



让我们共同打造气候中和的未来
Building a climate-neutral future together



中华人民共和国
住房和城乡建设部



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

intep
skat

Swiss Resource Centre and
Consultancies for Development

中瑞零碳建筑研讨会 北京拱辰社区中心及资源回收利用实践

ZEB Talk – ZEB COMMUNITY CENTER in GONGCHEN RESOURCES RECYCLING UTILIZATION PRACTICE

2025年7月23日

July 23th 2025

宋晔皓，清华大学建筑学院 / 长聘教授、博导，清华大学建筑设计研究院有限公司副总建筑师，素朴工作室创始人

Prof. SONG Yehao, School of Architecture of Tsinghua University,

Deputy Chief Architect of THAD (Architectural Design and Research Institute of Tsinghua University Co., LTD

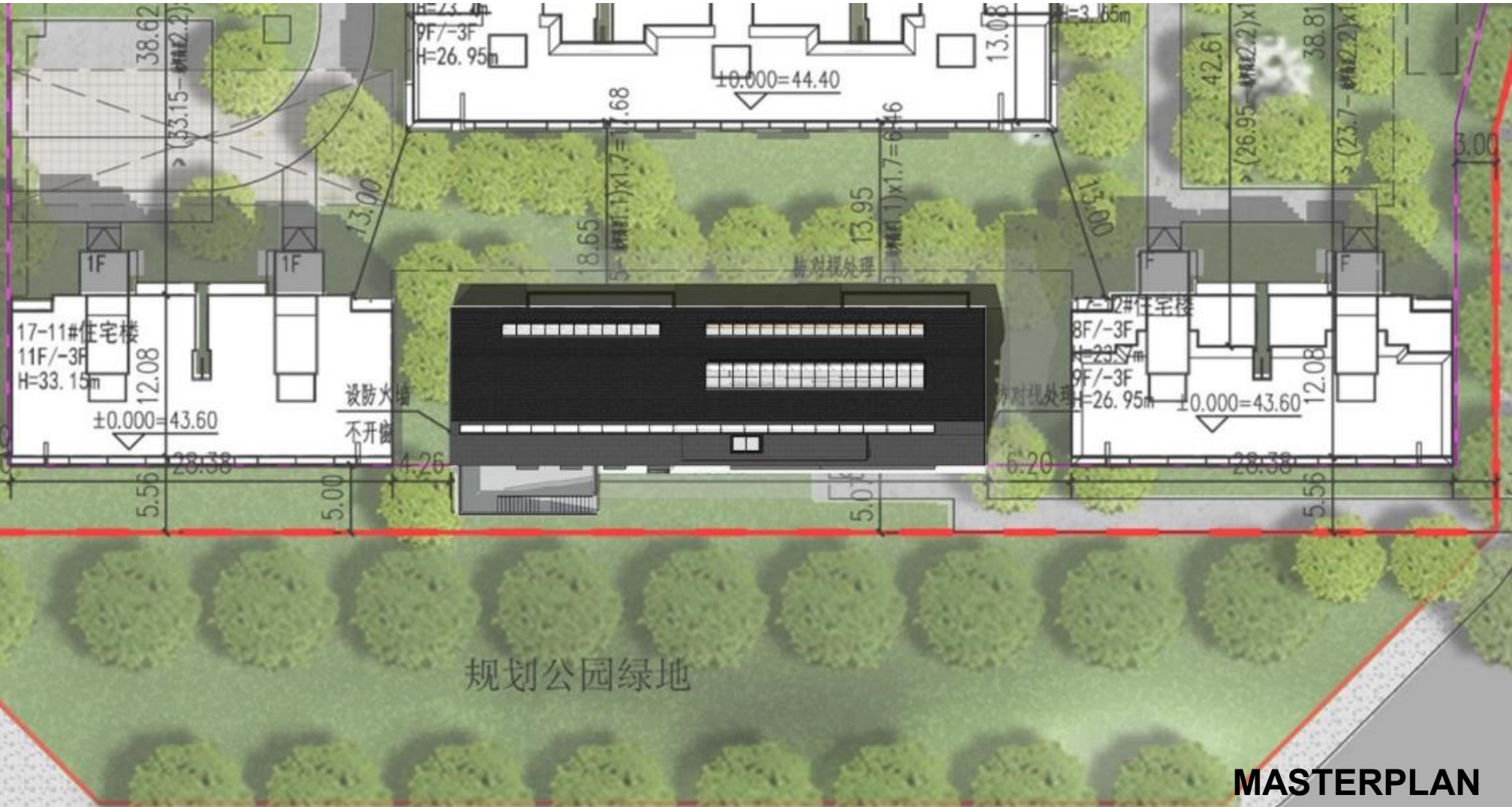
Founder of the SUP Atelier of THAD

ZEB COMMUNITY CENTER, GONGCHEN 北京拱辰社区中心

Beijing, Fangshan District, 2023
北京房山区, 2023



项目区位与场地
Project Location and Site





适度开放，接触自然

**Moderate openness, contact
with nature**



畅享日光，自然通风

**Enjoy natural sunlight and
ventilation**

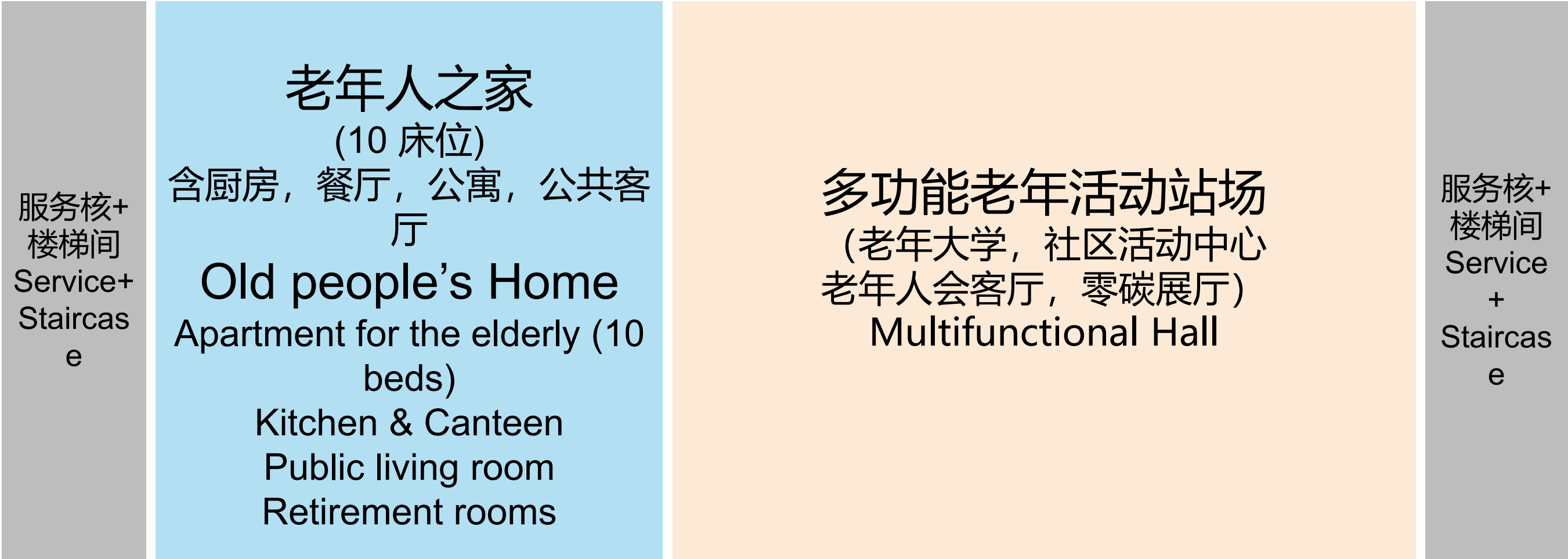


服务社区，尊重人文

**Serving the community, respecting
humanity**



分区策略： 为不同定位和性质的空间设定不同的温湿度， 从使用原则上减小建筑能耗
Zoning Strategy: Temperature and Humidity in different spaces

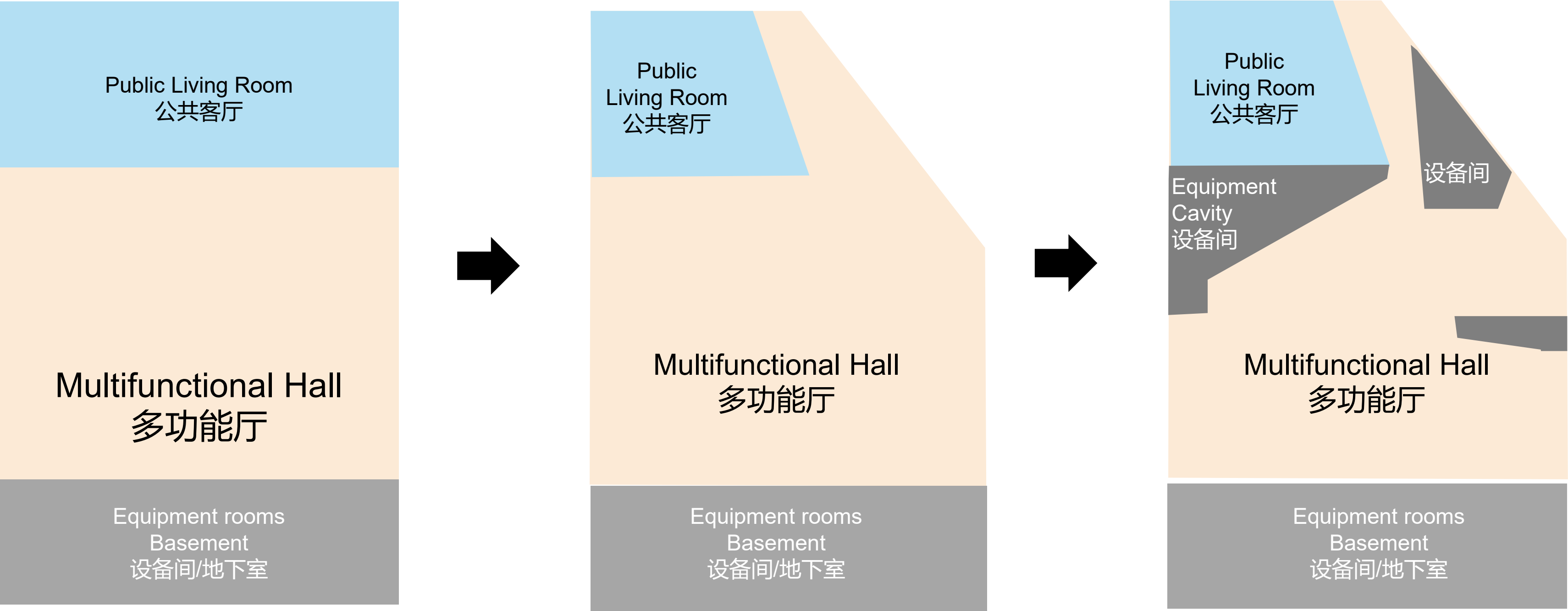


从建筑设计上减少能耗

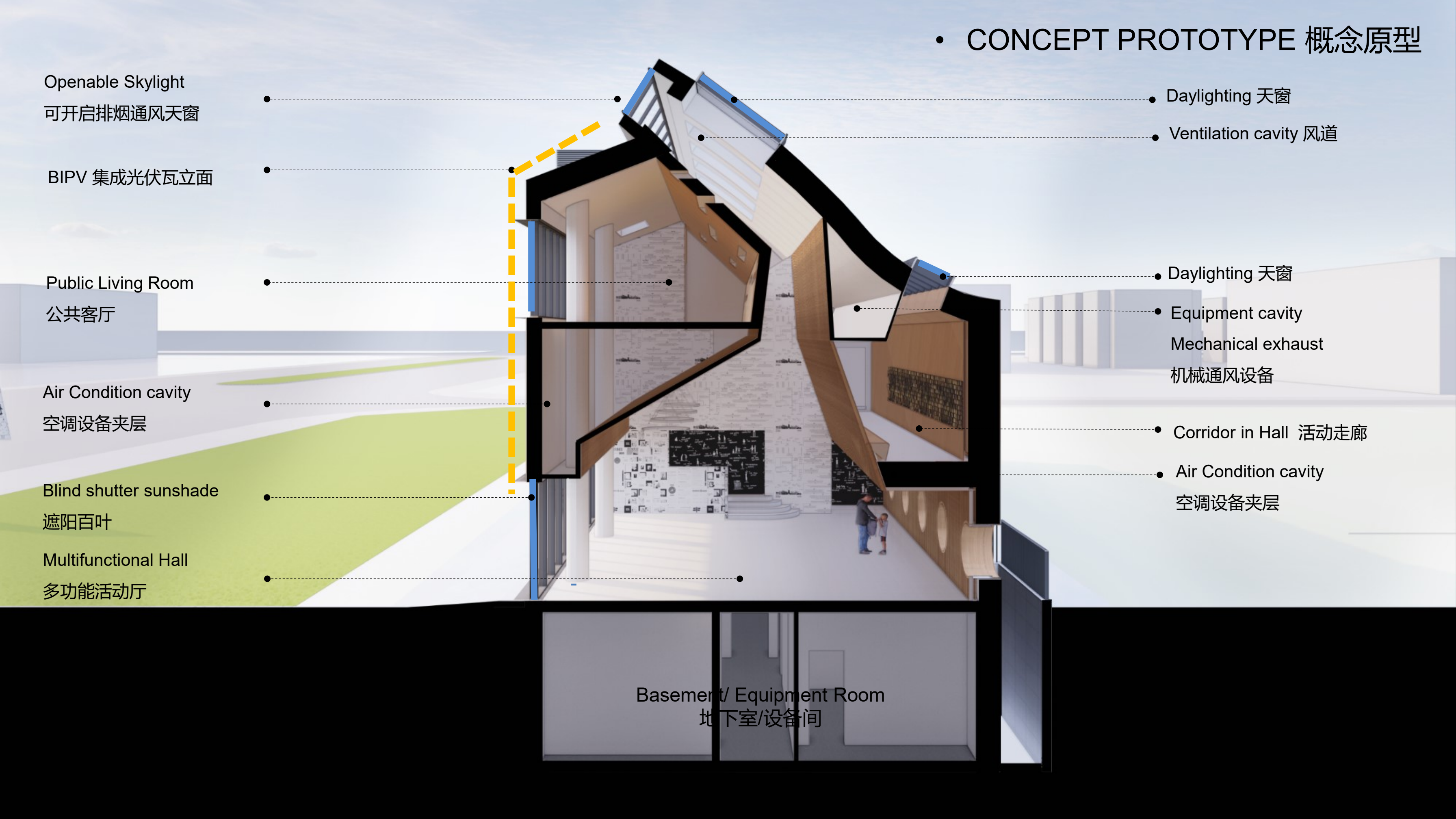
Reducing energy consumption through architectural design

分区控制 + 压缩体积

Partition control + Volume compression



• CONCEPT PROTOTYPE 概念原型



Openable Skylight
可开启排烟通风天窗

BIPV 集成光伏瓦立面

Public Living Room
公共客厅

Air Condition cavity
空调设备夹层

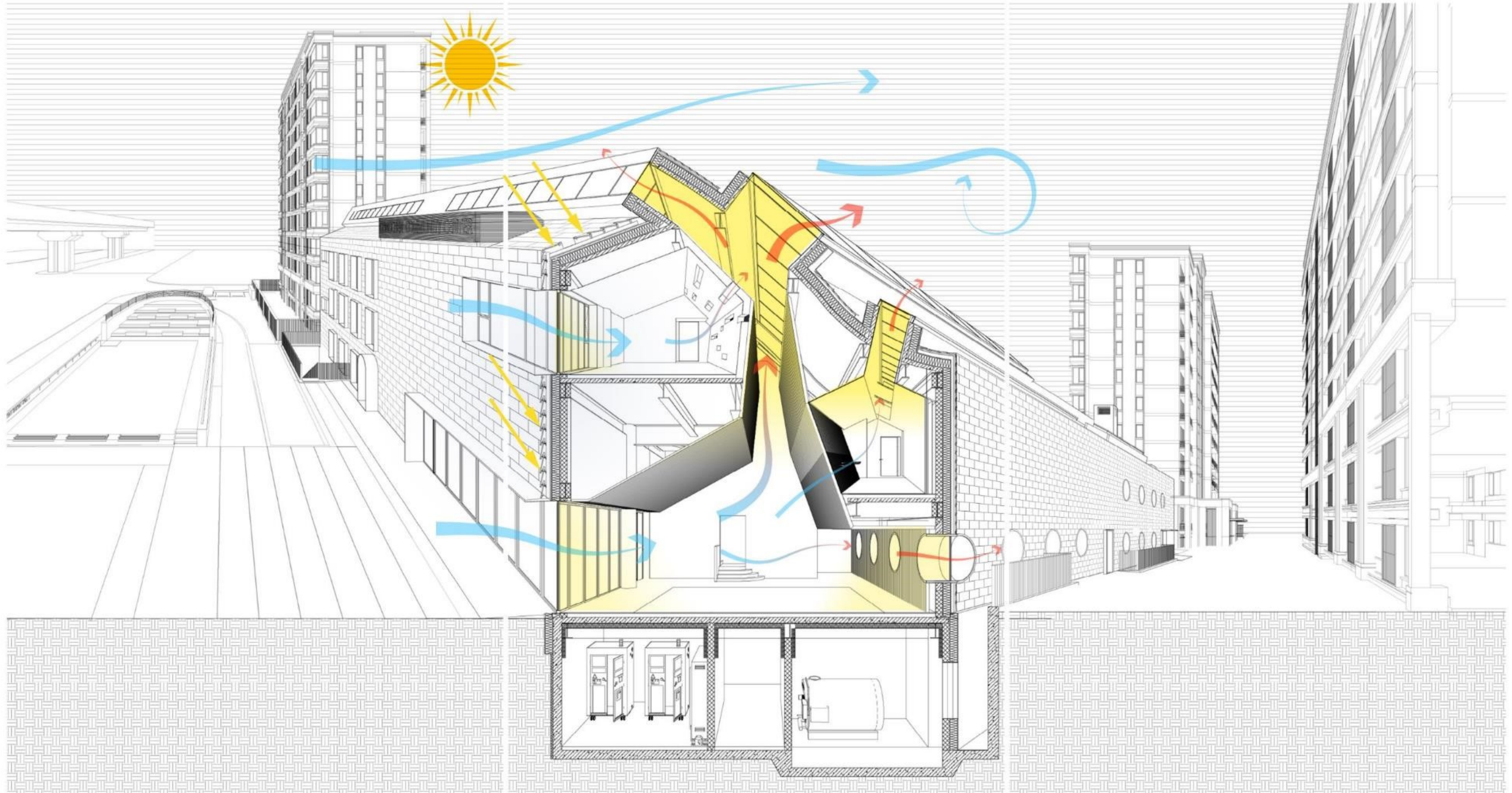
Blind shutter sunshade
遮阳百叶

Multifunctional Hall
多功能活动厅

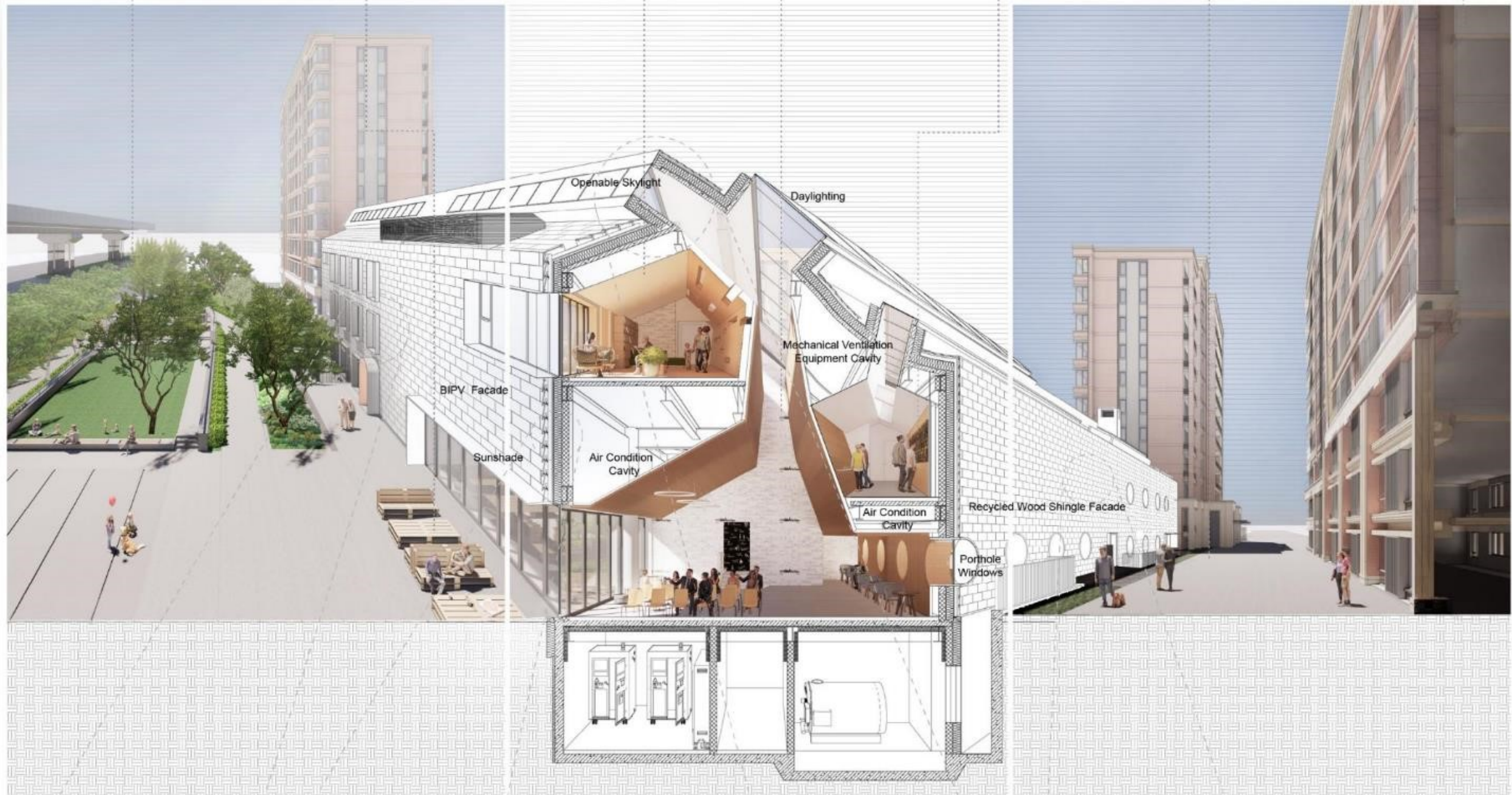
Basement/ Equipment Room
地下室/设备间

Daylighting 天窗
Ventilation cavity 风道

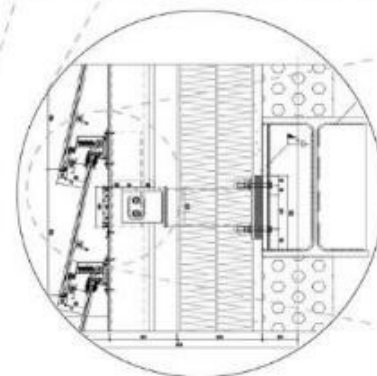
Daylighting 天窗
Equipment cavity
Mechanical exhaust
机械通风设备
Corridor in Hall 活动走廊
Air Condition cavity
空调设备夹层



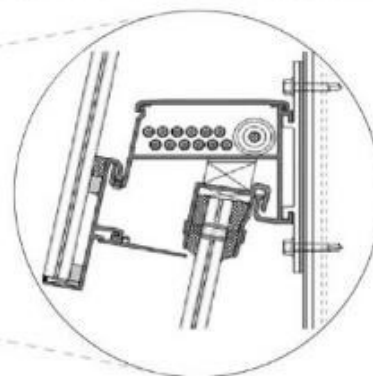
Public Rainwater Garden Public Gathering Space Public Living Room Multifunctional Hall Exhibition Corridor Inside the Community Residential Building



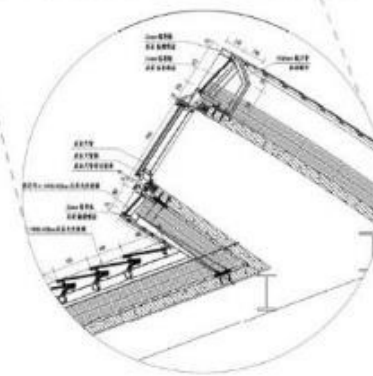
BIPV facade and roof



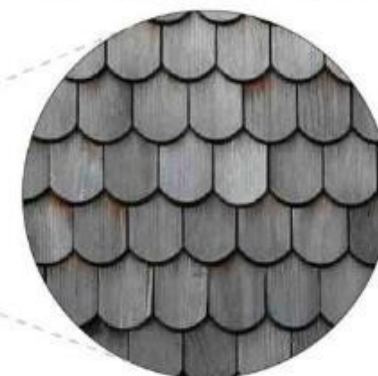
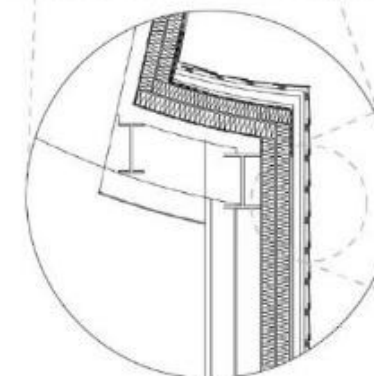
The detailed drawing of BIPV wall



