

鸟巢数字编织薄壳景亭

DIGITAL DESIGN OF A THIN-SHELL METAL WOVEN PAVILION

XISUI
喜随



XISUI

鸟巢数字编织薄壳景亭

如何在水面之上，实现一座跨度大又建造轻盈的现代景亭？

鸟巢数字编织薄壳景亭坐落在一个水池上，作为一个休息场所，可以遮挡风和阳光，同时仍然允许自然光进入其内部。

这个亭子引入了一种新颖的数字金属建造方法。其分段金属壳体的灵感来自鸟巢的仿生编织外观以及蛋壳拱形传力的结构原理，团队对此进行了深入研究。设计特点包括结构表皮一体化的超薄壳体和向心式穹顶，旨在营造一种纯净宁静的体验，引导人觉知自己，回归内在平和。

亭子在水面上跨越 11 米，采用最少的材料和人工建造，创造了一个独特的建筑空间。该项目通过跨学科团队的持续计算测试，探索了设计、工程和制造方面的新可能性。



DIGITAL DESIGN OF A THIN-SHELL METAL WOVEN PAVILION

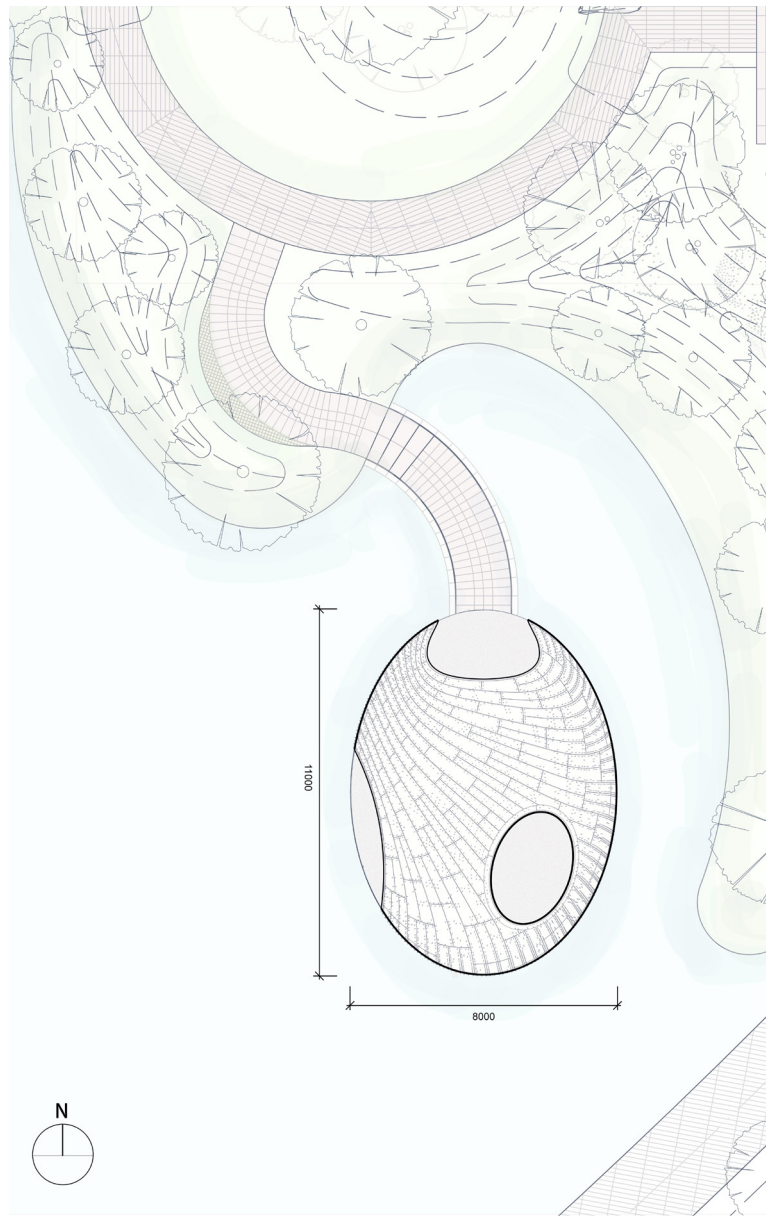
How to design and build a wide span and lightweight modern pavilion above the water surface?

