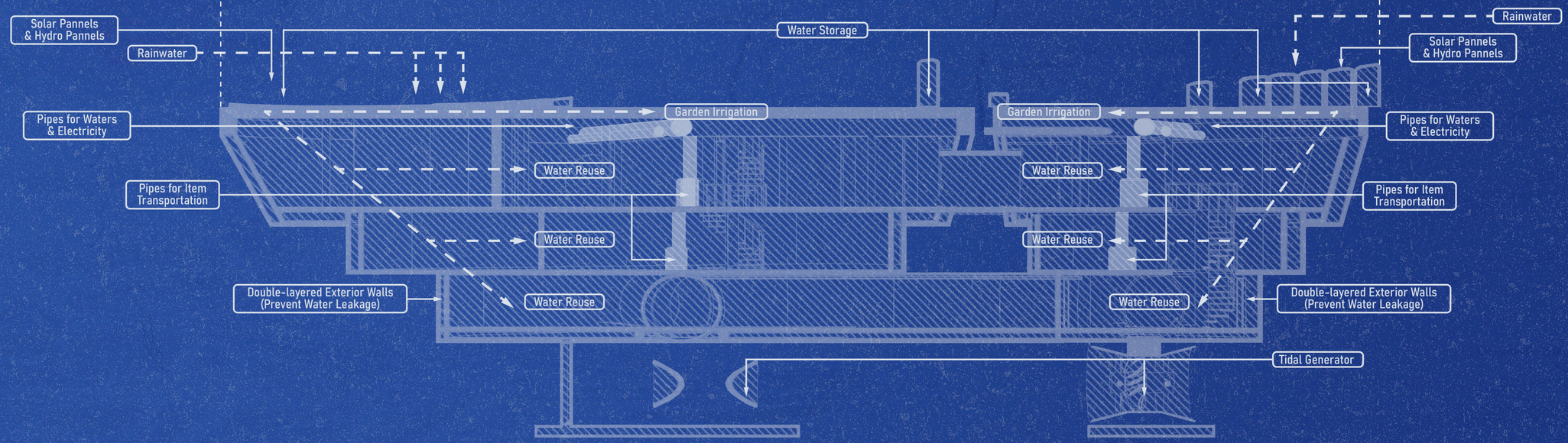
可持续方针
SUSTAINABLE METHODS

优化：优化建筑结构来匹配当地天气，使用可持续能源来降低能耗。
OPTIMIZE: Optimize building structures to match local weather conditions, and transition to sustainable energy sources to minimize energy consumption.
减排：用先进系统提高能源效率，减少浪费。
REDUCE: Enhance energy efficiency through advanced systems and devices to reduce leftover energy use.