The detailed drawing of the skylight

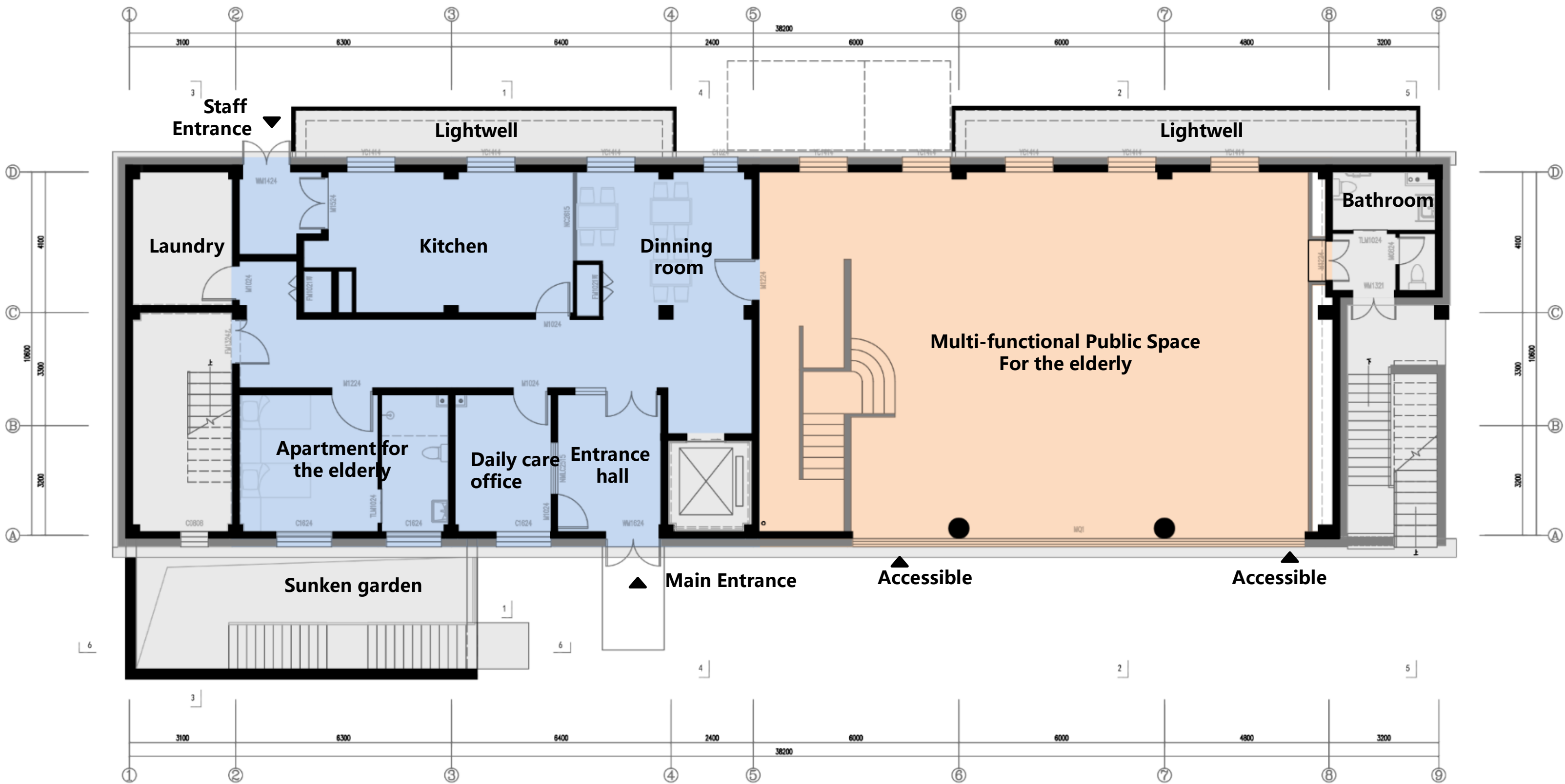


The detailed drawing of the shingle facade

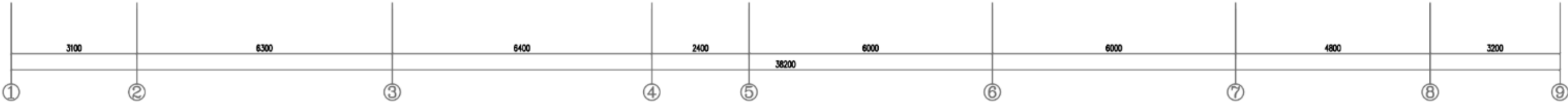
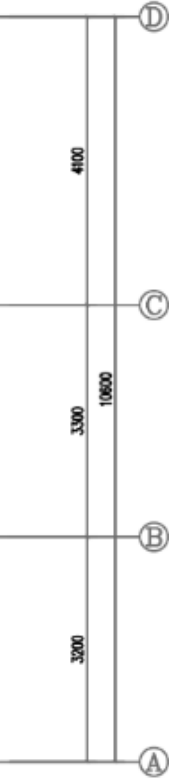
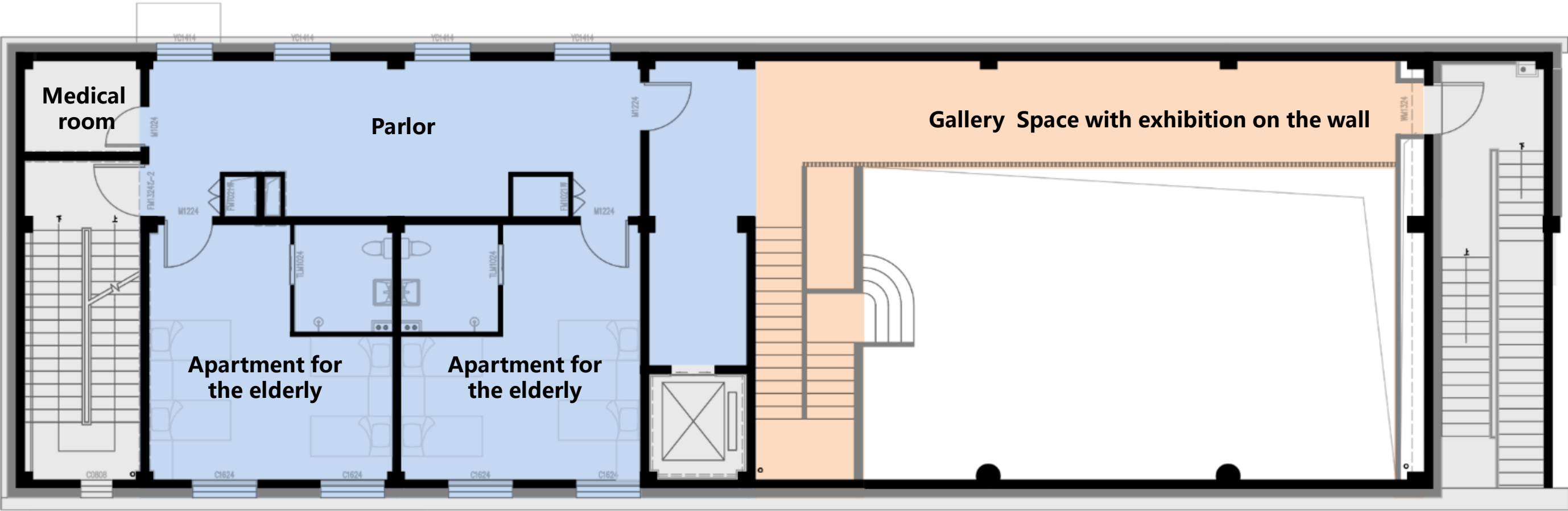
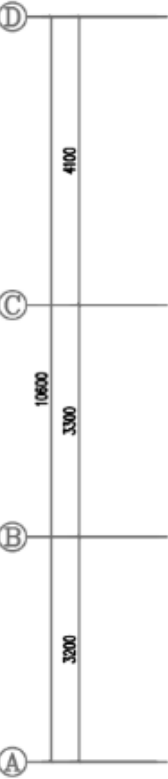
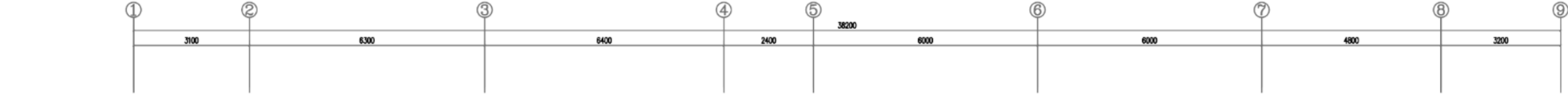


Recycled wood shingle facade and roof

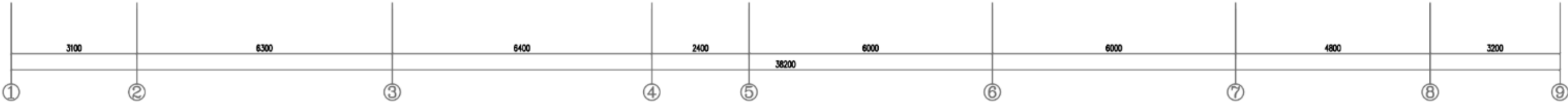
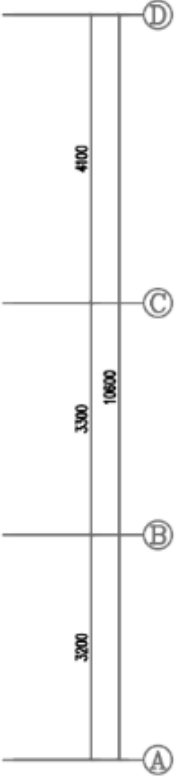
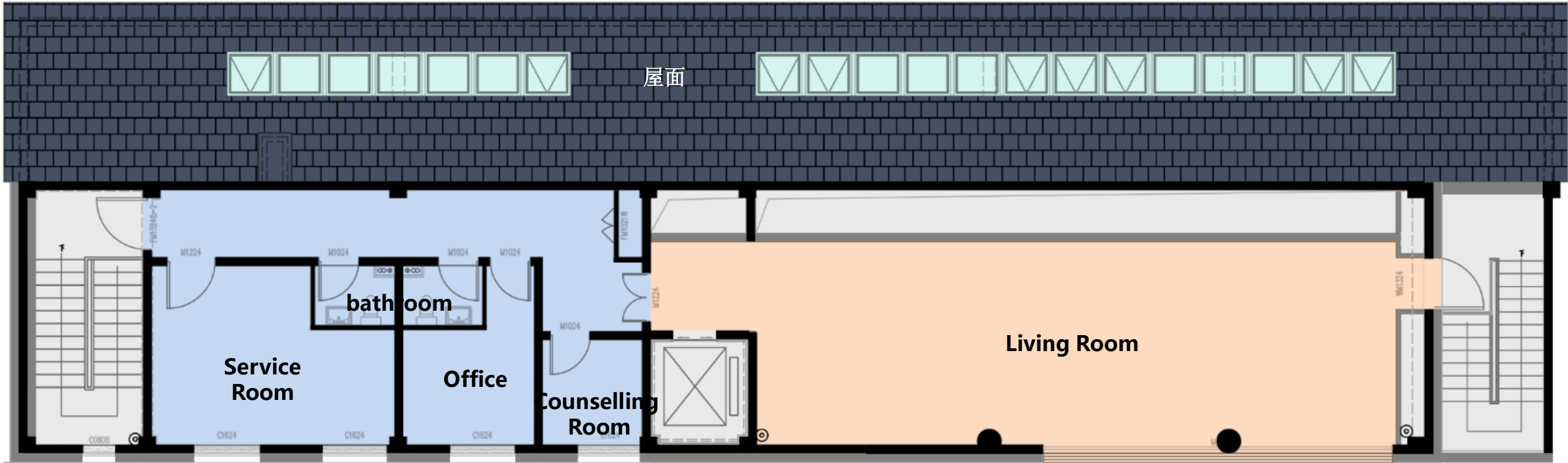
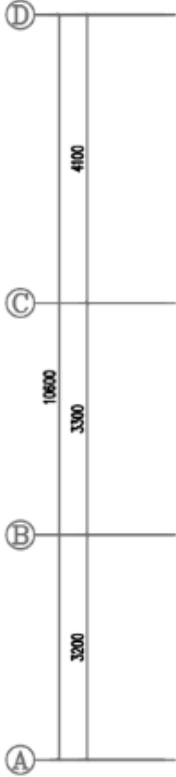
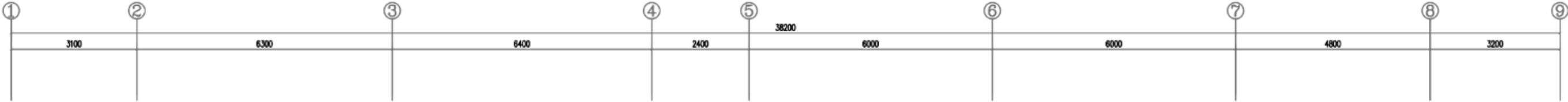
1st FLOOR