The Thin-shell Metal Woven Pavilion is situated over a pool, serving as a resting place that offers shelter from wind and sun, while still inviting natural light to penetrate its interior.

This pavilion introduces a novel approach to digital metal construction. Its segmented metal shell is inspired by the bionic weaving appearance of birds' nests and the structural principles of arched force transmission found in eggshells, which the team has studied in depth. The design features an integrated ultra-thin shell and a centripetal dome, aimed at fostering a pure and serene experience that promotes inner contemplation and peace.

Spanning 11 meters over water, the pavilion is constructed utilizing minimal materials and manual labor to generate a unique architectural space. The project explores new possibilities in design, engineering, and fabrication through continuous computational testing with interdisciplinary teams.



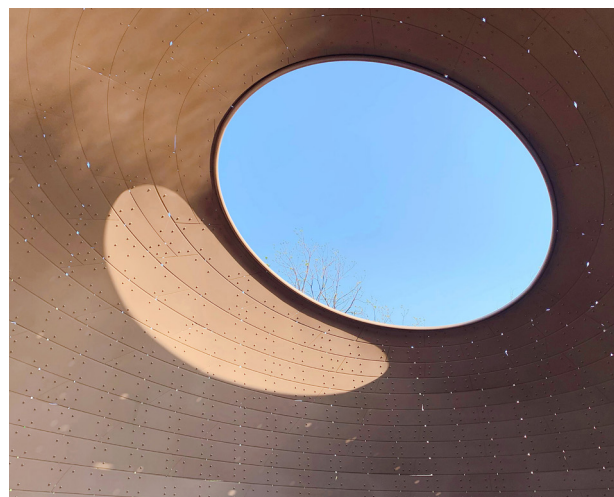


1. 沉浸式体验

参观者沿着水池下的下沉通道进入鸟巢数字编织薄壳景亭，这条路径帮助参观者在水面下放松身心，享受宁静。这条隐蔽的通道提供了半开放半私密的空间，丰富了感官体验，激发了参观者对自然的想象，增强了进入亭子前的期待感。

1. IMMERSIVE EXPERIENCE

Visitors are guided along a sunken passage below the pool to the Thin-shell Metal Woven Pavilion, which helps them to relax and enjoy themselves beneath the water surface. This secluded path provides partially open and private spaces, enriching the sensory experience and stimulating visitors' imagination of nature, heightening anticipation before they enter the pavilion.



许多小开口被巧妙地“嵌入”在物理编织留下的开孔缝隙之间，使光线能够穿透内部，形成透光的阵列。这些自然光点吸引参观者靠近，形成动态光影图案，同穹顶上旋转的结构流线相呼应。随着阳光和云层的移动，这些图案在一天中不断变化，为空间增添了动态元素。

Many tiny openings are carefully "embedded" between the woven gaps, allowing light to penetrate the interior and form a luminous array. These spots of natural light invite visitors to step closer, forming dynamic light patterns that reflect the rotating structural streamlines on the dome. These patterns change throughout the day with the movement of sunlight and cloud cover, adding a dynamic element to the space.



外表皮被涂成白色，优美地反射在水面上，营造出一种宁静纯净的美感。内壁则采用哑光的棕金色表面，降低光线反射亮度，让参观者仿佛置身于一个深邃的洞穴中，进入一种平和的状态。向心纯粹的穹顶和周围的水池如同山峦大海将人包裹庇佑，正常说话的音量会被穹顶结构带来的回音放大，为内省和反思提供了一个理想的环境。

The exterior, painted in white, reflects on the water's surface, creating a serene and pure aesthetic. The interior, with its matt brown-gold walls, reduces light reflection and immerses visitors in an experience as if exploring a deep cave, leading them to a state of calm. Inside, the centripetal dome and surrounding pool evoke a sensation of being enveloped by mountains and the sea. The dome's acoustics amplify normal speaking volumes, providing an environment conducive to introspection and reflection.