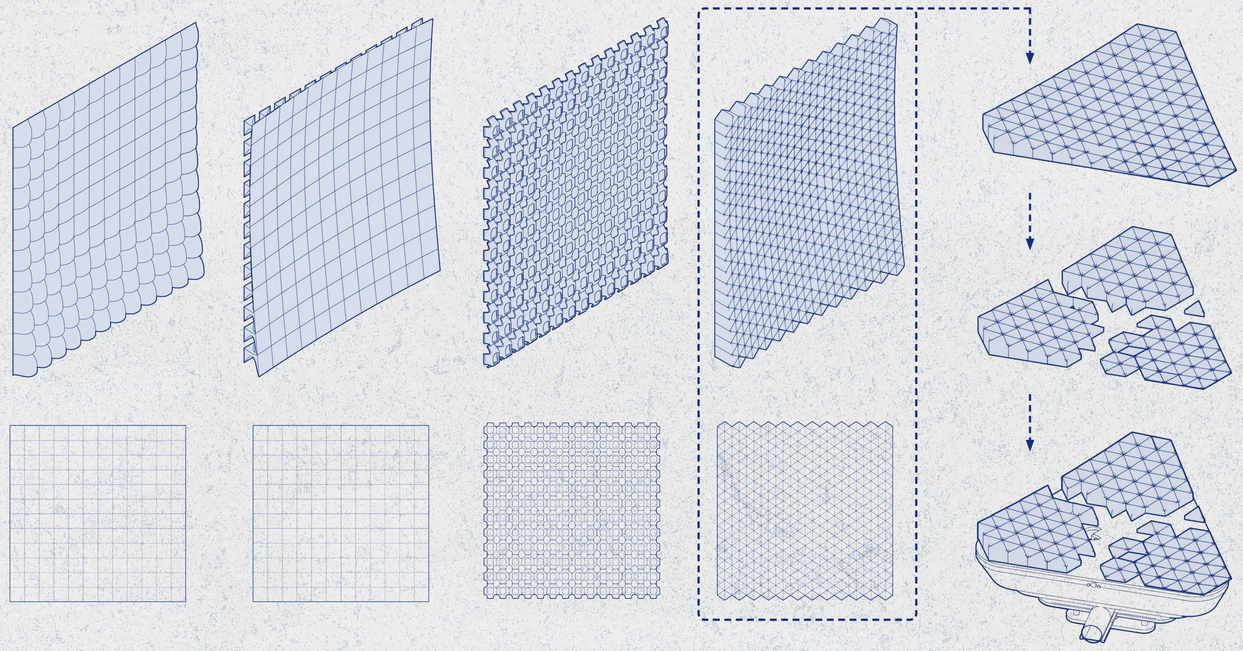






SECTION A-A'

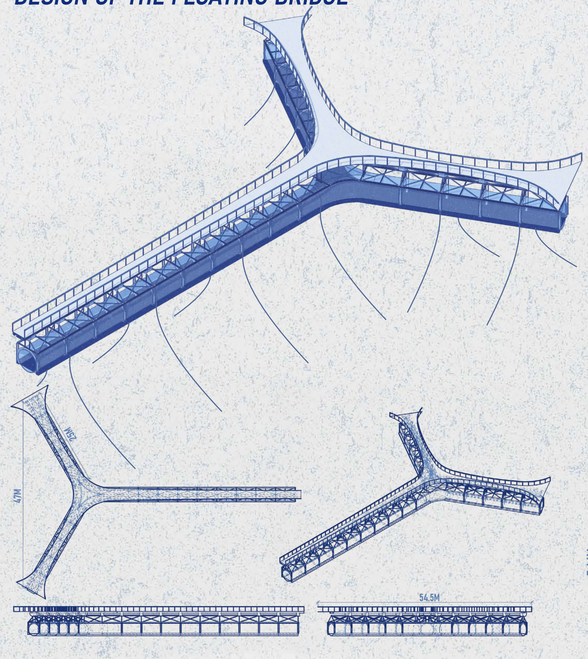
参数化屋顶
FABRICATION ROOFTOP

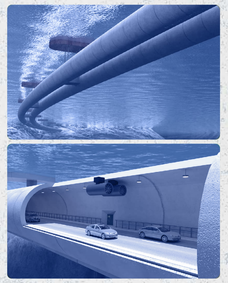


通过参数化设计，产生了许多不同的屋顶形式。它们被设计成波浪形结构，由轻型高强度钢结构框架构成，可以创造出不同的地形，并在上面种植不同高度的植物。最后一种被确定为最终方案，因为它的三角形与建筑的设计语言相似。然后，屋顶被安装到建筑单元中。

A number of different roof forms were generated through parametric design. They are designed as wave-like structures constructed of lightweight, high-strength steel frames, so that a diverse terrain can be created and plants of different heights can be planted on them. The last one was determined as the final solution because its triangular shape is similar to the design language of the building. And then, the roof was installed into the building unit.

浮桥设计
DESIGN OF THE FLOATING BRIDGE





挪威水下浮桥
一个基础设施项目承诺在 2035 年前安装横跨峡湾的永久通道，从而缩短从挪威南部繁华港口克里斯蒂安桑到特隆赫姆的路程 (Marshall, 2016)。浮桥和海底锚的组合使结构保持了完美的平衡。

Submerged Floating Bridge, Norway
A infrastructure project promises to cut the trip from Norway's bustling southern port of Kristiansand to Trondheim, by installing permanent crossings across those fjords by 2035 (Marshall, 2016). A combination of floating pontoons and seabed anchors keeps the structure perfectly balanced.