2nd FLOOR



3rd FLOOR



Southeast View
东南视角



Northeast View
东北视角



一层公共大厅
First floor
public hall



一层公共大厅
First floor
public hall



二层走廊展厅
Second Floor
Corridor
Exhibition Hall



二层走廊休息区
Second floor
corridor rest
area



二层老人公寓
Second floor
Retirement
room



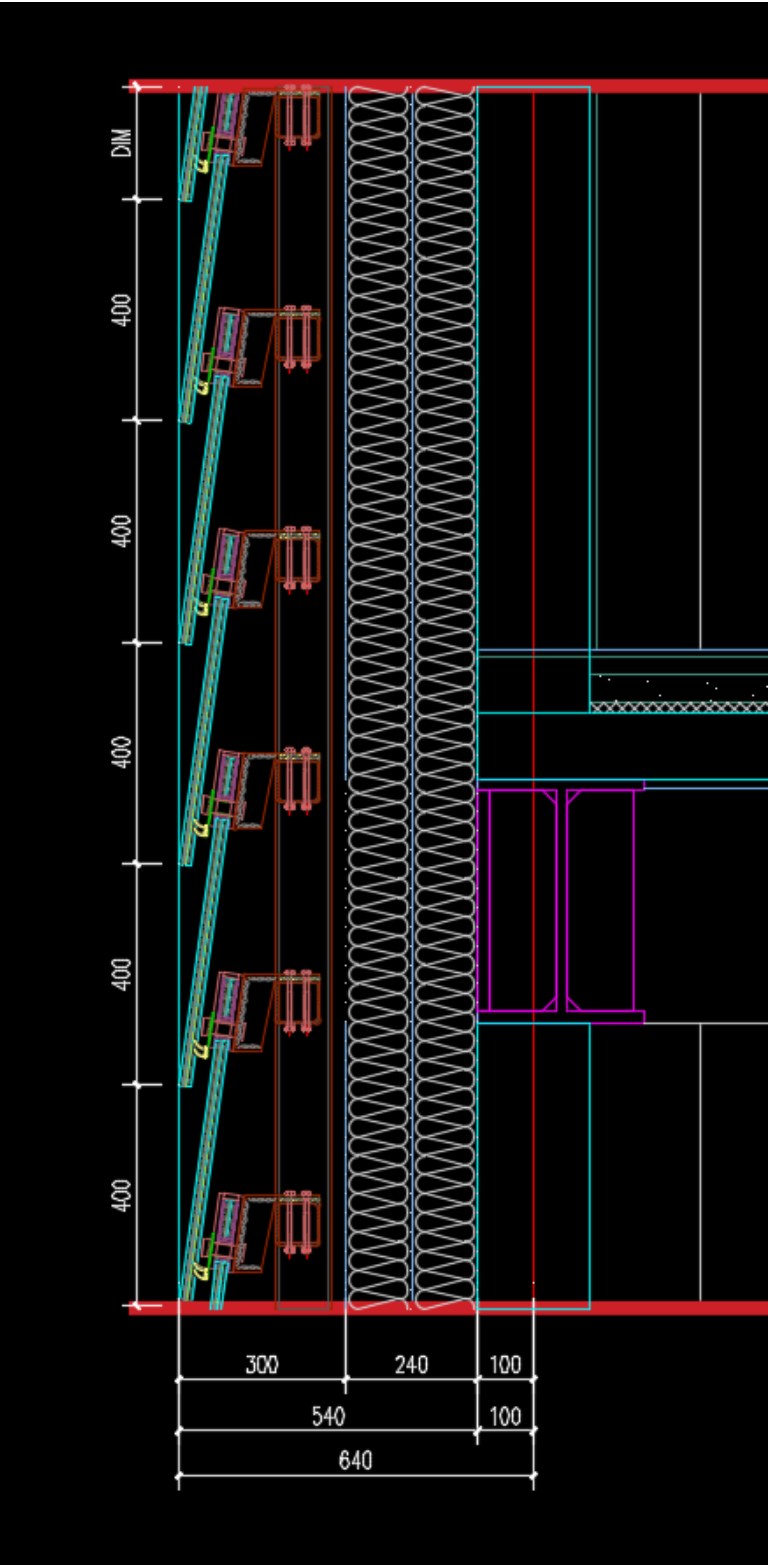
三层共享客厅
Third floor
shared living
room



立面屋顶一体化：镜面光伏瓦与环境的互动
Photovoltaic panels on the south façade and south-side roof

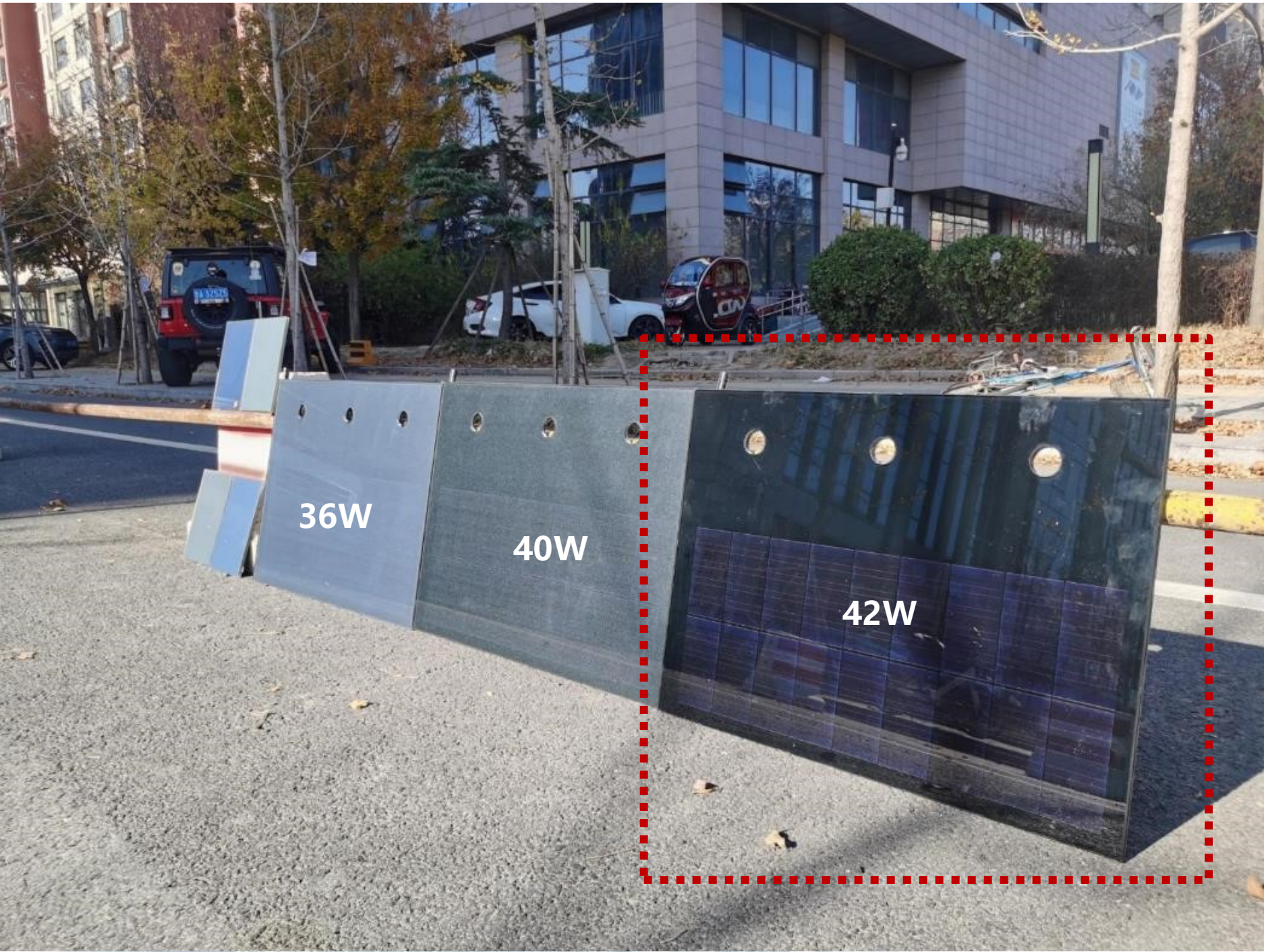


南立面关键技术-光伏建筑一体化
South Façade
BIPV System



Photovoltaic materials comparison

光伏组件对比



• 南立面关键技术-光伏建筑一体化

South Façade
BIPV System

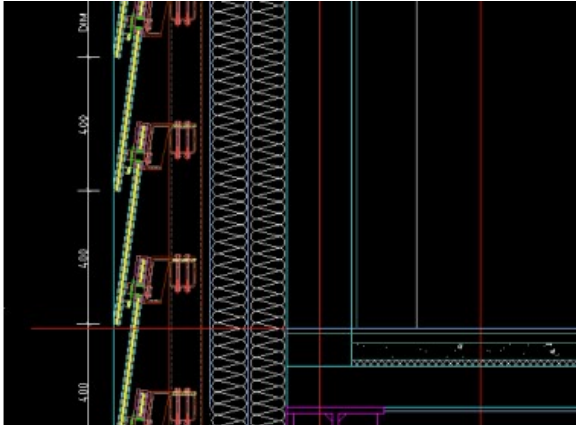
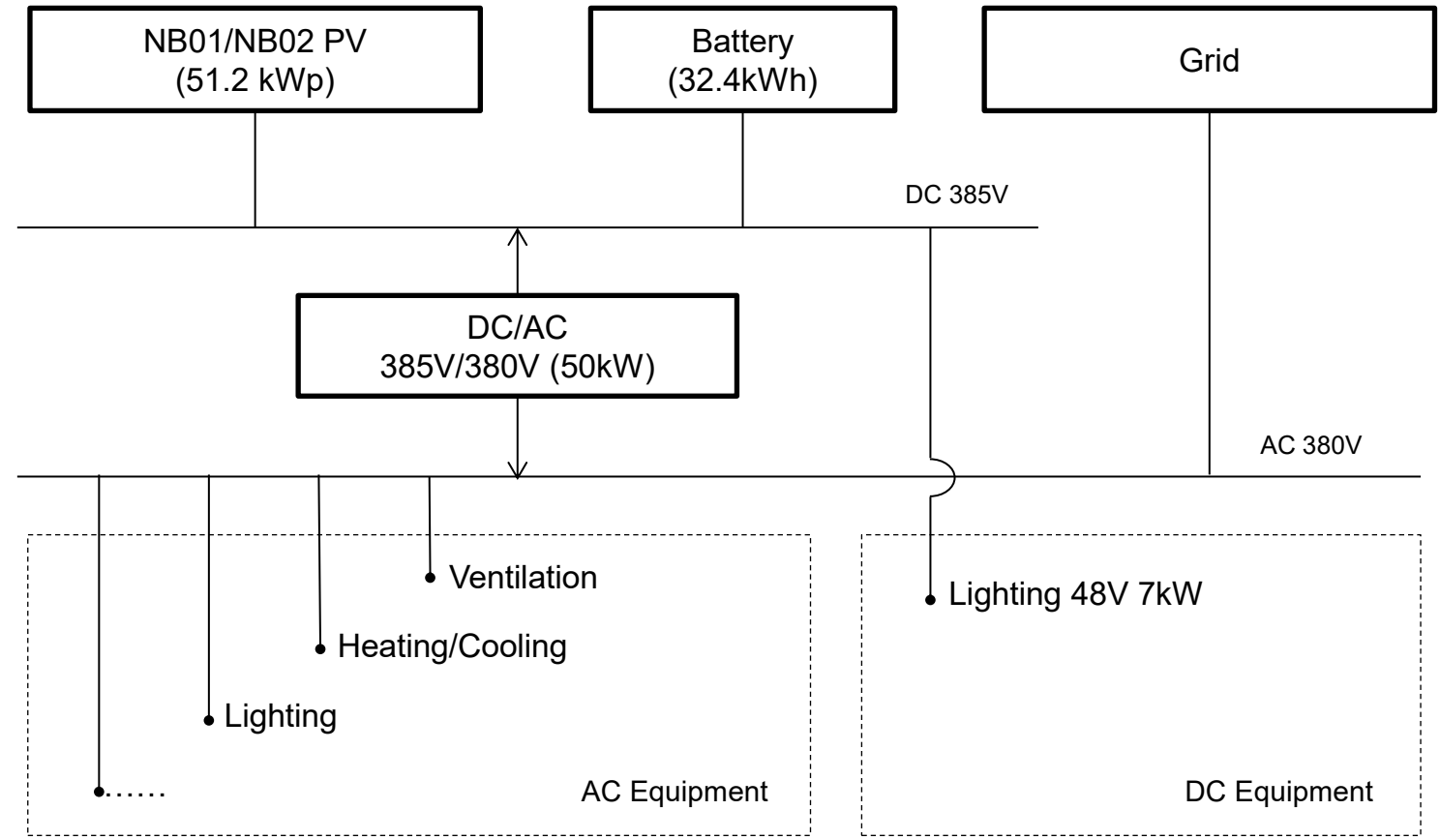
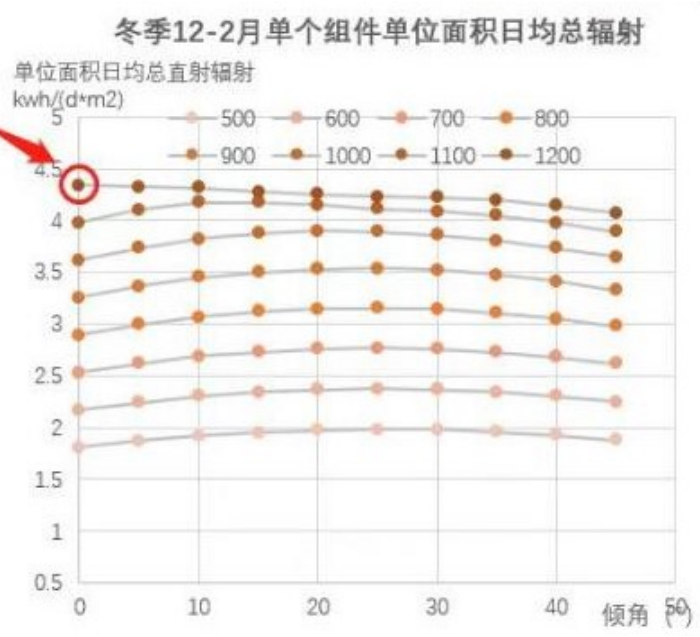
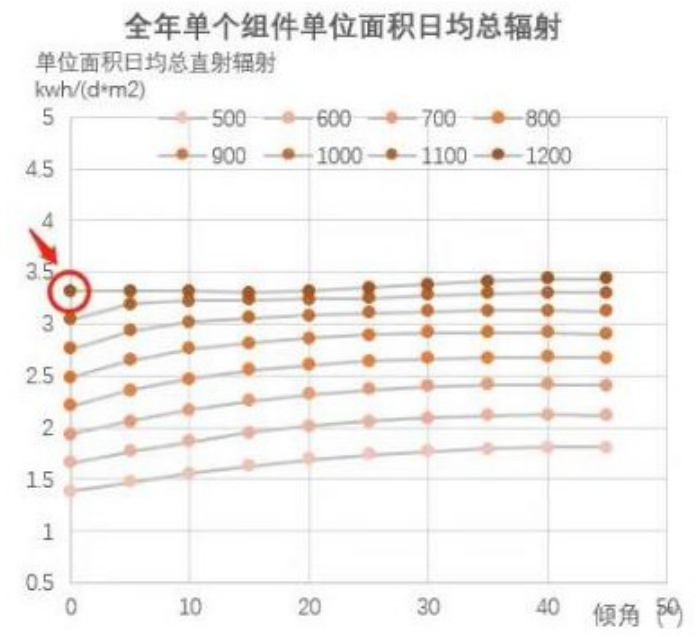
Parameters

Colour index	1262	555	1261
Power (W)	40	36	42
Peak voltage (V)	10.1	9.91	10.1
Peak current (A)	3.96	3.63	4.16
Open circuit voltage (V)	11.9	11.7	11.9
Short circuit current (A)	4.18	3.83	4.37



• 南立面关键技术-光伏建筑一体化

South Façade
BIPV System

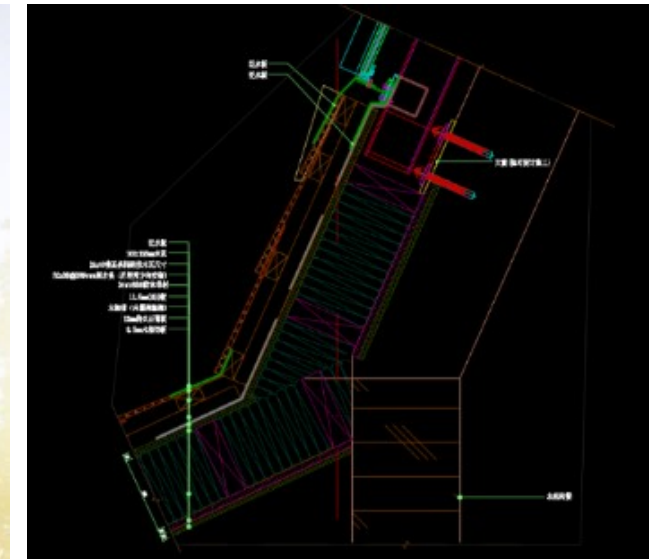


- 北立面-低蕴能量建材

North facade

回收木材，处理成碳化木（烧杉板），瓦片式单元安装

built with Recycled timber



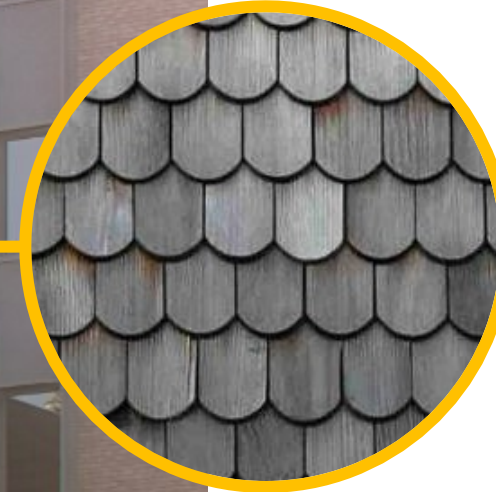
- 北立面-低蕴能量建材

North façade – Low embedded carbon material

回收木材，处理成碳化木（烧杉板），瓦片式单元安装

Recycled wood processed into carbonized shingle

回收木料碳化木瓦





East Façade
built with Recycled Pipes
东立面采用回收管材建造



东立面楼梯间的回收钢管墙面
East Façade
built with Recycled Pipes

DN 1200
DN 1000
DN 800

DN 500
DN 300

DN 200
DN 120

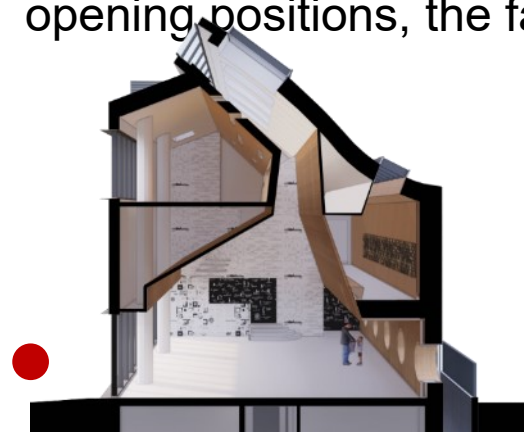


关键技术-自然通风采光优化

Key Technology - Natural Ventilation and Daylighting Optimisation

本项目东、西、北侧均有高层居住建筑遮挡。经过不同开启位置模拟，立面窗+高侧窗的模式可以有效提升室内空气扰动。

The east, west, and north sides of this project are all blocked by high-rise residential buildings. After simulating different opening positions, the facade window + high side window model can effectively improve indoor air circulation.



工况一：

打开南侧窗

室内几乎无风。
自然通风效果
不明显。



工况二：

打开南北两侧窗

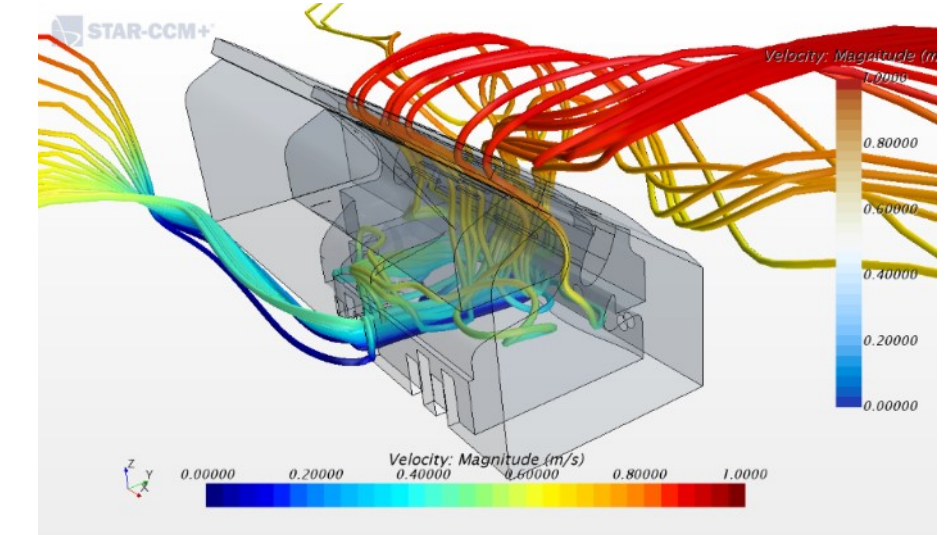
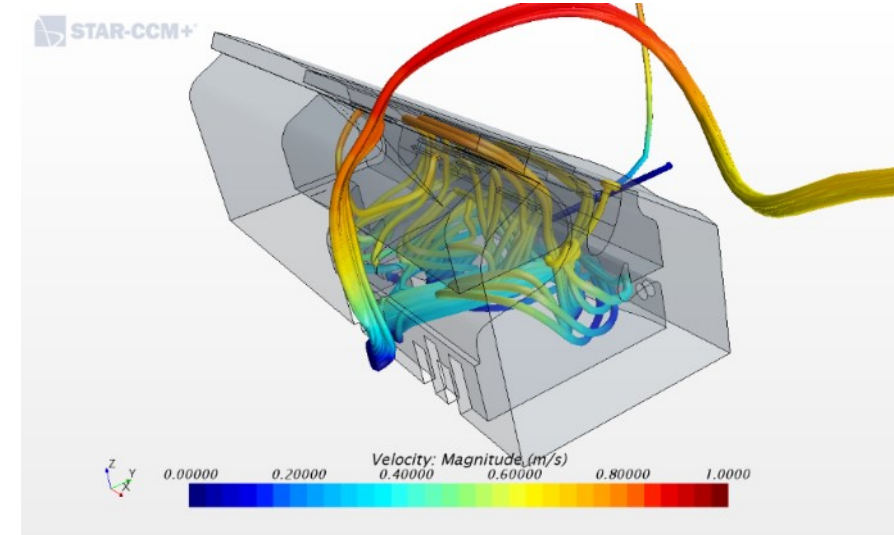
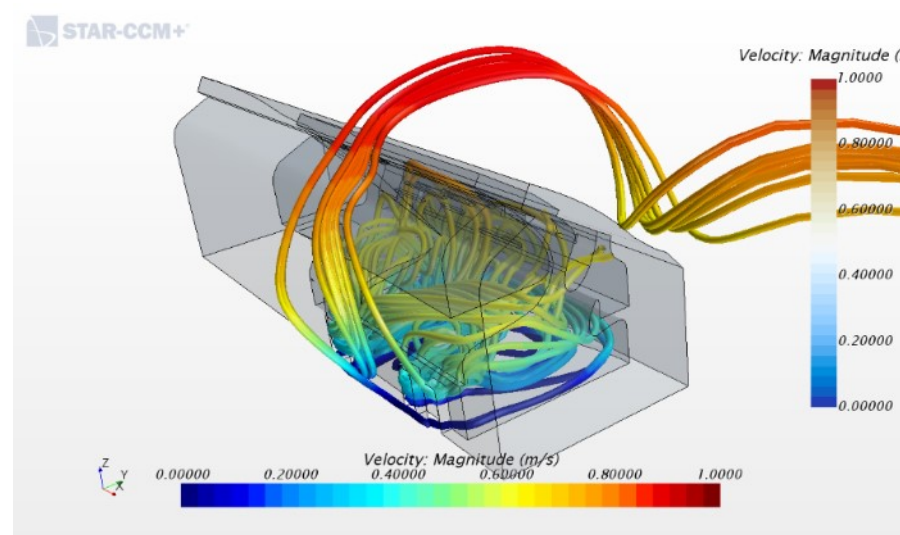
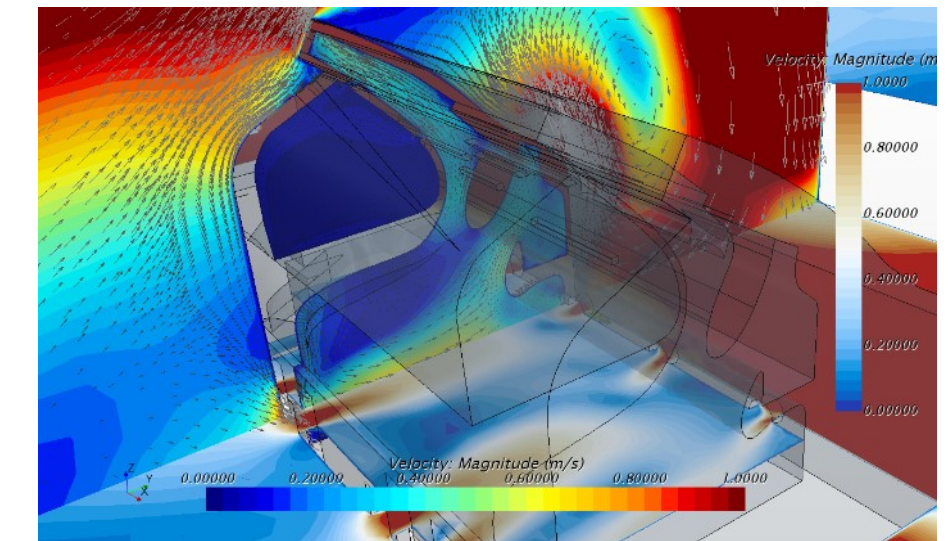
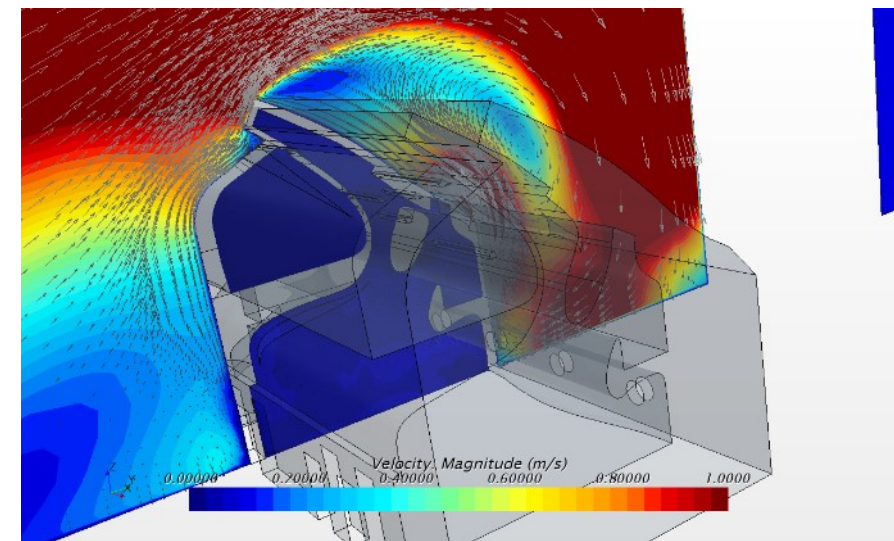
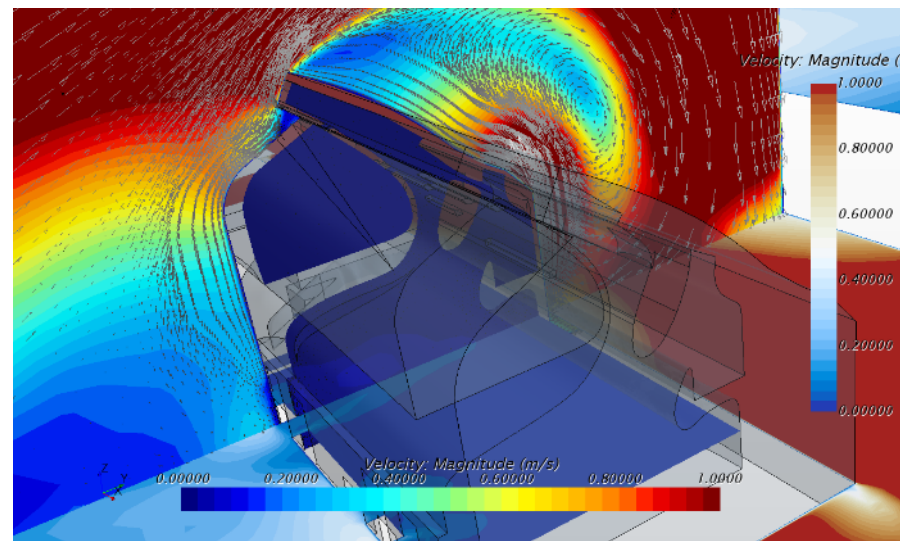
受北侧住宅影响，
南北对流自然通风
效果不明显。



工况三：

打开南北两侧窗及天窗

屋顶开启，利用负压，自然
通风效果明显。一层公共活
动区域有微风。



关键技术-自然通风采光优化

Key Technology - Natural Ventilation and Daylighting Optimisation

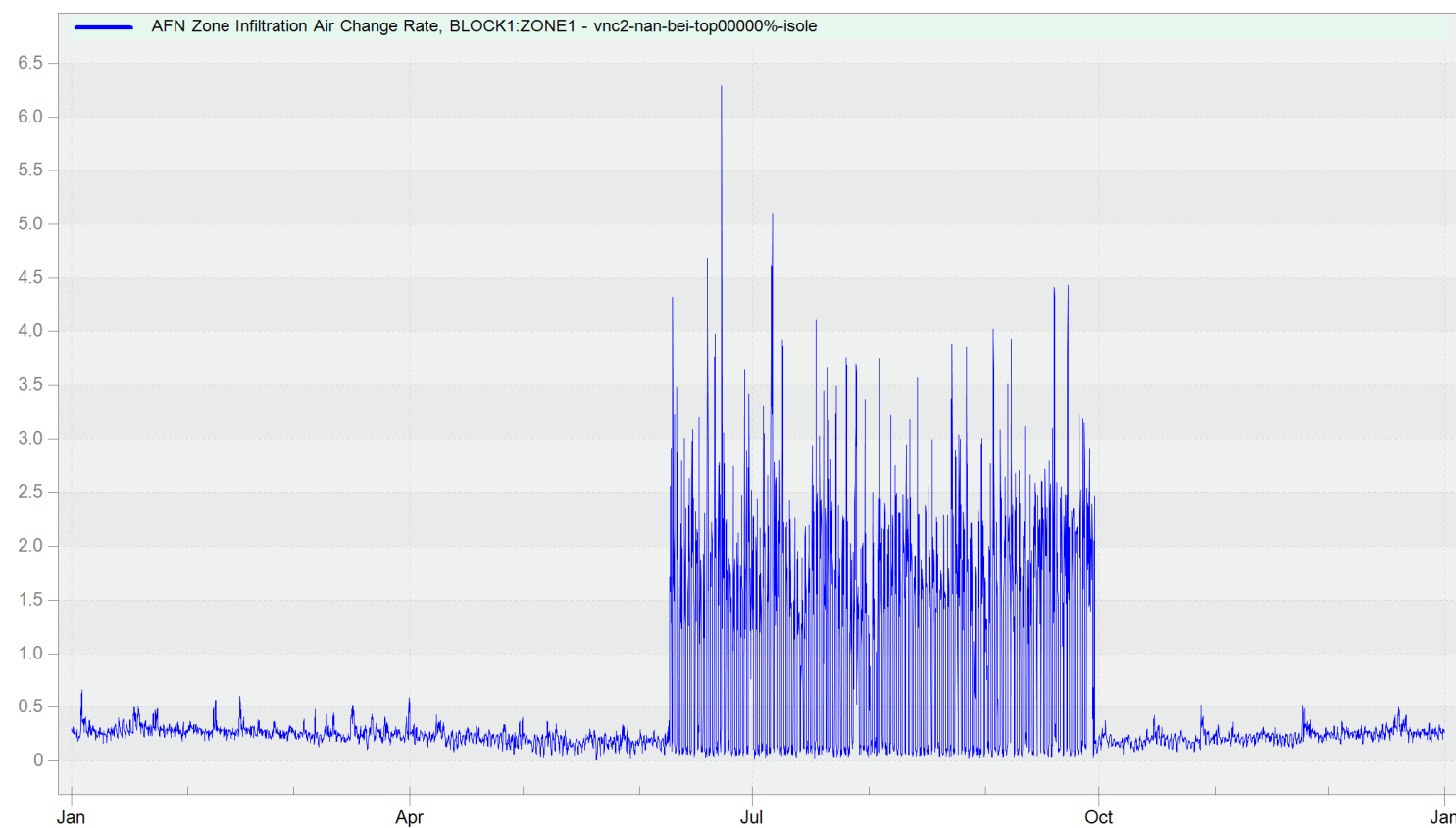


针对多功能大厅建筑利用“烟囱效应”及环境风压特点，采用高侧窗解决排烟及热空气排除，促进建筑内部自然通风效率。考虑到多功能厅晚上无人，可以利用夜间通风，降低建筑整体温度，达到次日空调能耗降低的效果。

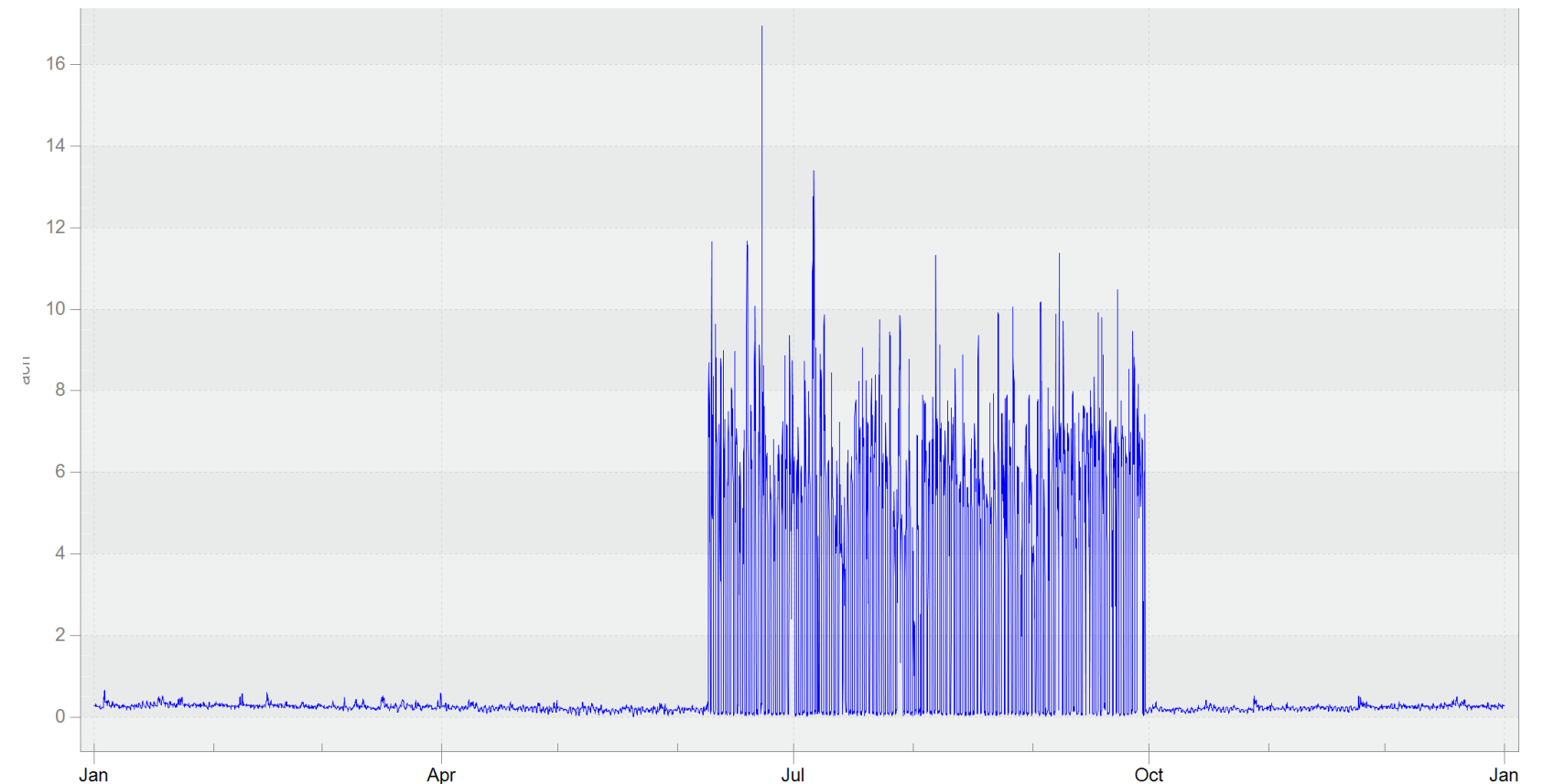
经模拟计算，夏季高侧窗开启10%，将比只有南北开窗提升约3倍通风效率。考虑到多功能厅晚上无人，可以利用夜间通风，降低建筑整体温度，达到次日空调能耗降低的效果。只有南北开窗夜间通风可使多功能厅制冷能耗降低10.6%；如果南北及高侧窗均开启，制冷能耗可以降低18.7%。

The multifunctional hall improves natural ventilation by using high clerestory windows based on the stack effect and wind pressure. Night ventilation (when the hall is unoccupied) helps reduce indoor temperature and cooling energy use.