2. 结构表皮一体化——表皮即结构

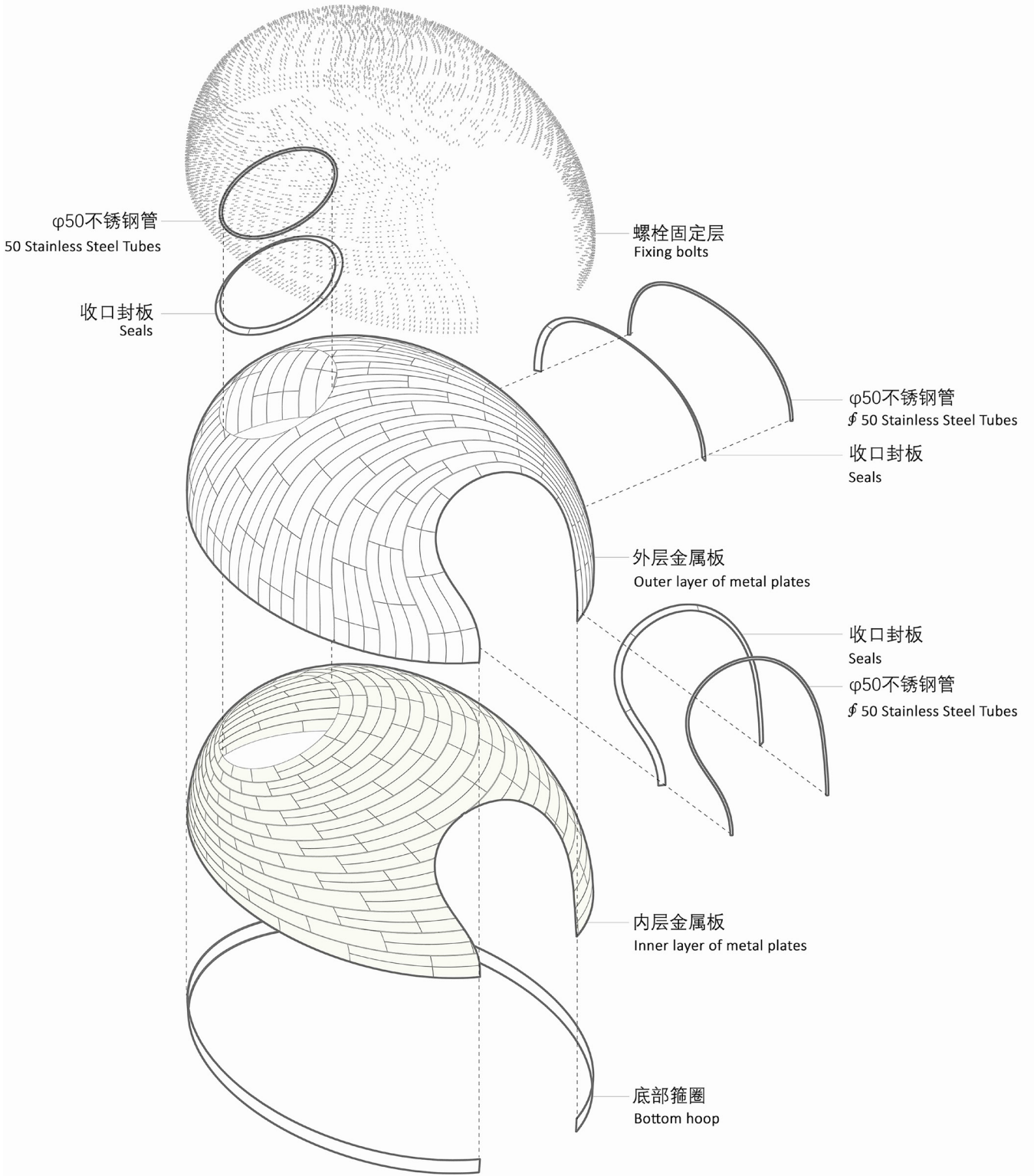
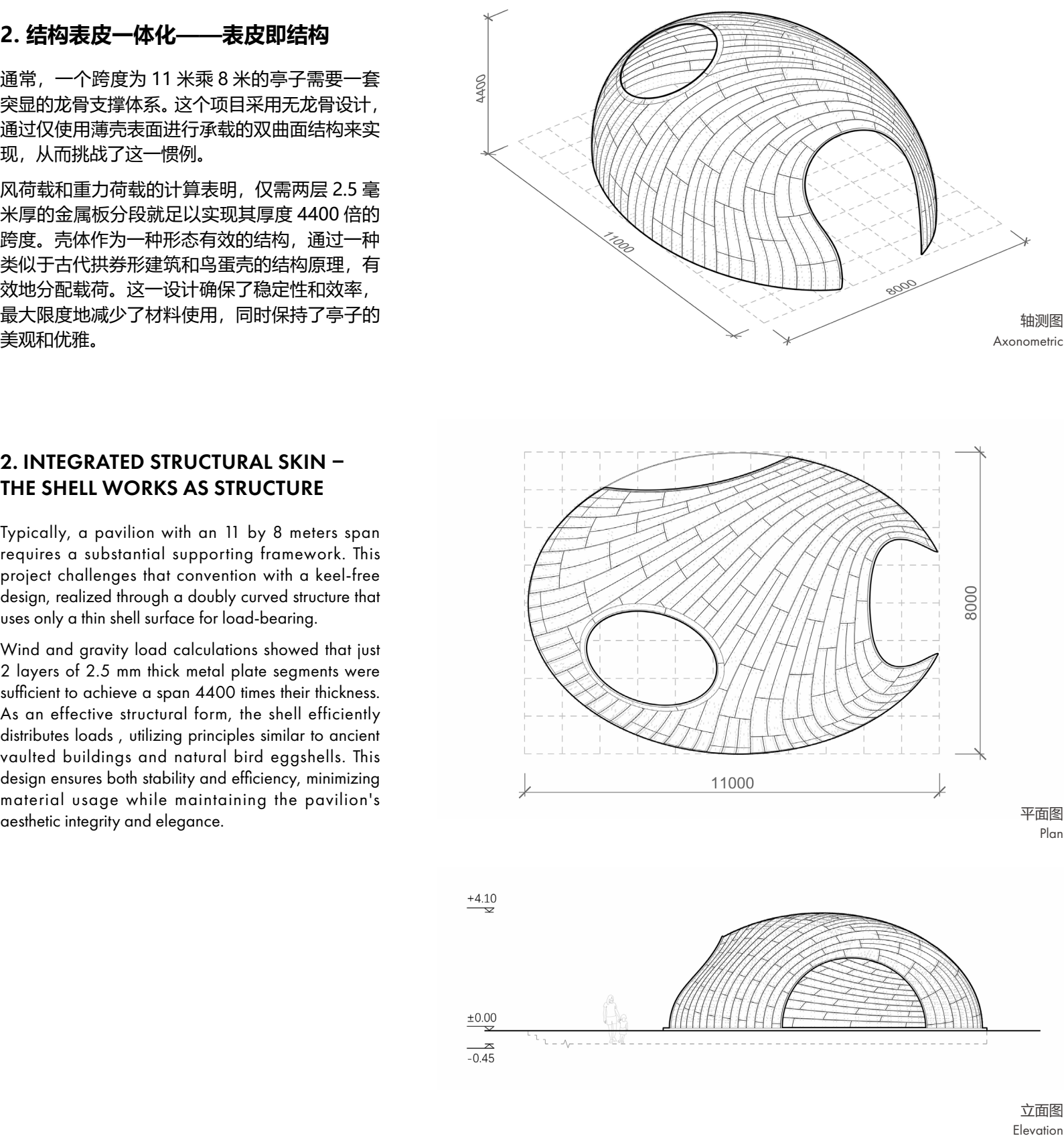
通常，一个跨度为 11 米乘 8 米的亭子需要一套突显的龙骨支撑体系。这个项目采用无龙骨设计，通过仅使用薄壳表面进行承载的双曲面结构来实现，从而挑战了这一惯例。