Fig 1-2. Marshall, A. "Yes, a 'Submerged Floating Bridge' Is a Reasonable Way to Cross a Fjord." WIRED, 2016, https://www.wired.com/2016/07/submerged-floating-bridge-isnt-worst-idea-norways-ever/?utm_medium=website&utm_source=archdaily.com. Accessed 11 Nov. 2024.

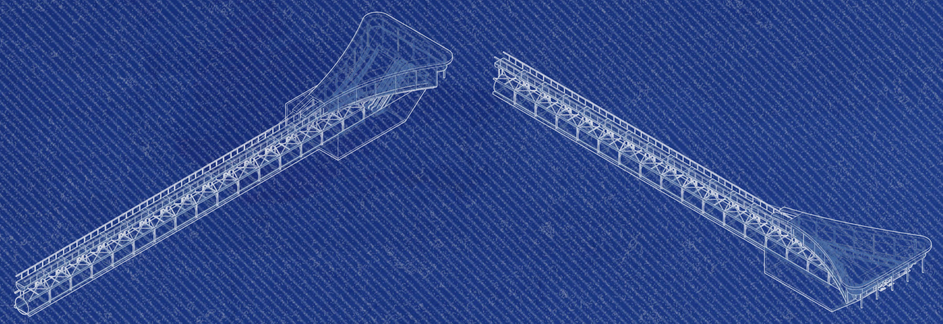
浮桥分为上下两层：上层供步行和骑自行车使用，下层由隧道组成，隧道内有专门的列车往返，通勤速度更快，隧道由钢筋混凝土制成，表面有防水涂层和钢化玻璃。与挪威 E39 高速公路的浮动隧道类似，该结构将锚定在海面以下，由漂浮在海面上的浮桥支撑，钢缆相互牵引并锚定在海床上，以避免海浪造成的过大位移。船舶、潜水艇和海洋生物可在隧道下方自由通过。

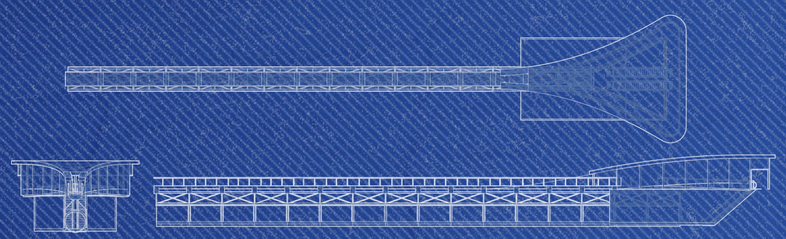
The bridge is divided into two levels: the upper level for walking and biking, and the lower level, consisting of a tunnel in which a special train travels to and from for faster commuting, which is made of reinforced concrete with waterproof coatings and tempered glass. Similar to Norway's E39 highway's floating tunnel, the structure will be anchored below the surface and supported by pontoons floating above, with steel cables pulling each other and anchoring to the seabed to avoid excessive displacement due to waves. Ships, submarines, and sea creatures could pass below the tunnel freely.

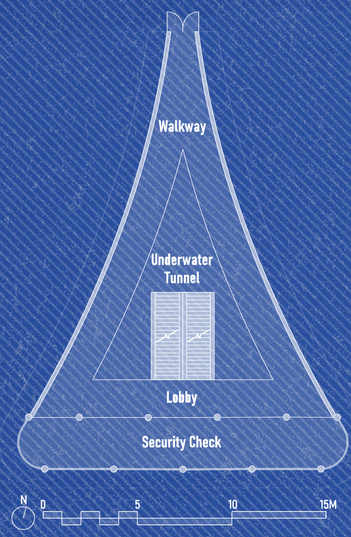
车站入口
STATION ENTRANCE

在隧道的另一侧，有一个入口用于连接厦门岛上的选址。这里建有一个简易车站，同样分为两层。安检区确保只有经过授权的人才能进入。
在上层，人们可以通过人行道步行或骑自行车前往海洋实验室，而在下层，人们可以使用水下隧道和小型列车。

On the other side of the tunnel, an entrance is used to connect to the site location on Xiamen Island. A simple station was built, again divided into two levels. A security check area ensures that only authorized people can enter the site.
On the upper level one can walk or cycle to the marine laboratory via walkways, while on the lower level one can use the underwater tunnels and compact trains.







SECTION B-B'