南北开窗5%



南北开窗5%+高侧窗10%



关键技术-自然通风采光优化

Key Technology - Natural Ventilation and Daylighting Optimisation

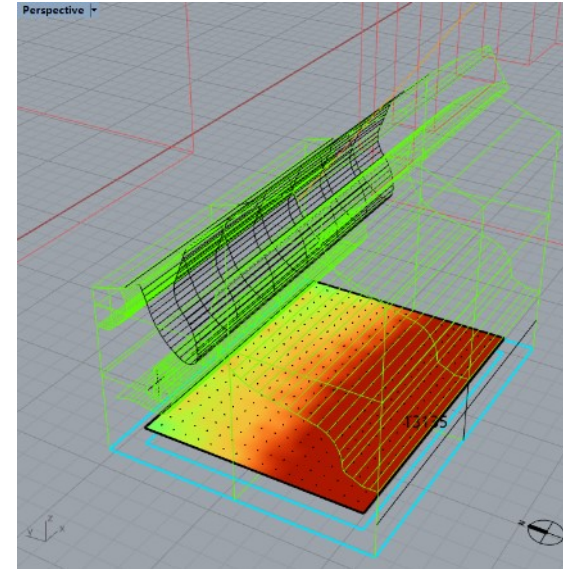
全年平均照度来看，天光与遮阳结合能够提升室内自然光均匀性，营造舒适光环境。光线均匀度提升32%，直射炫光区降低至0%，同时室内照度较单独遮阳条件下提升50%。

节点模拟来看，南侧遮阳可以有效的降低空间照度分布不均问题、天窗可以提升内部均匀照度。天窗设计可以提升中部室内照度120%，有效解决了原来照度分布不均的问题。

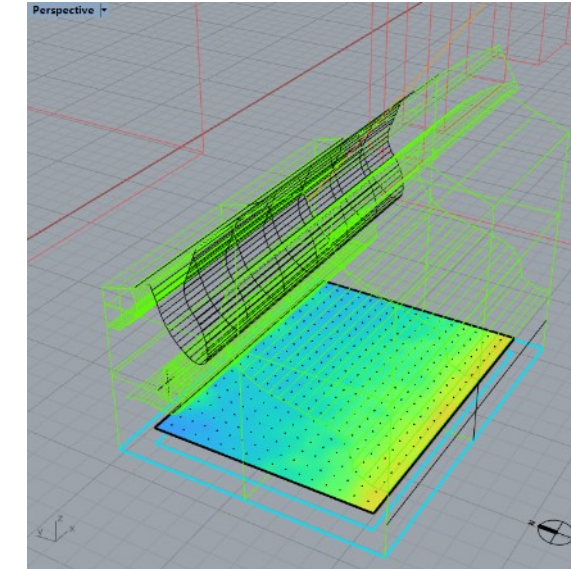
Combining daylighting with shading significantly improves indoor lighting conditions:

- Light uniformity increases by 32%.
- Glare zones are eliminated (0% direct glare).
- Overall illuminance increases by 50% compared to using shading alone.
- South-facing shading balances light distribution.
- Skylights improve central zone illuminance by 120%, solving uneven lighting issues.

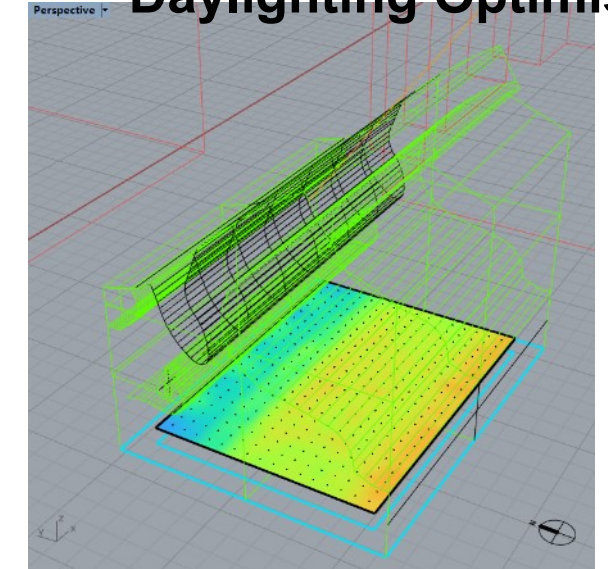
全年平均照度模拟



南北开窗
avg UDIa=54.4%
ASE1000,250=36.0%
avg lux = 4287 lux

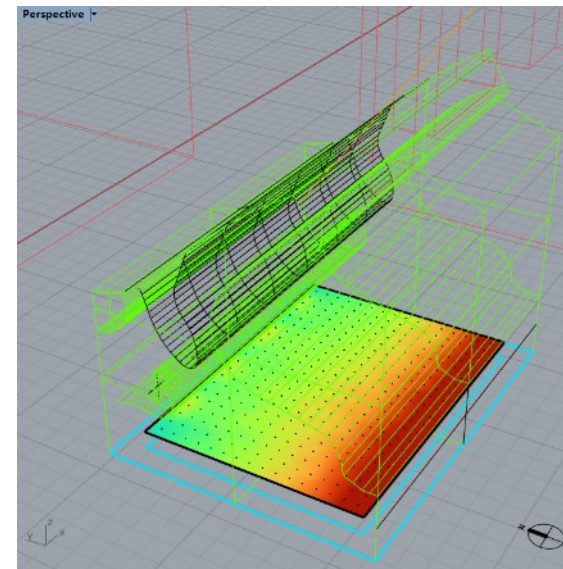


引入遮阳
avg UDIa=85.6%
ASE1000,250=0.0%
avg lux = 1024 lux

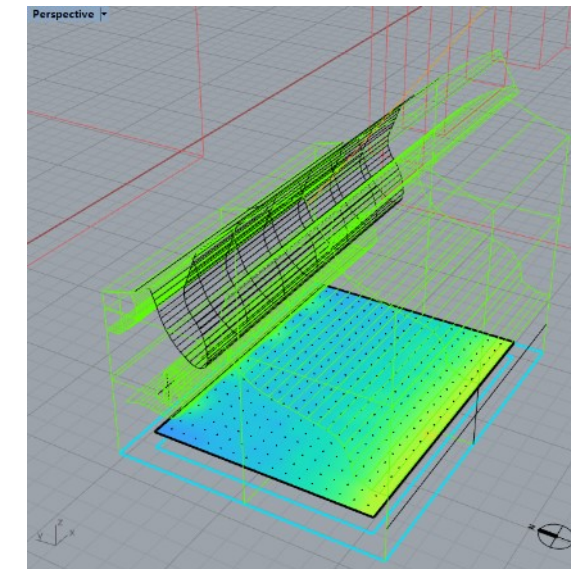


天窗辅助遮阳
avg UDIa=86.2%
ASE1000,250=0.0%
avg lux = 1505 lux

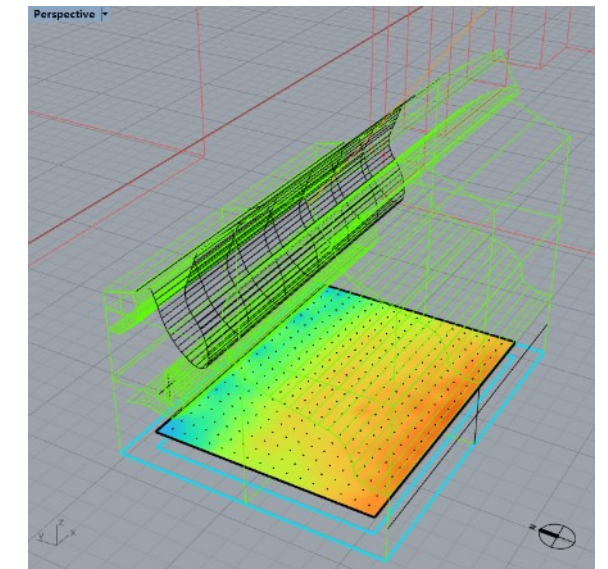
单日照度模拟（7月31日中午12点）



Mean = 1971
Median = 1718
SD = 710.9



Mean = 915
Median = 814
SD = 262.4



Mean = 1738
Median = 1835
SD = 327.8

关键技术-低蕴能量建材

Key Technology – Low-Embodied-Energy Building Materials

十年后报废
Disposed after ten years

成为建筑部件
Becomes building components

加工处理
Processing

原始材料
Raw materials

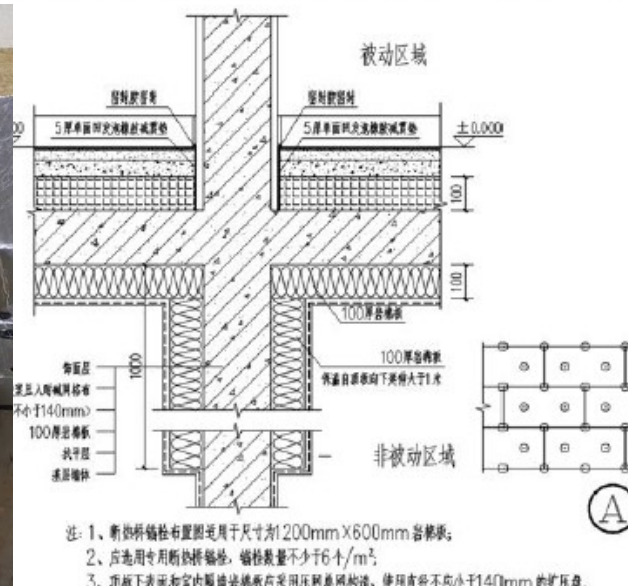
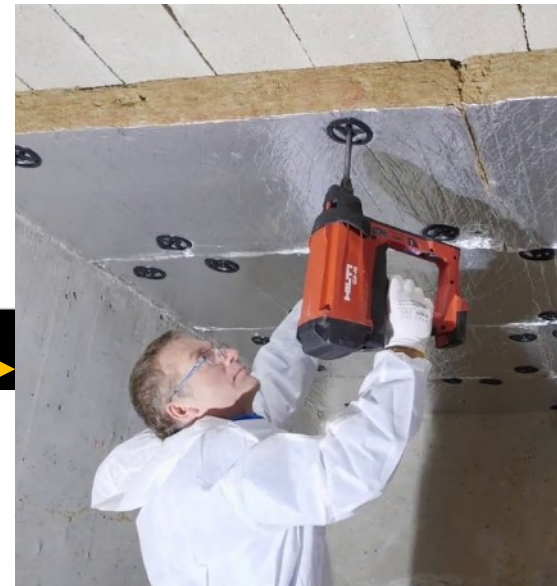
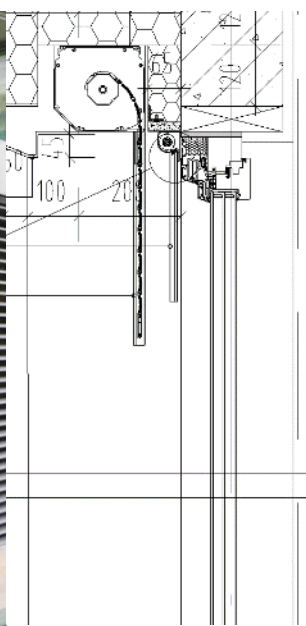
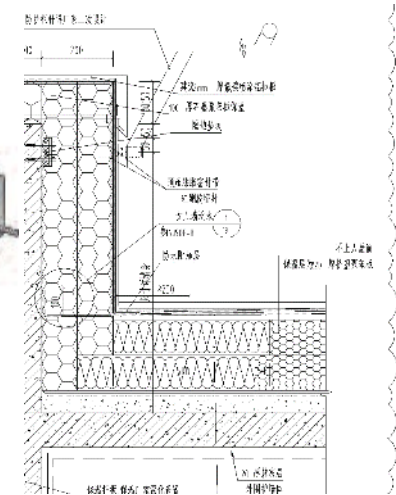
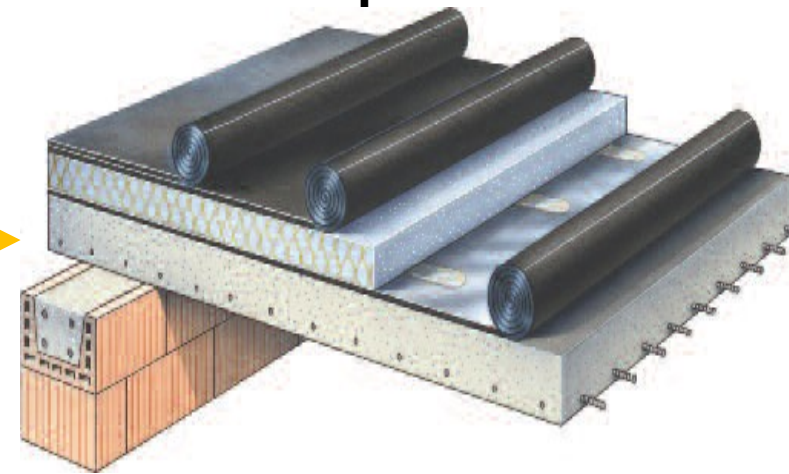
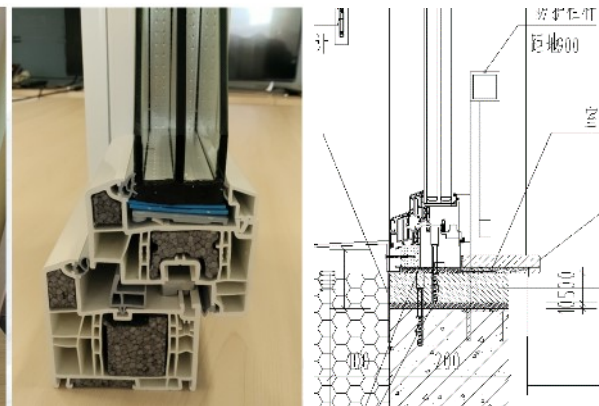
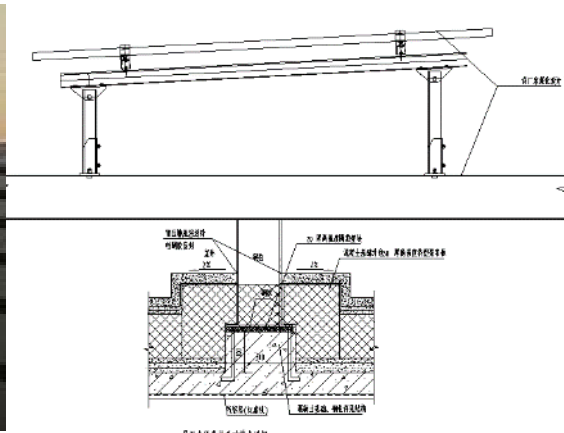


关键技术——高性能围护结构

Key Technology – High-Performance Building Envelope

高性能外围护结构无热桥及高气密性施工工艺

High-performance building envelope with thermal bridge-free and high airtightness construction techniques



- 1. 断桥铝窗框布置间距为1200mm X 600mm 窗框。
- 2. 应采用专用断桥铝窗框，窗框数量不少于64/m²。
- 3. 窗框下表面和室内侧墙漆饰板应采用压网网构造，使用直径不应小于140mm 的膨胀盘。

空气源热泵+新风全热回收 Air-Source Heat Pump + Total Heat Recovery for Fresh Air

采用高效空气源热泵作为冷热源。采用新风热回收机组分区设置，即一组用于公区，另一组用于住宅区，新风控制策略可以根据公区和住宅的不同使用情况进行“因地制宜”般的优化。

An efficient air-source heat pump is used as the heating and cooling source. Fresh air heat recovery units are installed in zones — one set for public areas and another for residential areas. The fresh air control strategy can be optimized in a site-specific manner according to the differing usage patterns of the public and residential zones.

设备	备注	位置
空气源热泵 室外机	采用超低温空气源热本，冬季 名义工况能效比不低于 2.3	室外花园与景观结合
终端	风盘/地暖辐射系统	夏季风盘制冷：壁挂式或悬挂式 冬季地暖辐射系统采暖：装配式或浮筑 楼板
新风热回收 系统	设置两组分别用于公区和住宅 区，全热回收效率 > 70% 新风量30 m³/p/h	地下室新风机组机房

关键技术——高效冷热源及新风热回收机组
Key Technology – Efficient Heating & Cooling Sources and Fresh Air Heat Recovery Units



关键技术——智能照明与遮阳控制

Key Technology – Intelligent Lighting and

全建筑采用智能照明系统，装备调光灯具及照度传感器。

设置：

优先享用自然采光，立面外窗及北坡面外窗。

自然采光不足时，采用照度补偿

- 恒照度控制:电气照明补偿照度保证在75cm高度的工作平面照度不低于300 lux。

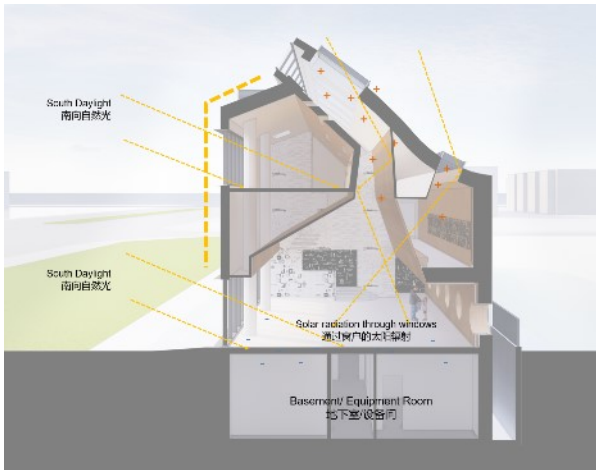
- 运行：7/7天运行

智能照明相对72节能建筑照明节能率约为 60%

The entire building is equipped with an intelligent lighting system, featuring dimmable fixtures and illuminance sensors. Setup: Priority is given to natural daylight, utilizing façade windows and north-facing slope windows. When natural daylight is insufficient, illuminance compensation is applied: Constant illuminance control: Electrical lighting supplements the illuminance to ensure that the work plane at 75 cm height maintains at least 300 lux. Operation: 7 days a week Compared to lighting in a standard 72-compliant energy-saving building, the intelligent lighting system achieves approximately 60% energy savings.

在零碳建筑中，高性能的外围护结构使得照明热扰难以散出室外。采取智能照明既能减少照明能耗又能降低制冷能耗。

In zero-carbon buildings, high-performance building envelopes make it difficult for heat generated by lighting to dissipate outdoors. Using intelligent lighting not only reduces lighting energy consumption but also helps lower cooling energy consumption.

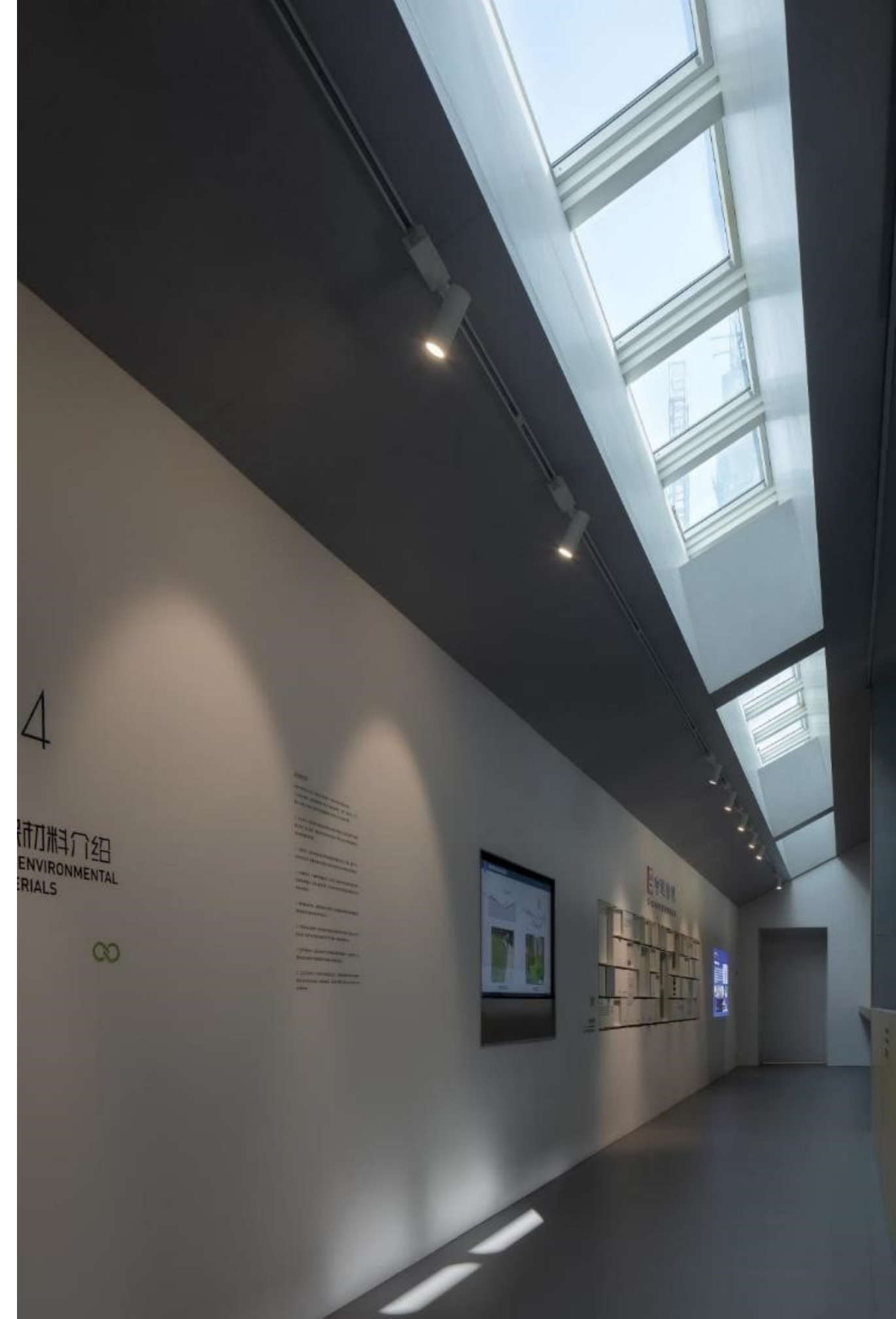


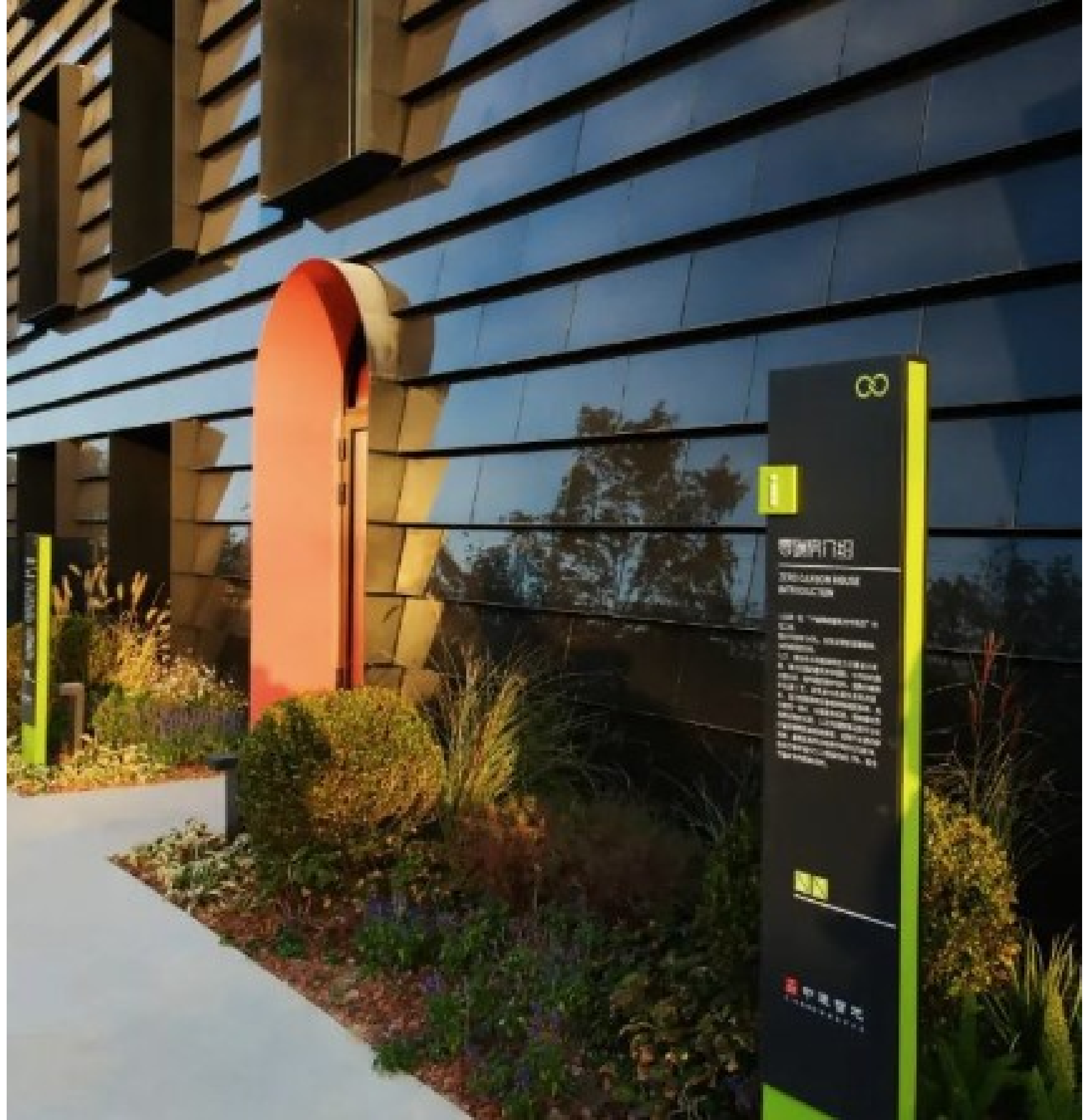






















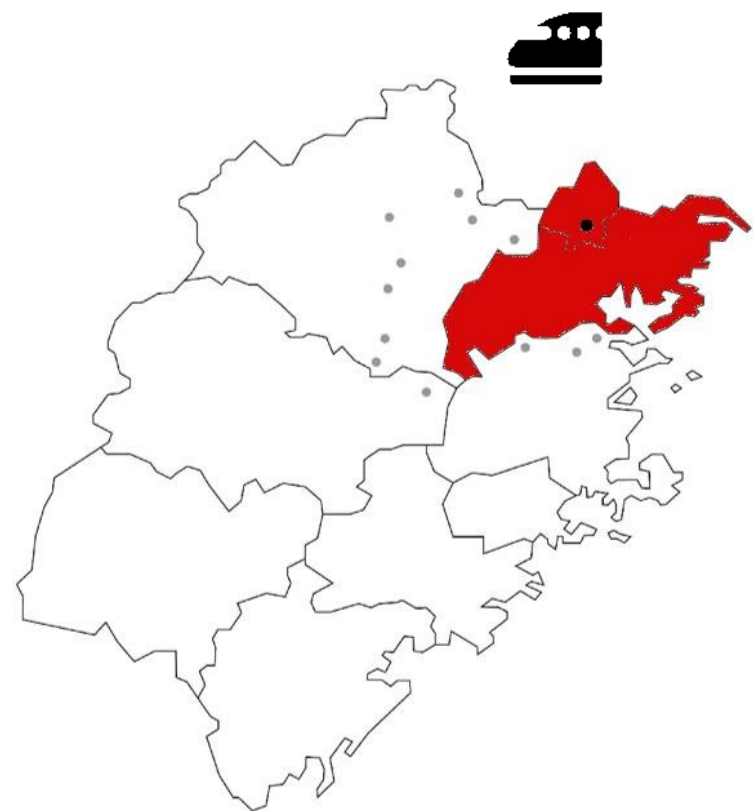


Tea Market in Fujian 福建茶叶市场

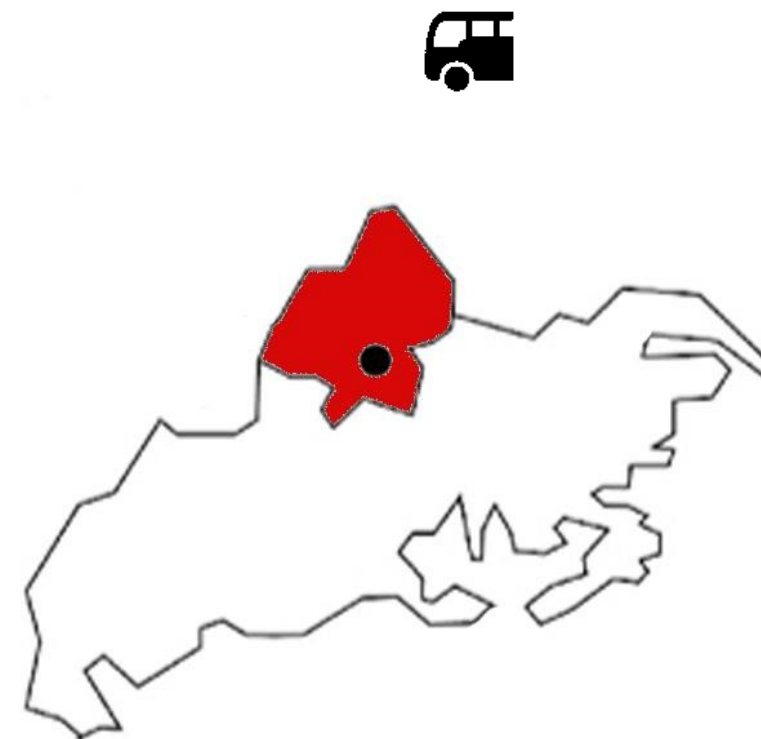
School of Architecture, Tsinghua University
SUP Atelier, THAD



Fujian



Ningde City



Shouning County



Zhuguanlong Village



Materials ≤ 20Km

本地材料 (≤20 公里)

Tea

Rammed Earth

Traditional Chinese Timber Bridge

茶

夯土

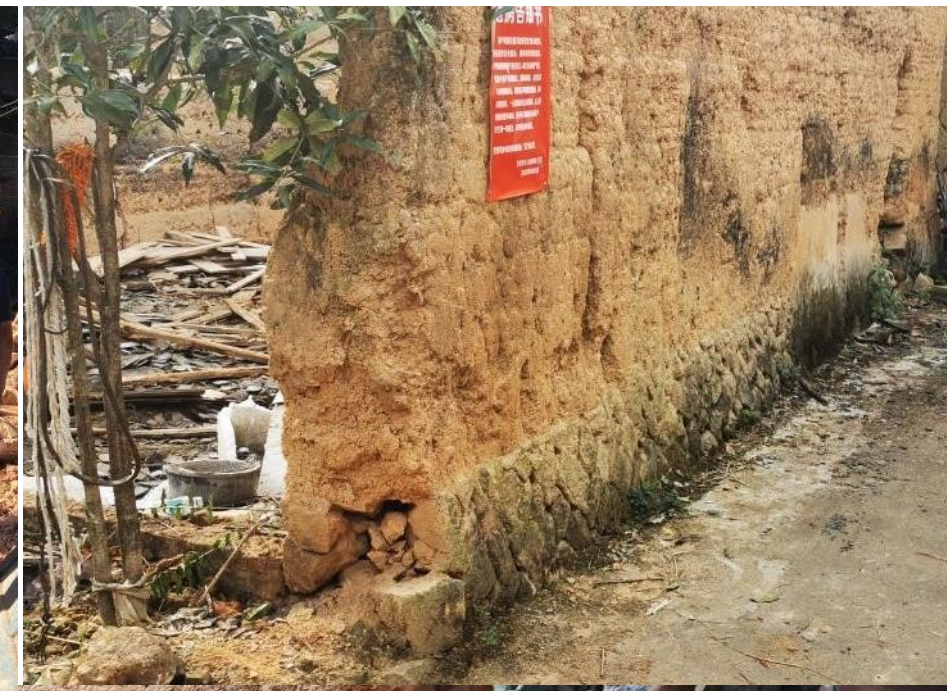
中国传统木桥



Abandoned Natural Stone 废弃天然石材

Vernacular elements

REUSE



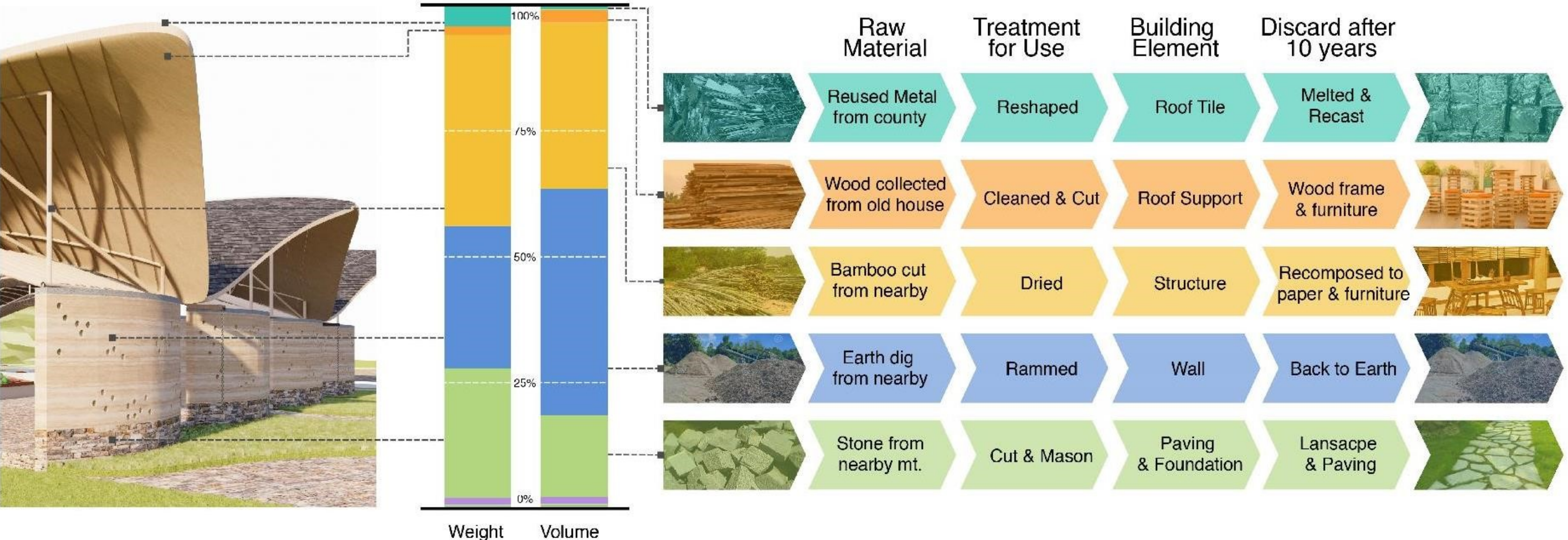
Abandoned Timber 废弃木材



Broken Stone Plates
碎石板



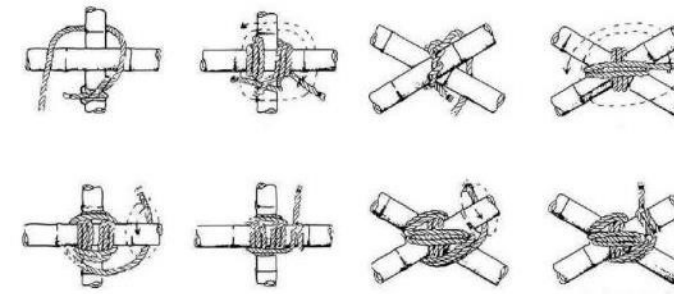
Lifecycle Material Treatment



Craftsmen $\leq$ 20Km

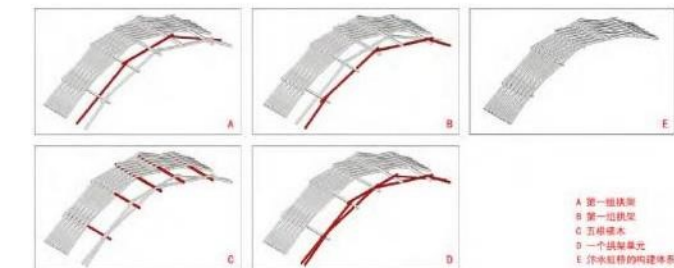
本地工匠 (≤ 20 公里)

Bamboo for roof



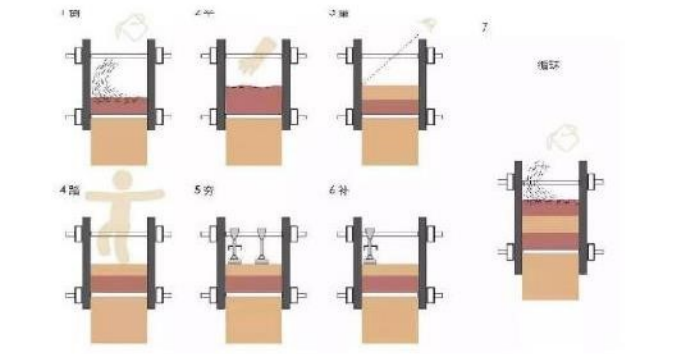
The roof secondary structure is made of bamboo, which is widely planted in Fujian and Zhejiang, China. As a building material, due to its light weight and good toughness, the earthquake resistance of bamboo is very outstanding, and it is a widely accepted regional building material. Durable bamboo can be used in pavilions, observation decks, corridors, pontoons, etc.

Arched Wooden bridge as pototype for large span structure

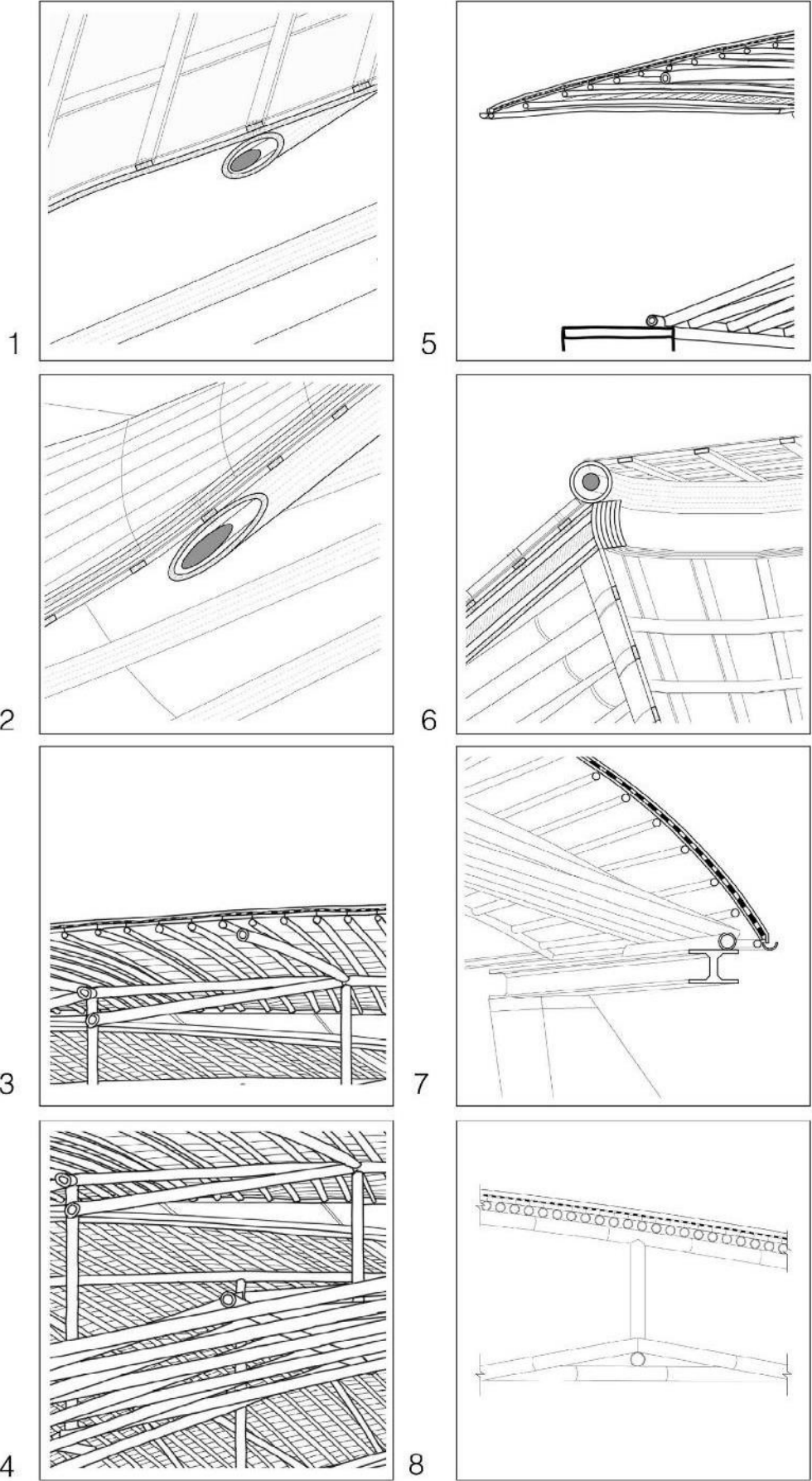


The main structure of the building's large-span structure is inspired by the arched wooden bridge. The wooden arch bridge is a traditional bridge structure form in Fujian, China, which utilizes the principle of overlap between bamboo and wood to convert deflection into side thrust and solve the need for long spans. At present, the technique of wooden arch bridge has become China's intangible cultural heritage.

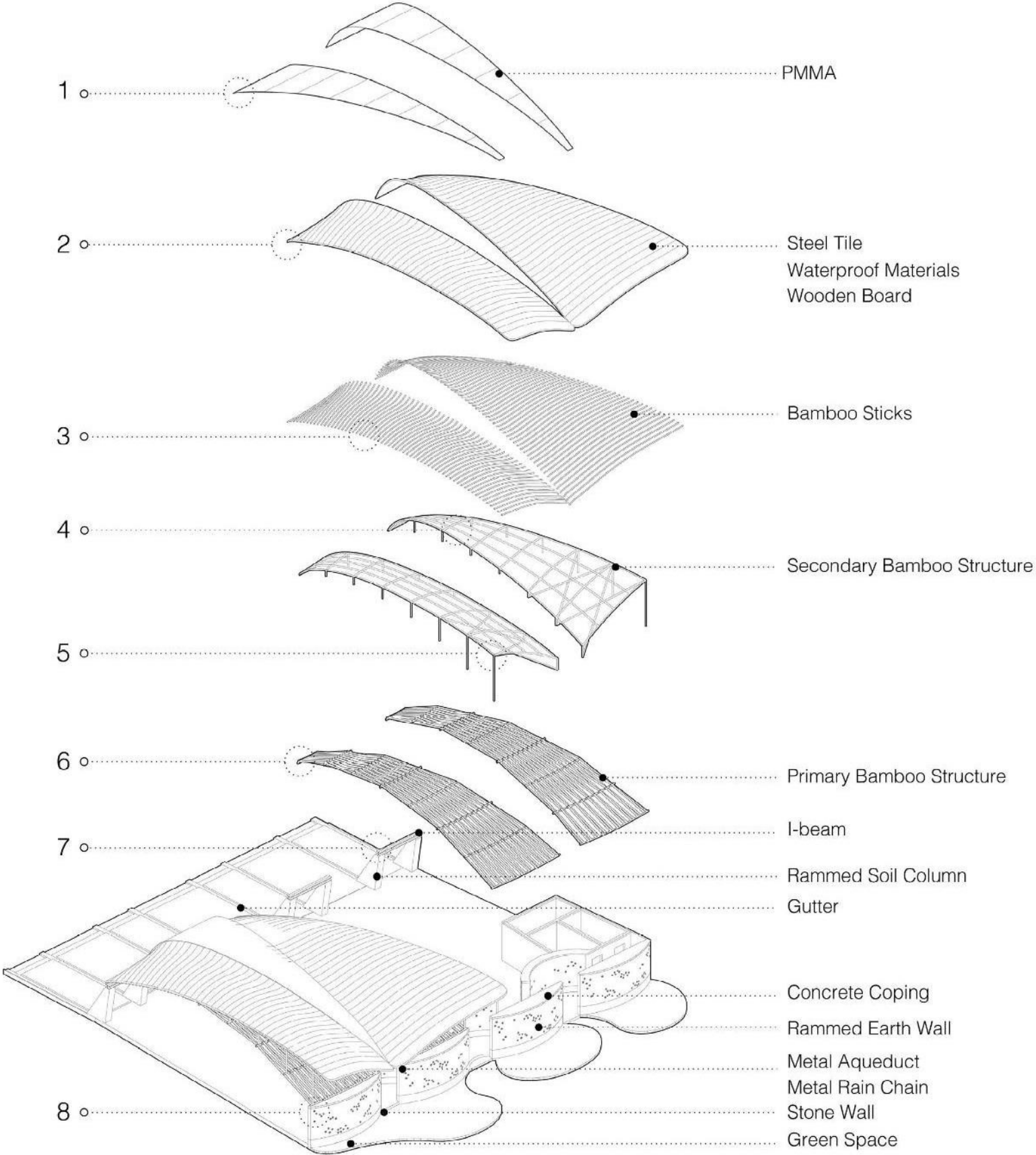
Rammed earth for Wall



Details of Construction



Assembly Diagram

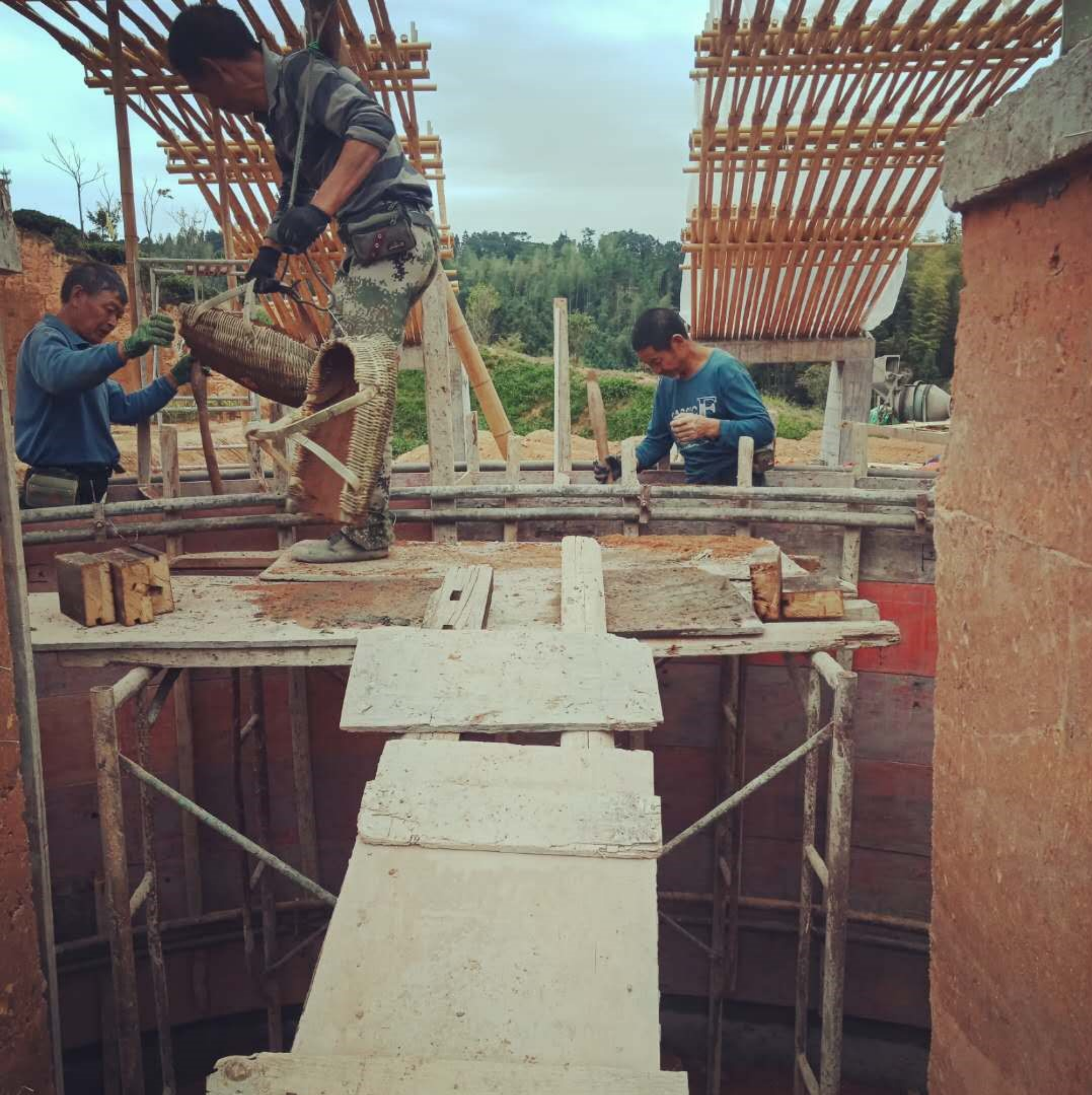


Traditional Stone Base
传统石材基座



Rammed Earth
夯土

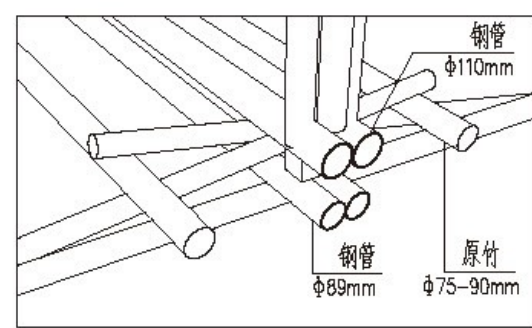
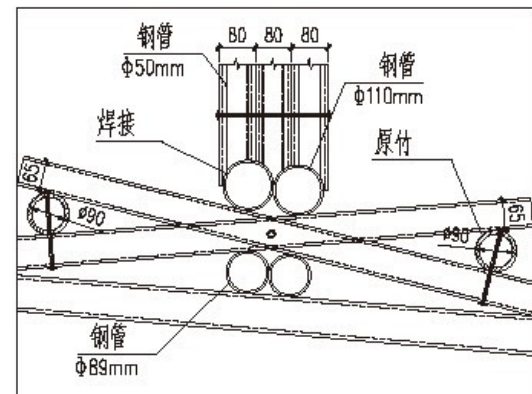
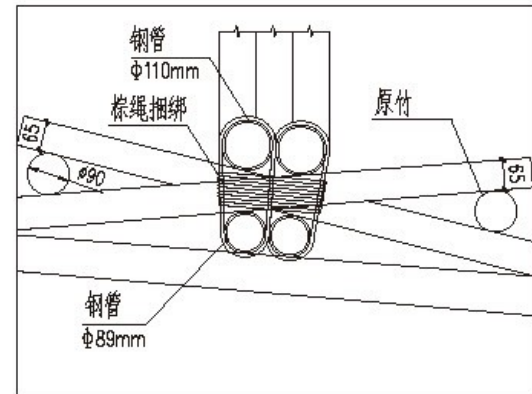
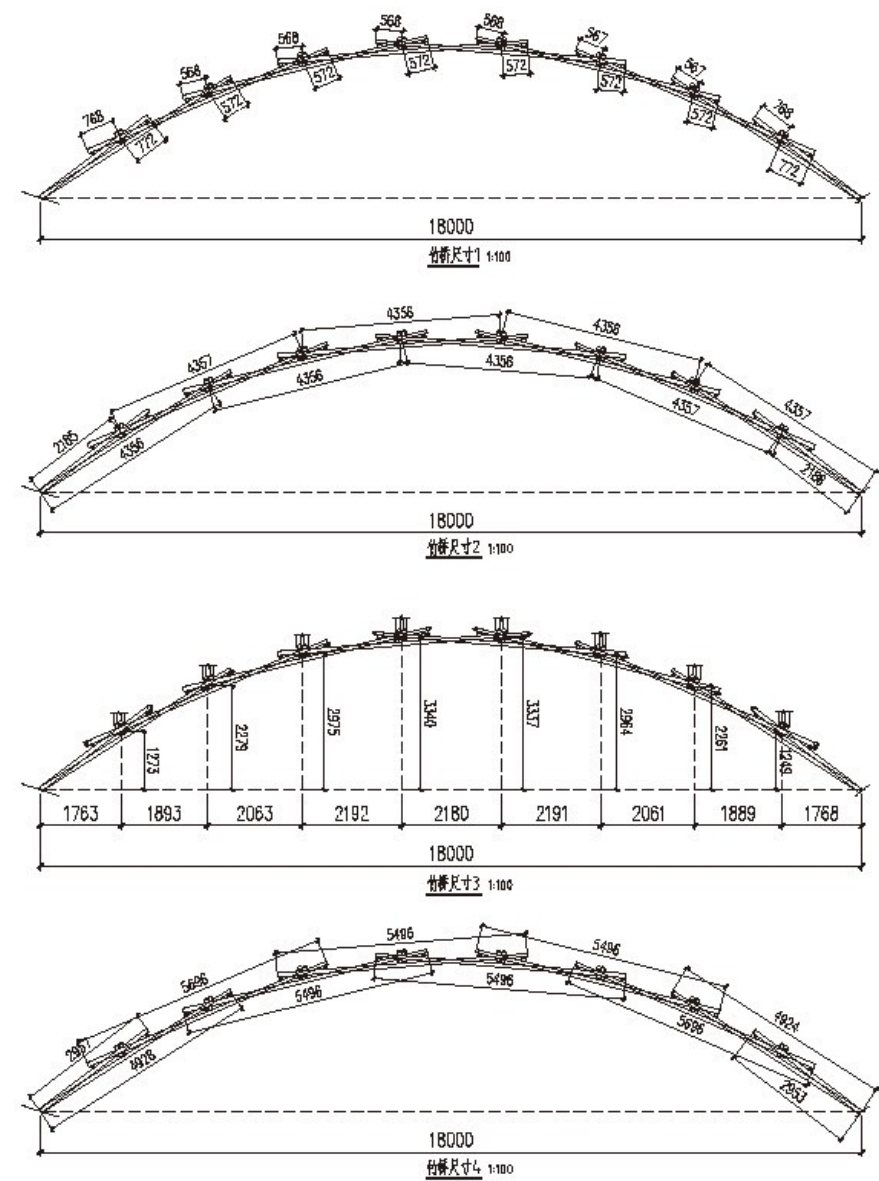
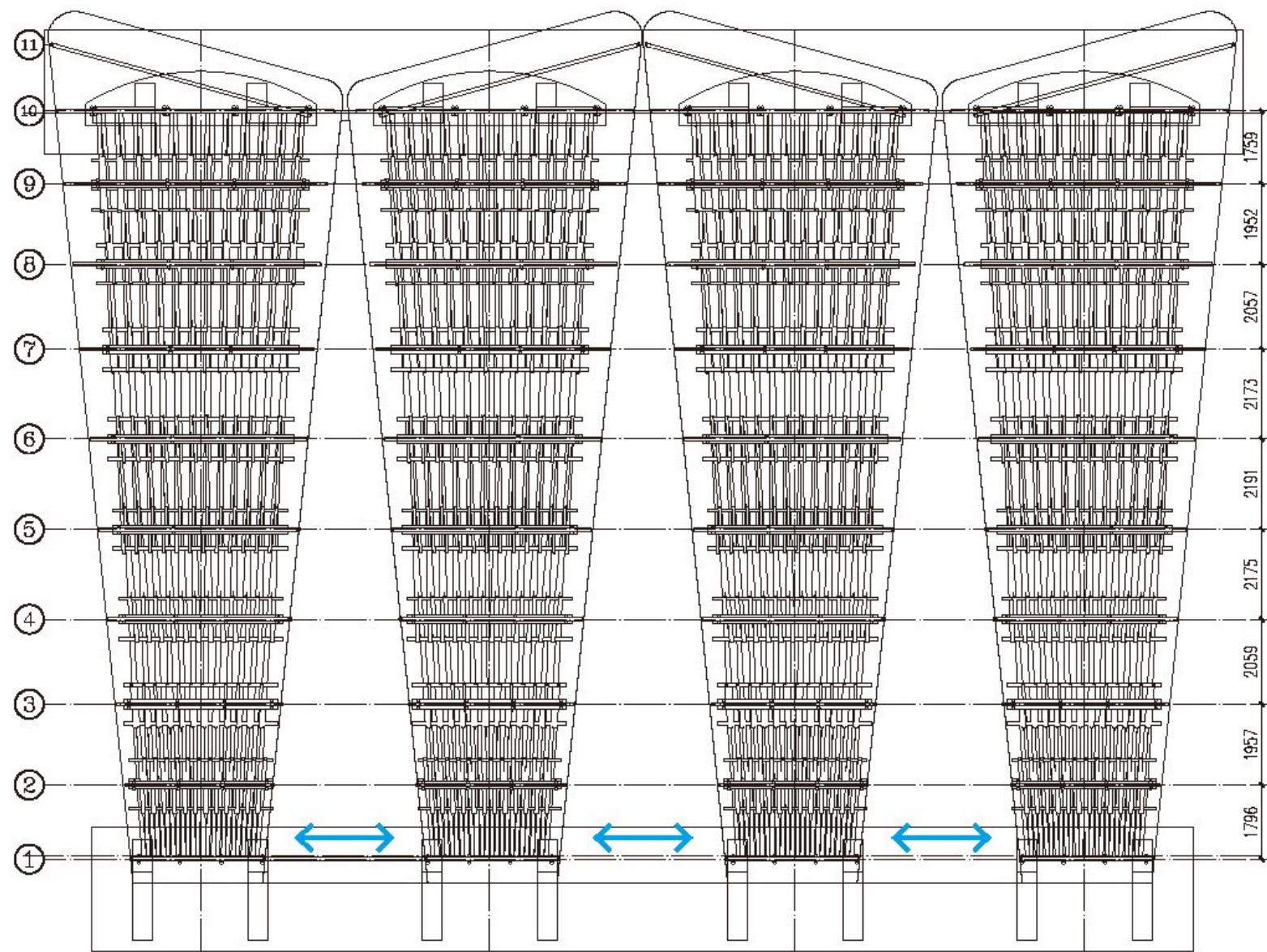




Shouning Vaulted Timber Bridge
寿宁拱形木桥



Vaulted Bamboo Structure 拱形竹结构



Timber to Bamber 从木材到竹材



Time: 2020.08.07 13:30-16:30

Venue: Bamboo Factory

Method: Vaulted Bamboo+ load



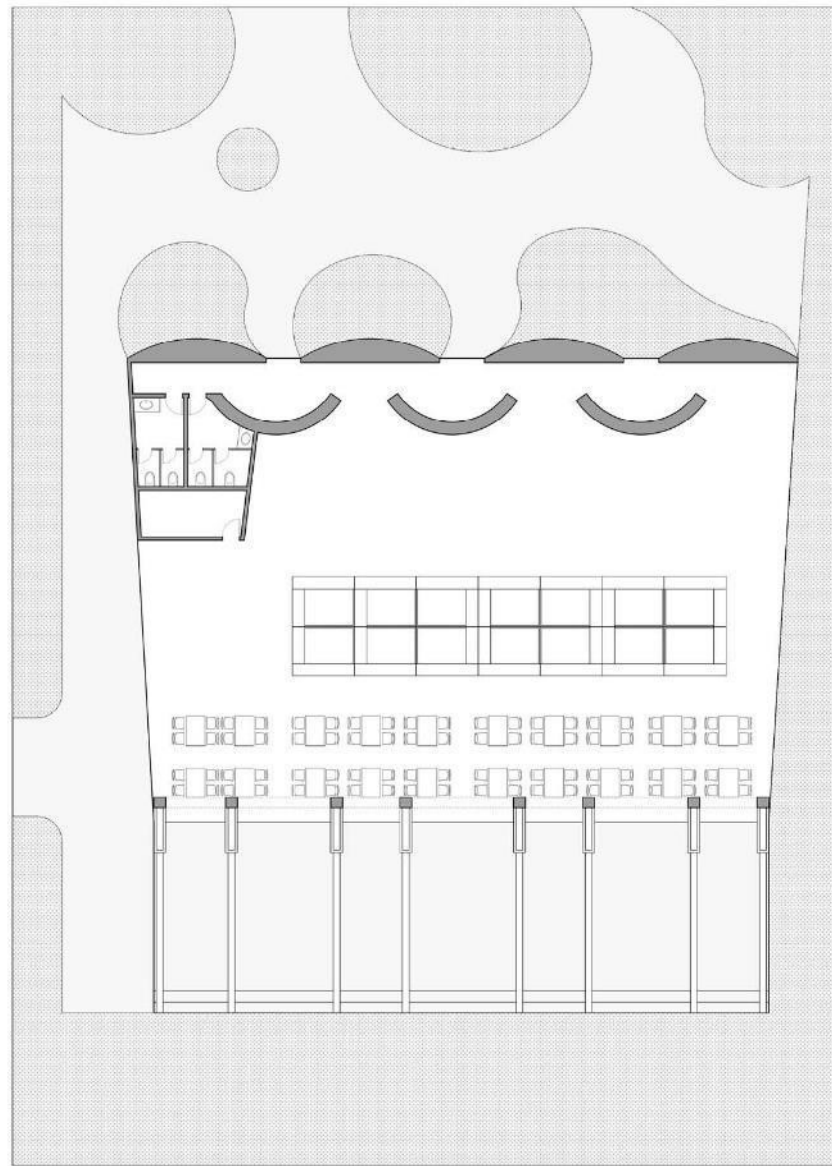
Structural Experiment 结构试验



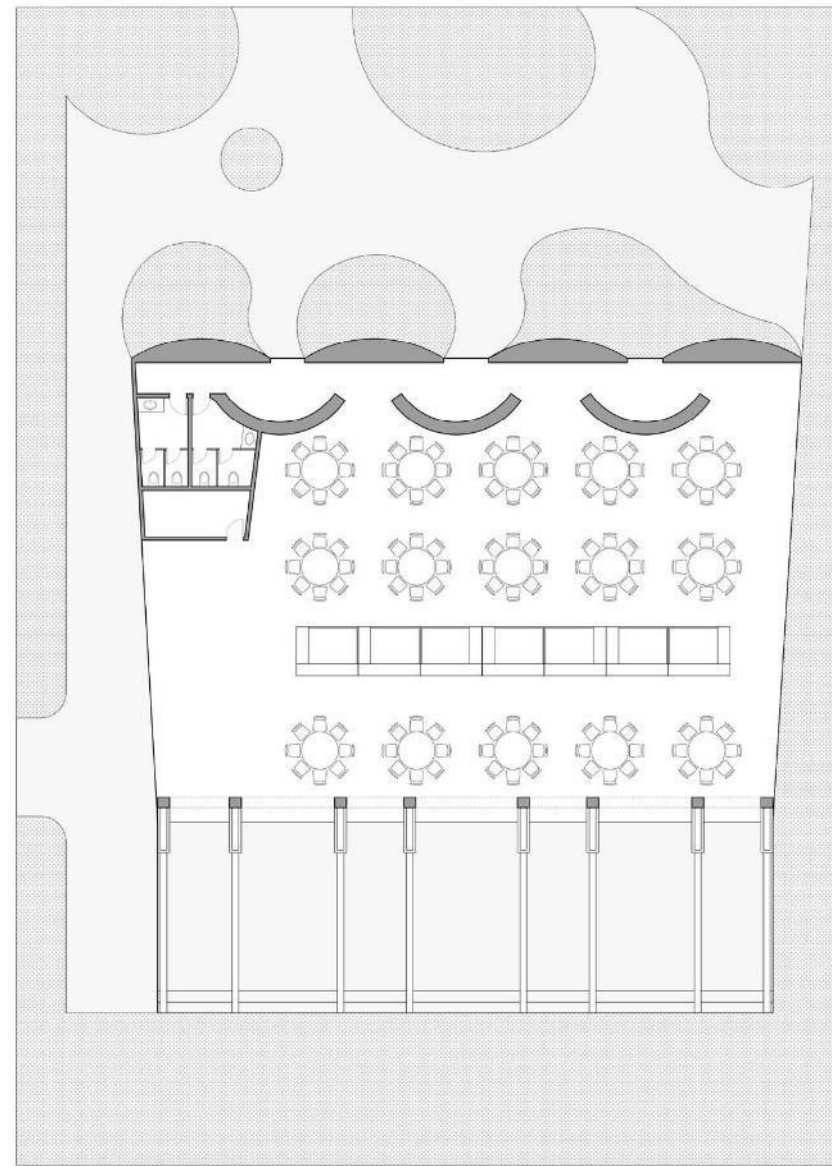




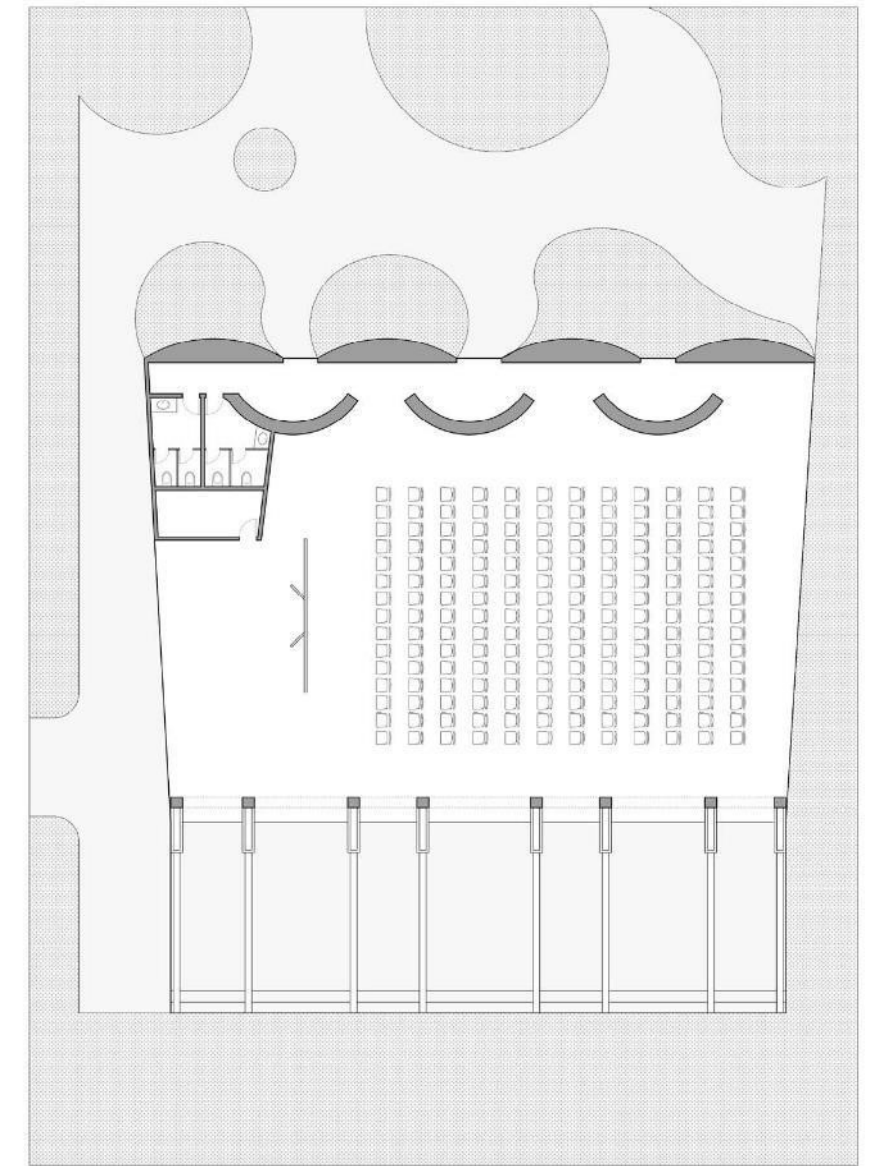




For local tea trade market

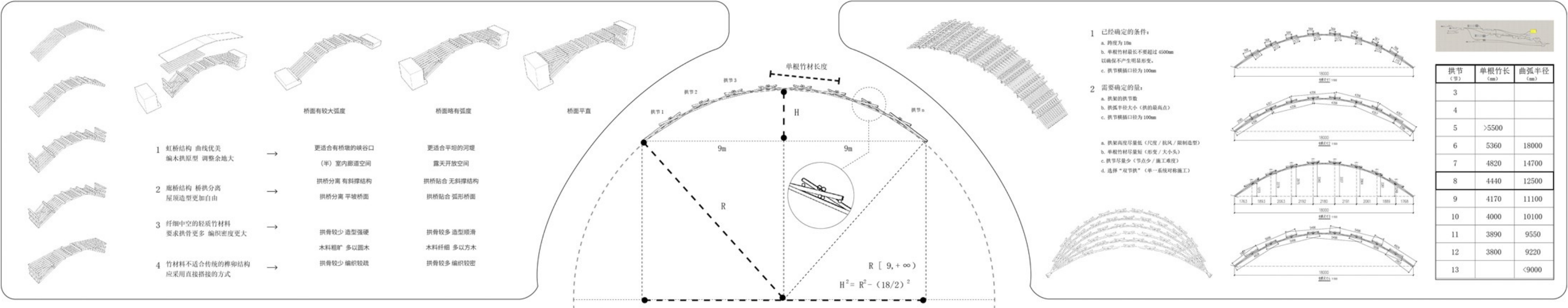
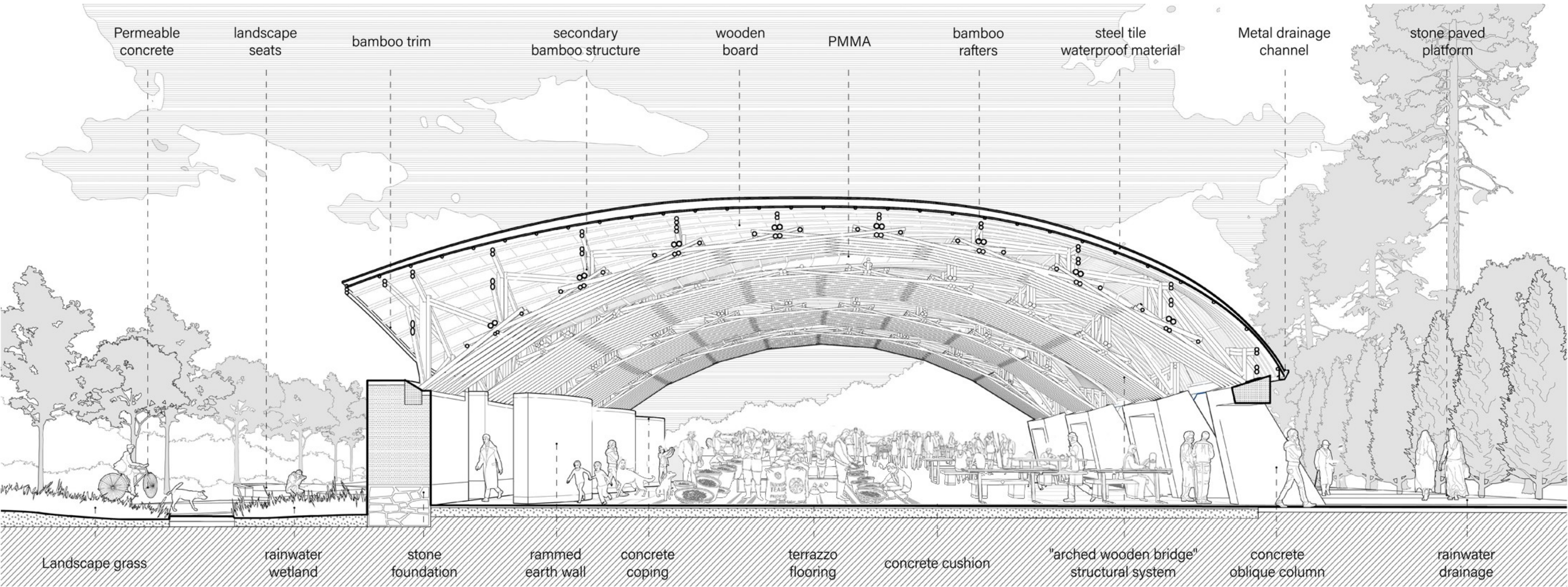


For village banquet



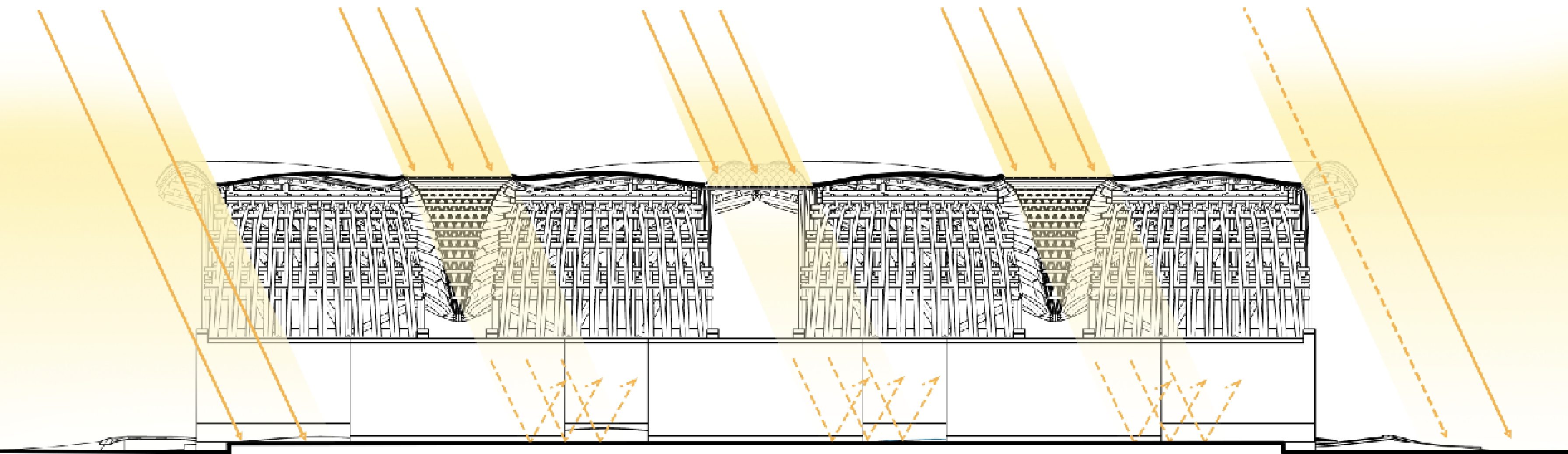
For films and performance





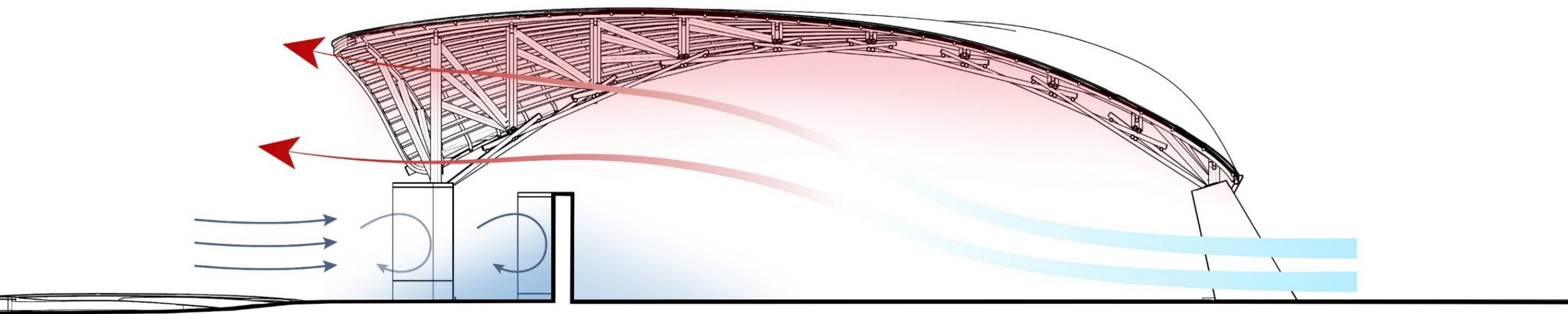












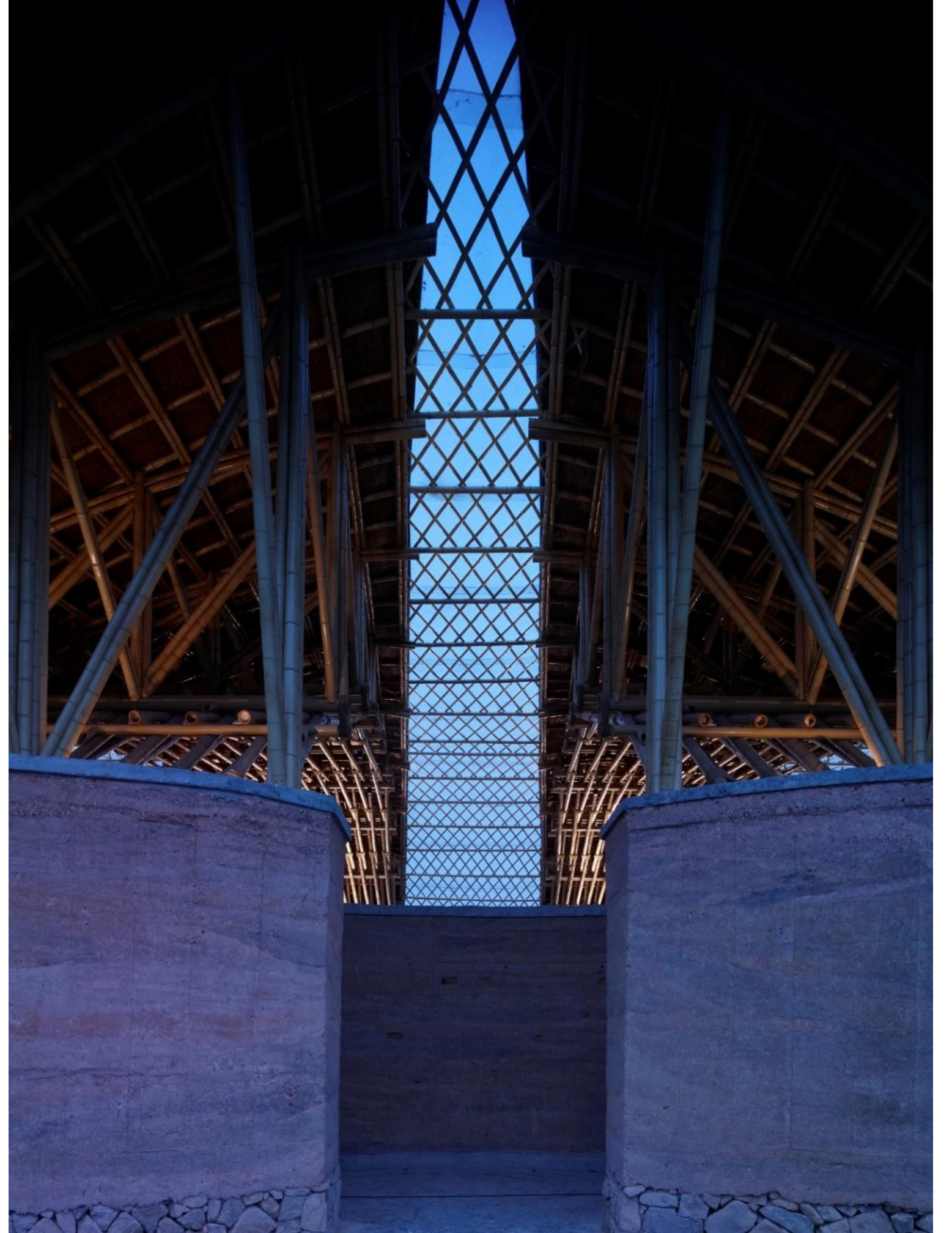












Location: Zhaoshan Village, Bao'an township, Daye County, Huangshi City, Hubei Province,
China

Building Area: 2993m²

2023-2024



Taoli - Zhaoshan Village Center

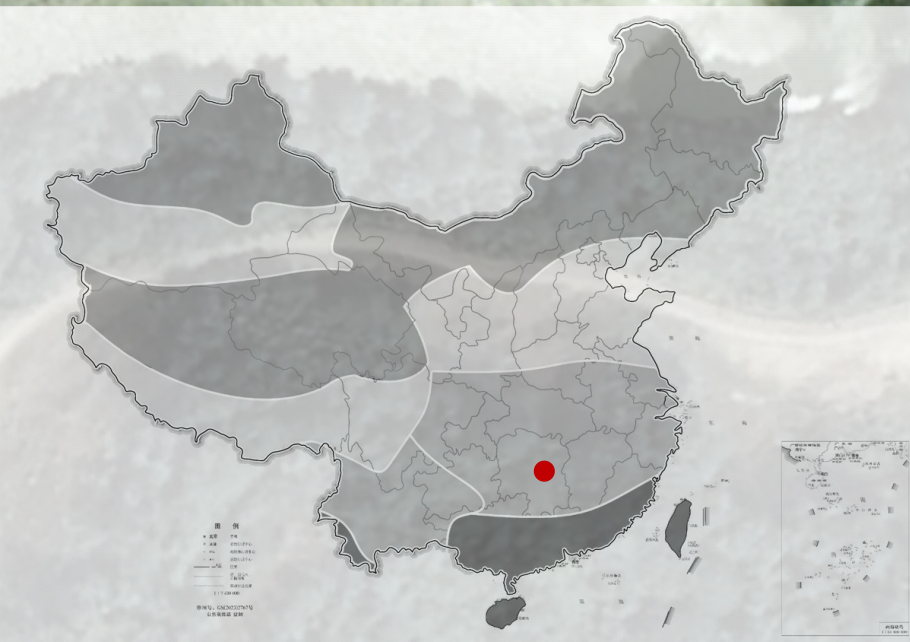
桃里 — 沼山村中心



沼山水库
Reservoir

桃里研学农场
TAOLI Farmland

桃里 TAOLI



Conditions Before Renovation

改造前状况



Conditions After Renovation

改造后状况



Conditions Before Renovation
改造前状况



Conditions Before Renovation
改造前状况

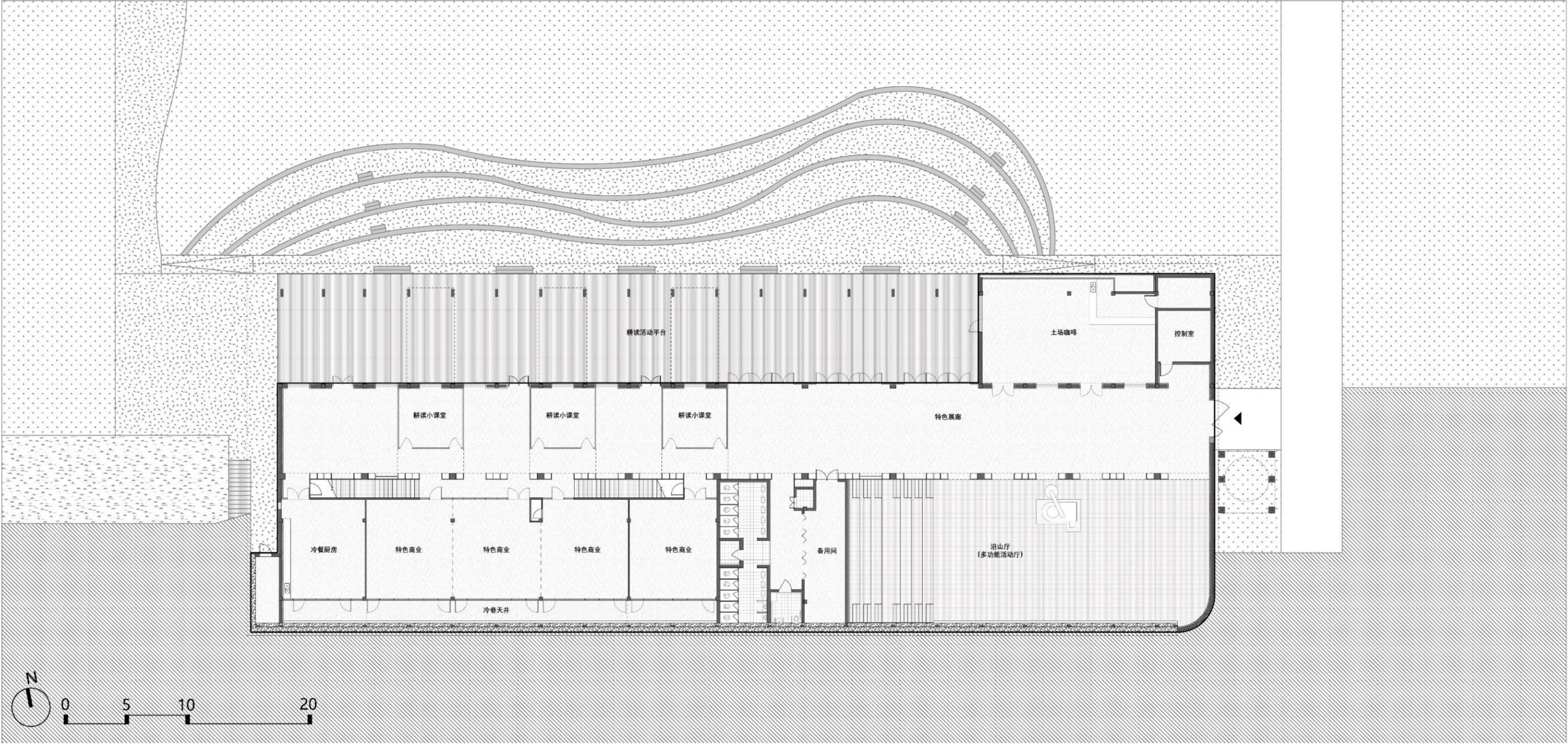


Research on Local Materials

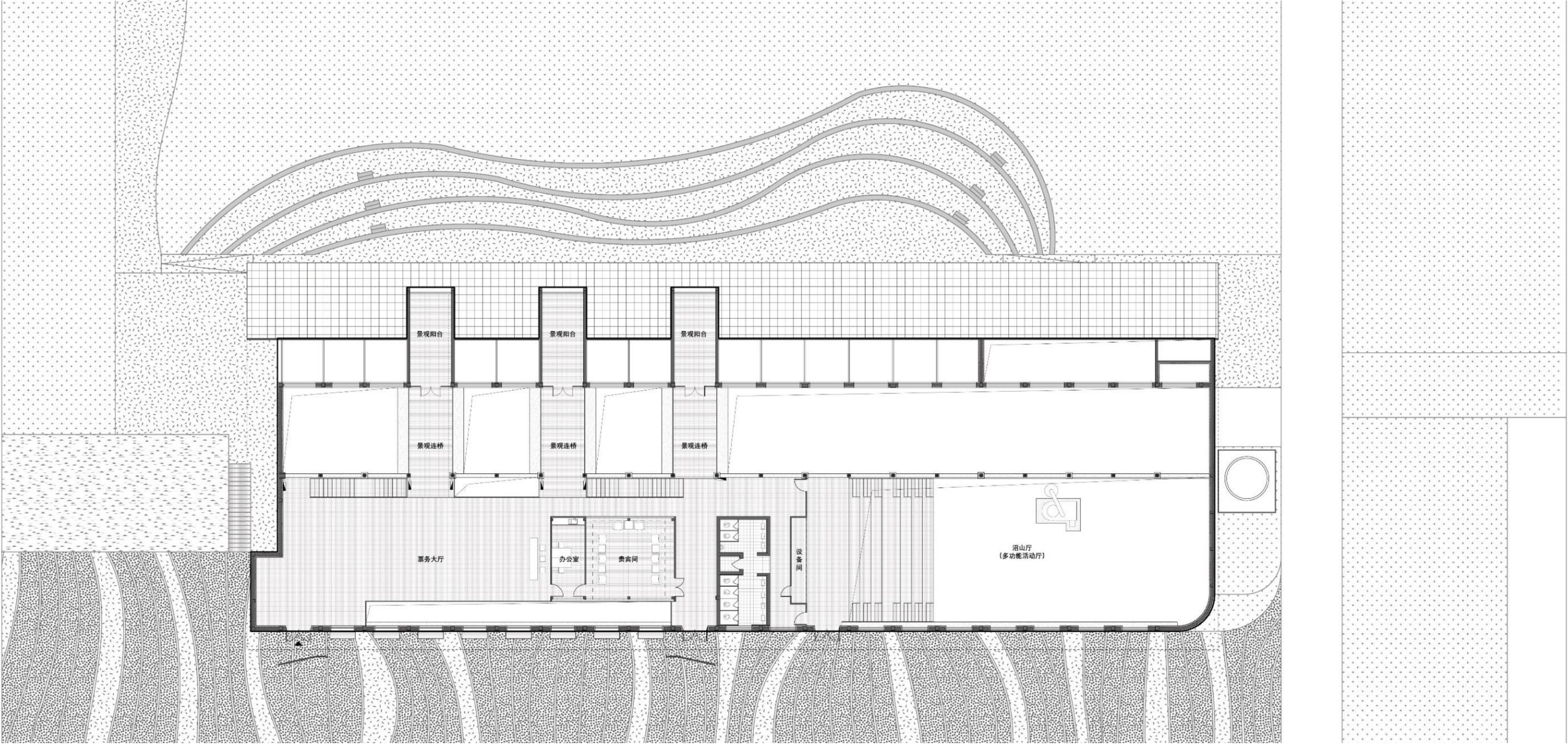
本地材料研究



Plan 1F



Plan 2F



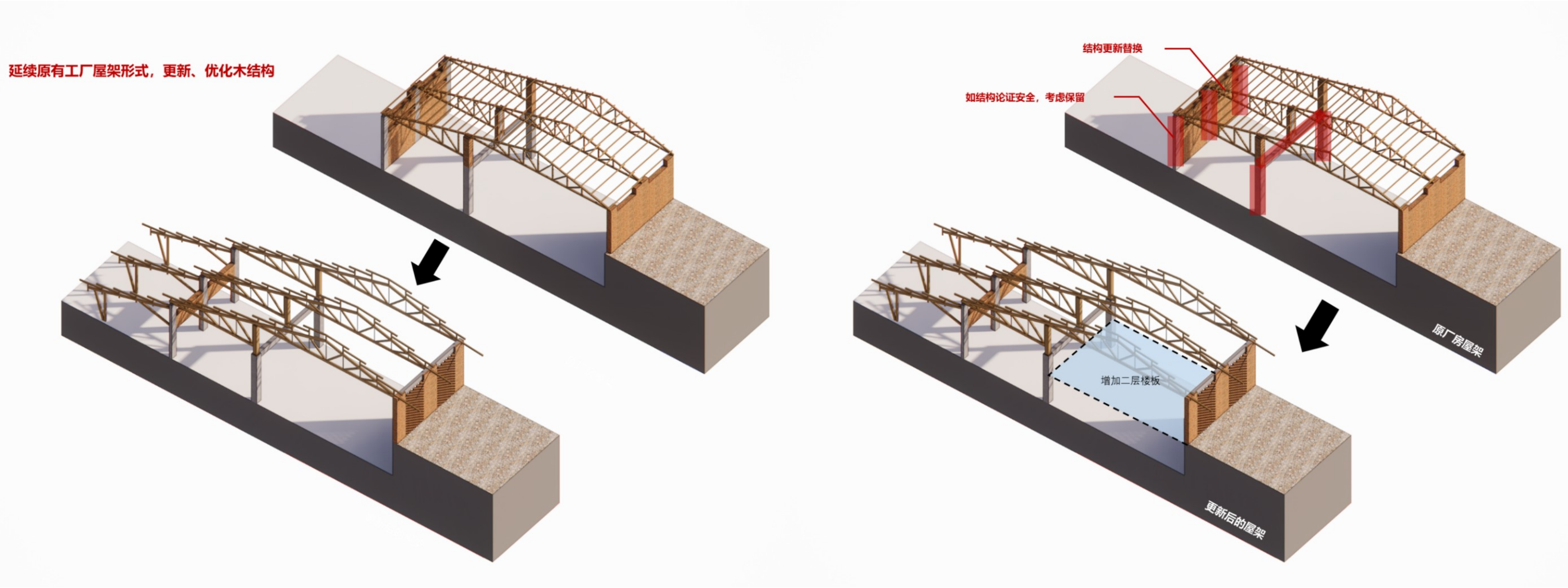


Prototypes of integrated structural design for natural lighting and ventilation

自然采光与通风一体化结构设计原型

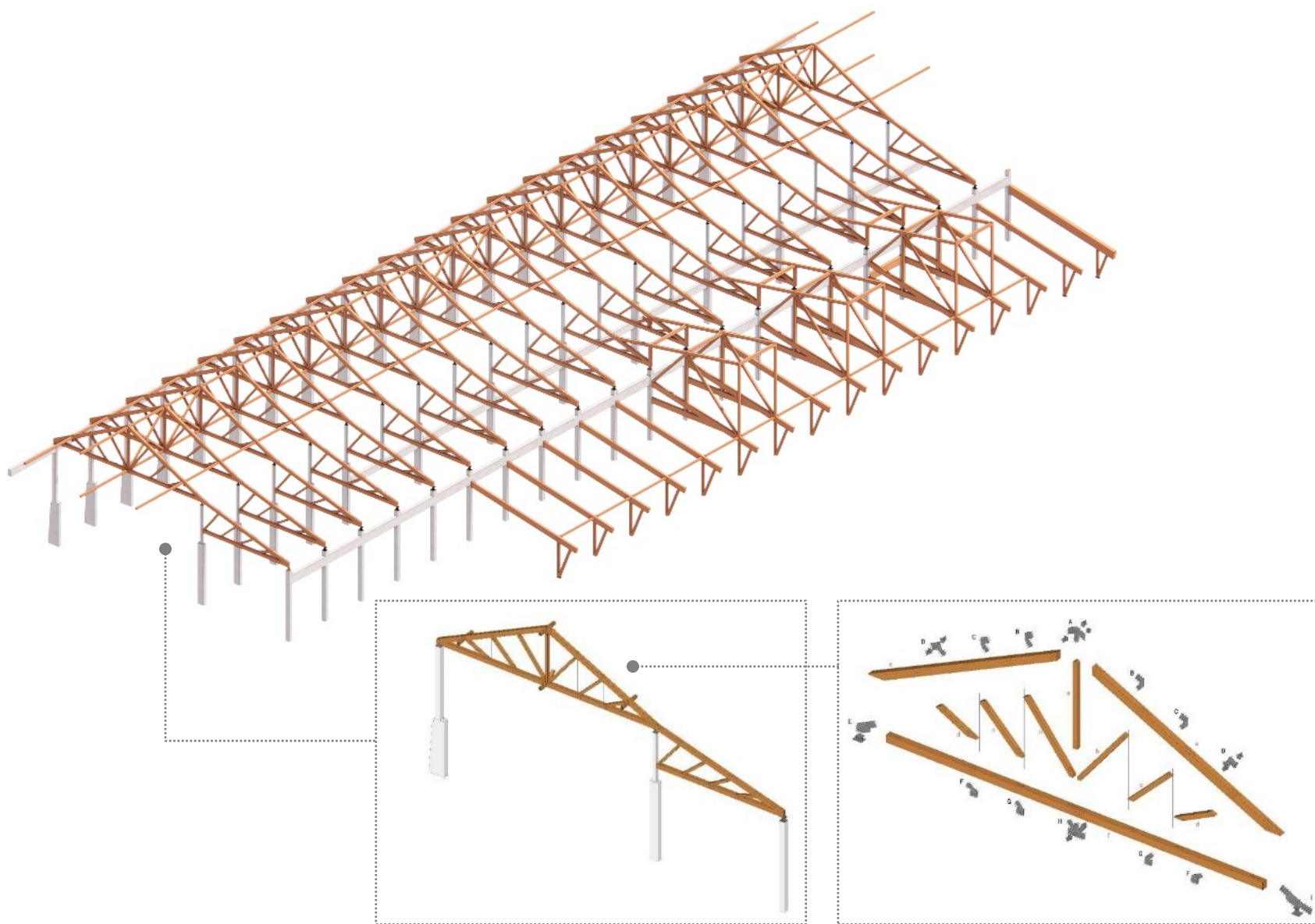


Improvement of indoor timber trusses
室内木桁架的优化改进



Continue with the original factory truss form,
and update and optimize the timber structure.

Structural renewal and replacement.
If the structure is proven to be safe through assessment, consider retaining it.



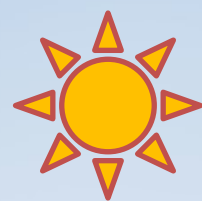
组装完成的单榀木屋架

Assembled timber truss









自然采光漫射光利用

Utilization of Diffuse Natural Light

光伏发电

South Roof PV

雨水场地一体化组织

Integrated Organization of
Rainwater and Site

自然采光

Natural lighting

废弃材料回收利用

Recycling and Reuse
of Waste Materials

沼山厅
多功能活动厅

Multipurpose Activity Hall

展示特色文化展廊
多功能厅

Exhibition Gallery

文化体验空间

Cultural Experience Space





Material Recycling and Sustainable Construction

材料回收与可持续建筑

LOCAL MATERIALS 本土材料

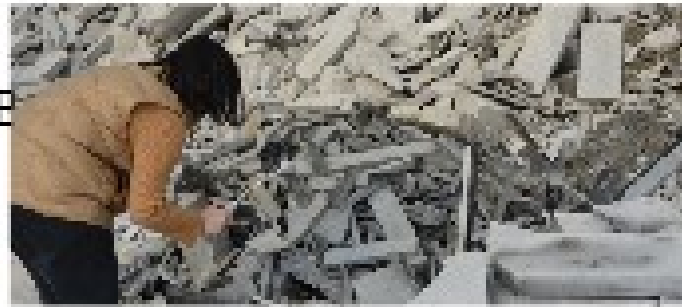
BRICK
清水砖



RUBBLE
毛石



SLATE WASTE
石刻废料



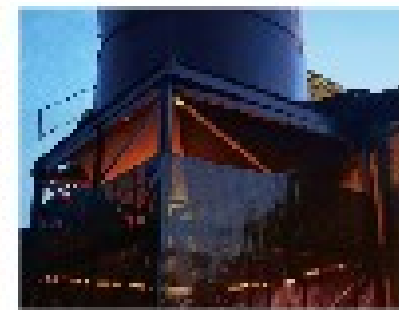
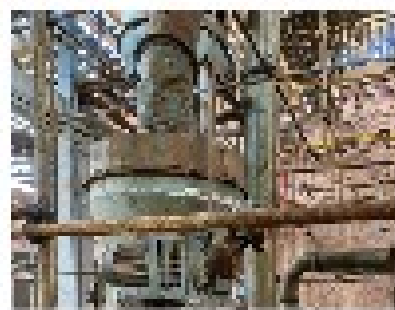
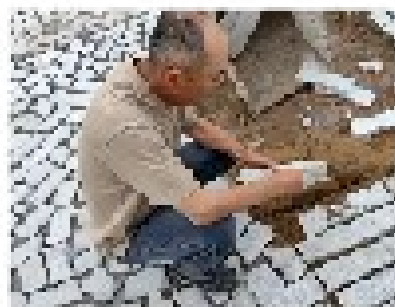
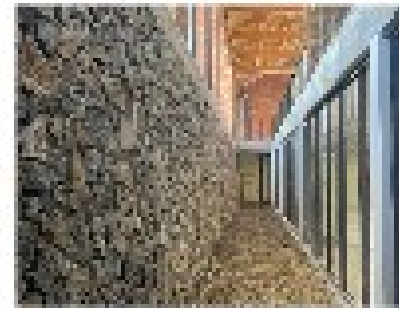
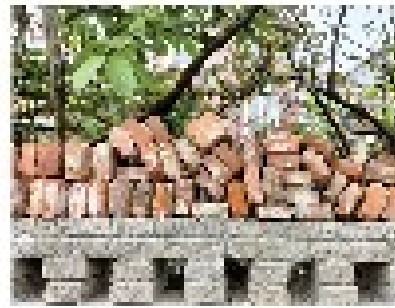
RECYCLED
WOOD
回收木料



METAL
金属利旧



TREATMENT & PROCESSING 材料处理加工及再利用



BUILT PHOTOS 建成实景



材料运输的路径

The transportation routes of materials



碳排放节约策略效果：材料策略

Carbon Emission Reduction Strategy: Material Strategies

基础建筑

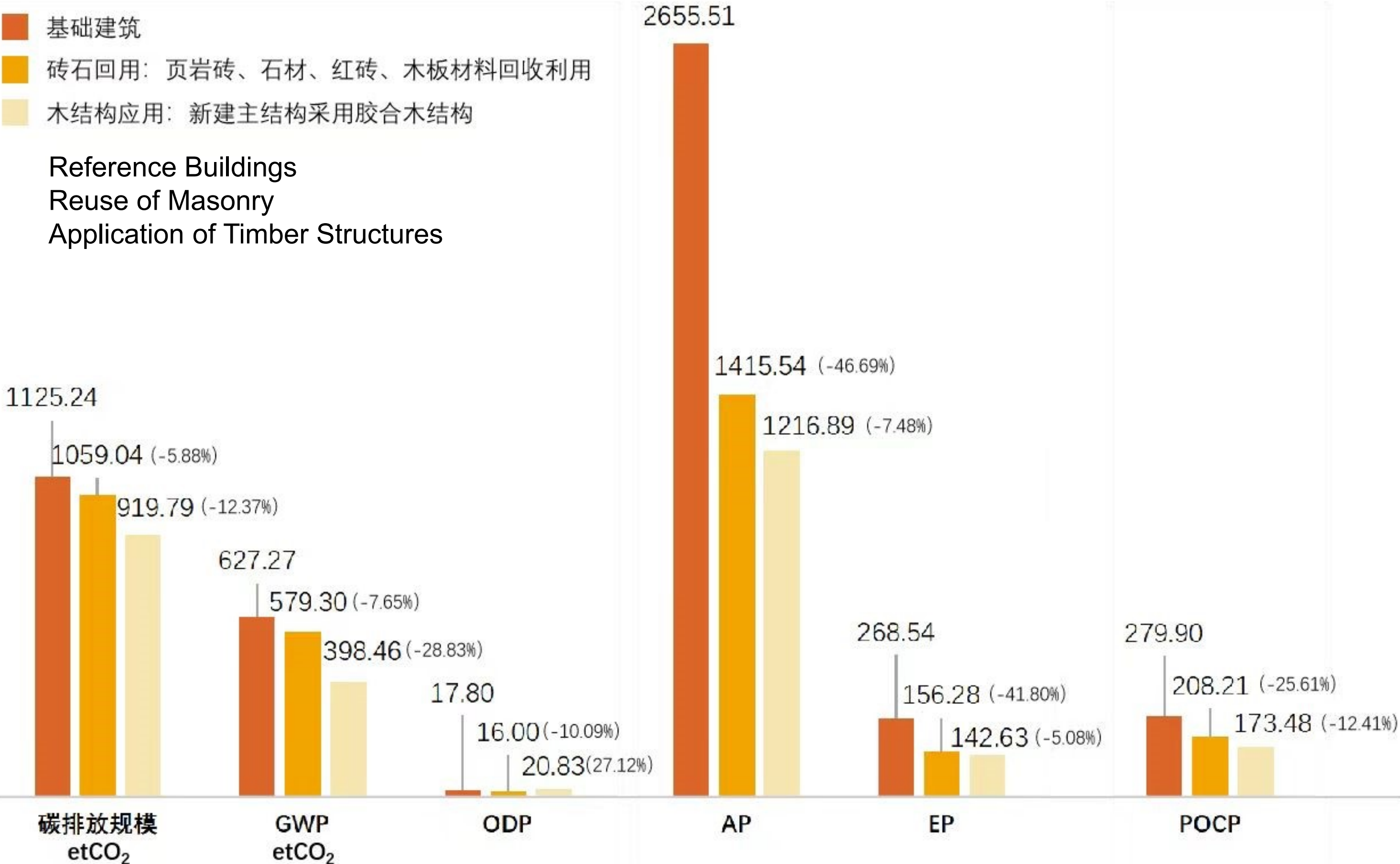
砖石回用：页岩砖、石材、红砖、木板材料回收利用

木结构应用：新建主结构采用胶合木结构

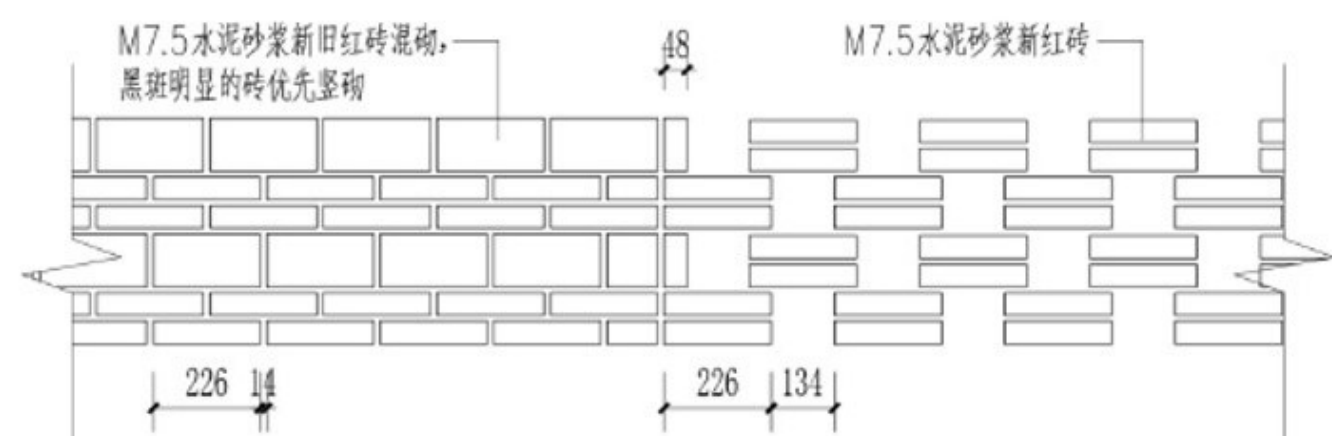
Reference Buildings

Reuse of Masonry

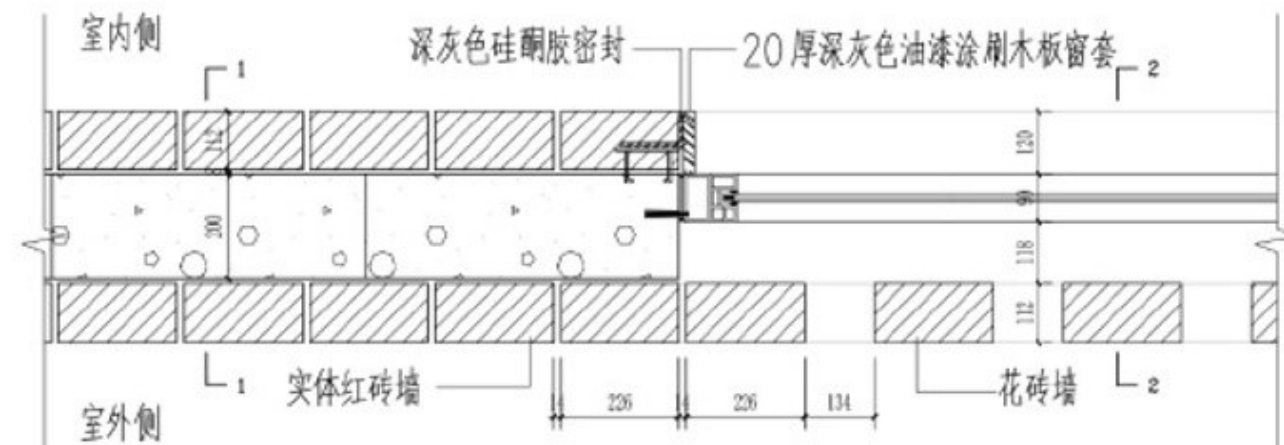
Application of Timber Structures



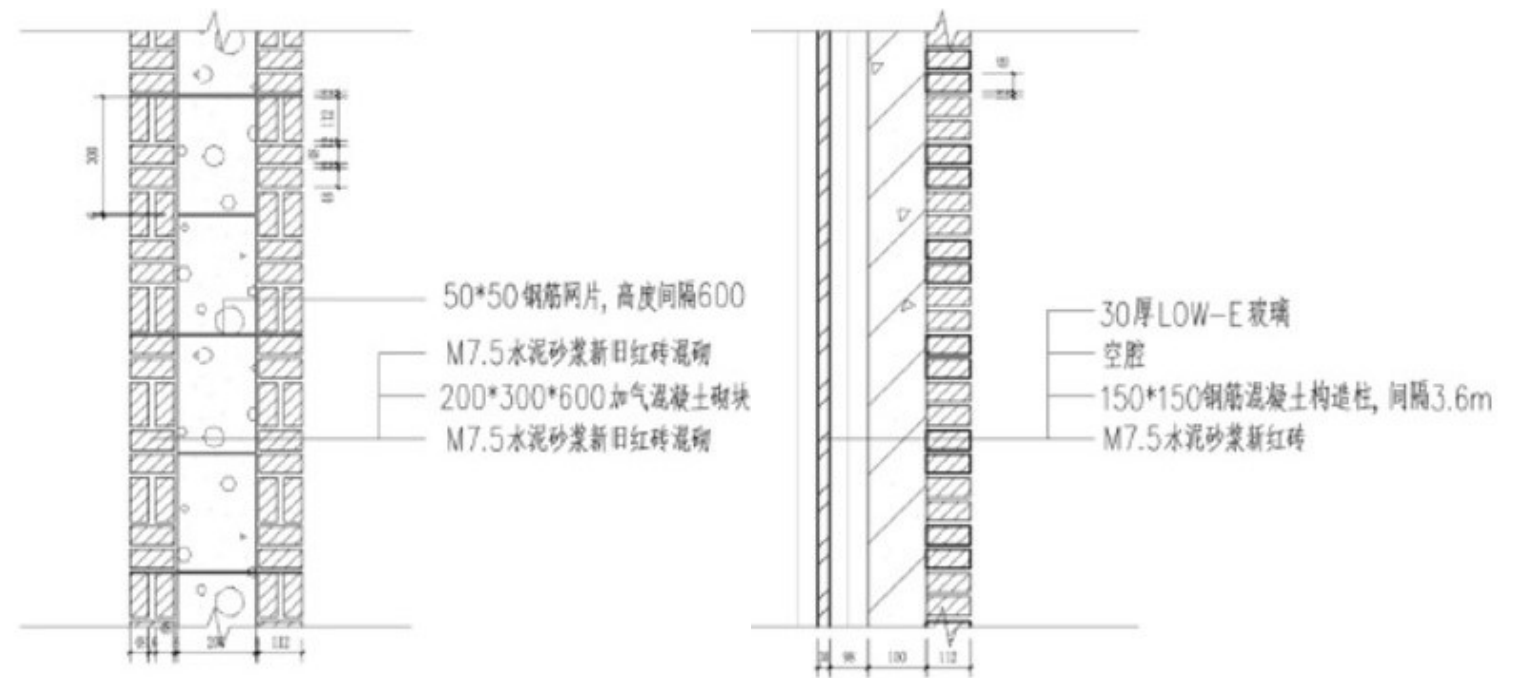




红砖墙立面详图 Elevation Detail of the Red Brick Wall



红砖墙平剖面详图 Horizontal Sectional Detail of the Red Brick Wall

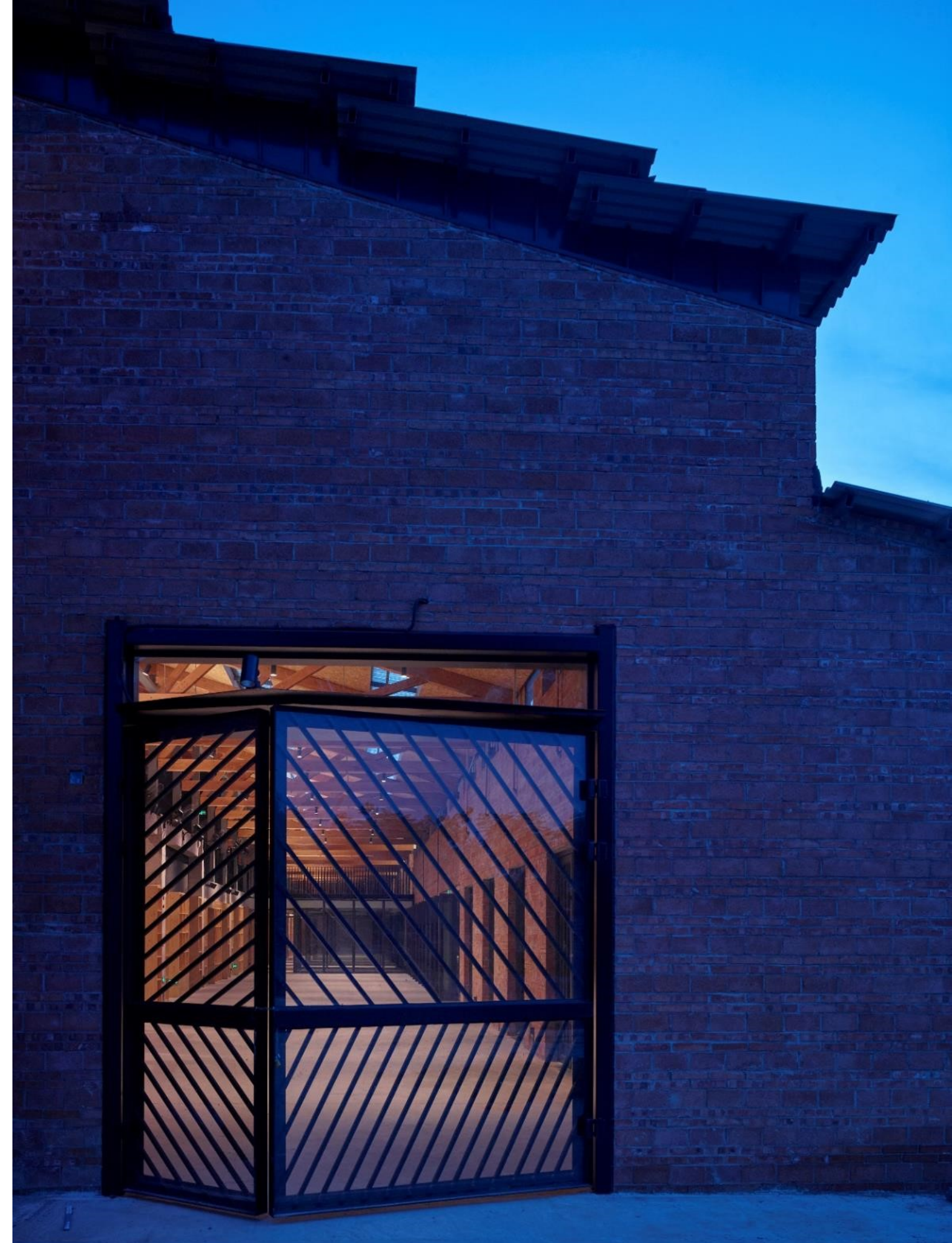


红砖墙剖面详图 Sectional Detail of the Red Brick Wall







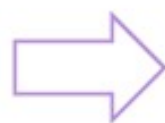




废弃石料 Abandoned stones



石刻加工厂废料



a.细长条形



b.圆柱形



c.立方体形



切割石板废料



d.扁长板形



e.黑色石材



f.特殊纹理石材

废 弃 石 板 用 于 地 面 铺 装

Abandoned stone slabs used for ground paving



废 弃 石 柱 用 于 景 观 路 收 边

Abandoned stone columns used for edging landscape
p a t h w a y s





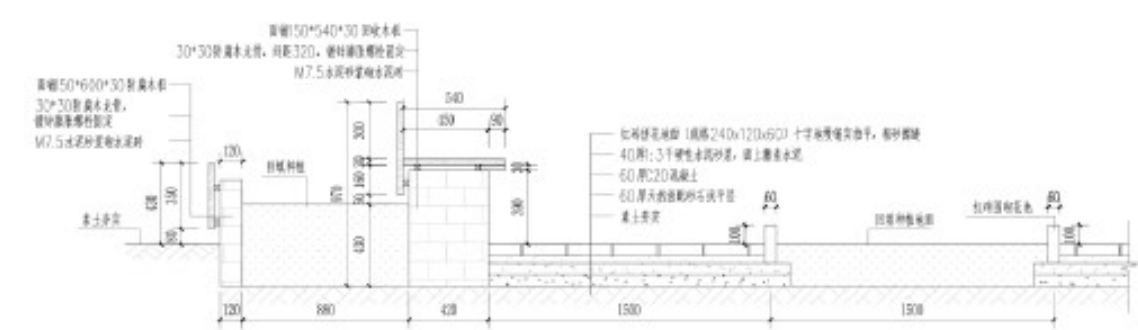
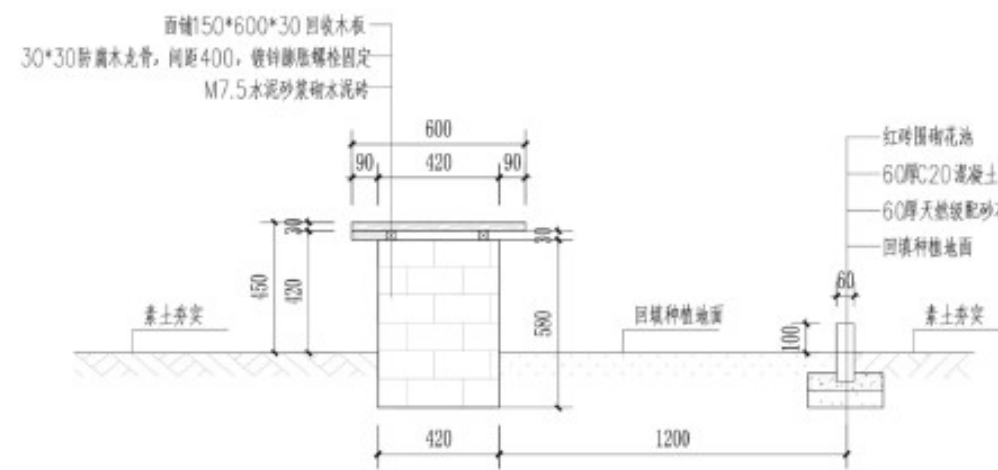
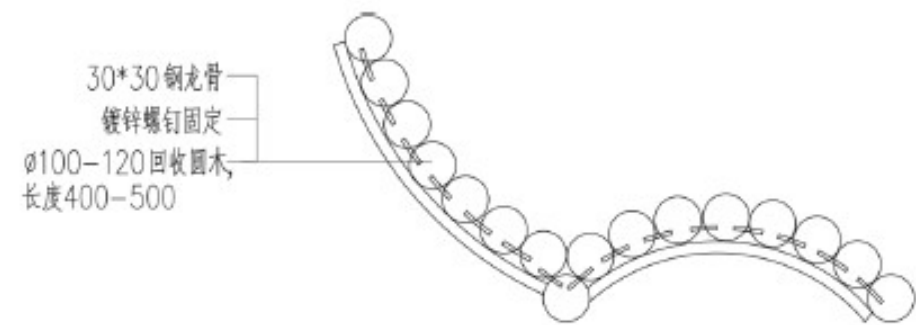
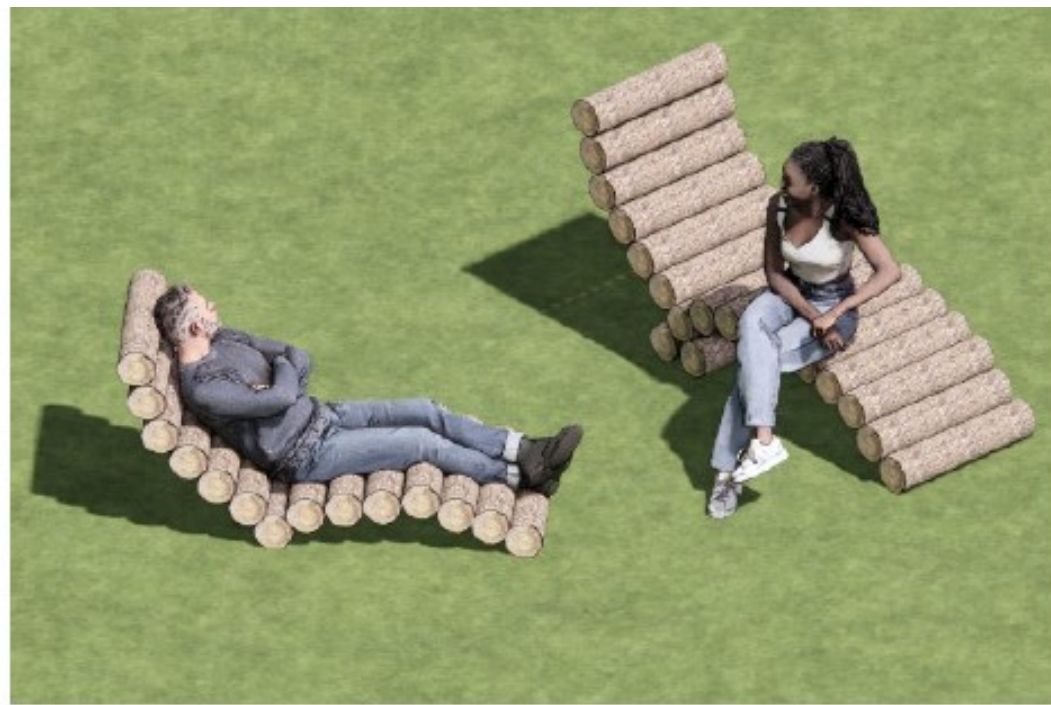
回收再利用木料 Recycled and Reused Timber



原建筑拆除木桁架



另一建设工地多余防腐木













让我们共同打造气候中和的未来
Building a climate-neutral future together



中华人民共和国
住房和城乡建设部



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

intep
skat Swiss Resource Centre and
Consultancies for Development

感谢您的关注!

THANK YOU!

提问环节

YOUR QUESTIONS?