风荷载和重力荷载的计算表明，仅需两层 2.5 毫米厚的金属板分段就足以实现其厚度 4400 倍的跨度。壳体作为一种形态有效的结构，通过一种类似于古代拱券形建筑和鸟蛋壳的结构原理，有效地分配载荷。这一设计确保了稳定性和效率，最大限度地减少了材料使用，同时保持了亭子的美观和优雅。

2. INTEGRATED STRUCTURAL SKIN – THE SHELL WORKS AS STRUCTURE

Typically, a pavilion with an 11 by 8 meters span requires a substantial supporting framework. This project challenges that convention with a keel-free design, realized through a doubly curved structure that uses only a thin shell surface for load-bearing.

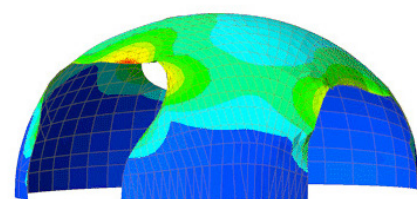
Wind and gravity load calculations showed that just 2 layers of 2.5 mm thick metal plate segments were sufficient to achieve a span 4400 times their thickness. As an effective structural form, the shell efficiently distributes loads, utilizing principles similar to ancient vaulted buildings and natural bird eggshells. This design ensures both stability and efficiency, minimizing material usage while maintaining the pavilion's aesthetic integrity and elegance.



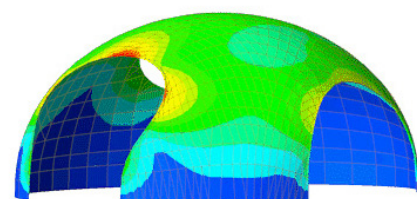
爆炸图
Explosion Diagram



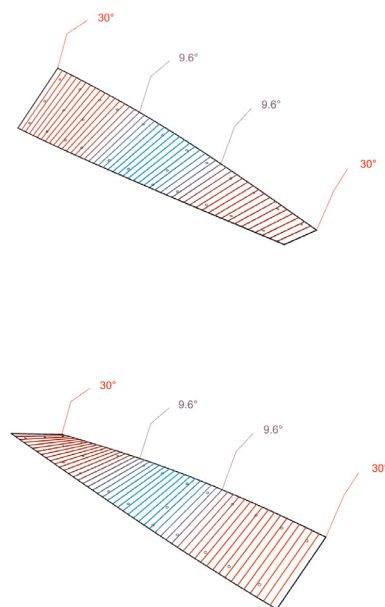
现场施工
On-Site Construction



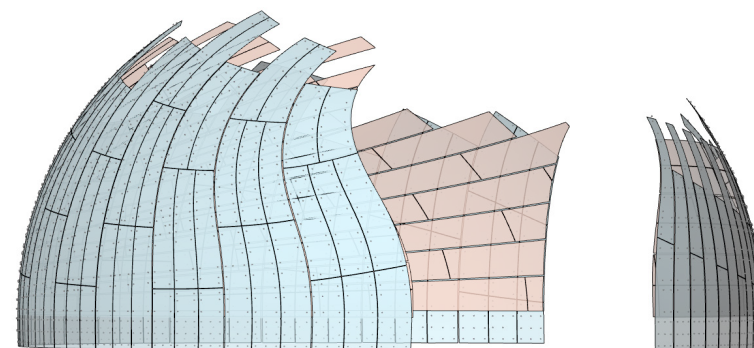
荷载分析 (仅壳体)
Load Analysis (Shell Only)



荷载分析 (强化封边)
Load Analysis (Reinforced Edge Sealing)



曲率分析和变形计算
Curvature Analysis And Deformation Calculation



主体部分拼接
Main Body Assembly

3. 易于建造的数字化施工

设计团队专门编写了一套程序用以进行曲率分析、变形计算和曲面划分。整个双曲面结构被分为 469 个不同尺寸的定制金属分段。通过数字化设计、制造，这些分段被精确设计，以确保拼合的精度，简化了加工过程。

这个亭子是无焊接的构造，所有壳体分段都通过数控加工设备预先制作，进行编号，再运至现场进行精确组装。这种方法在建设时不需要使用大量的定位龙骨和找形模板，仅需少数工匠即可高效地完成整个结构的组装。

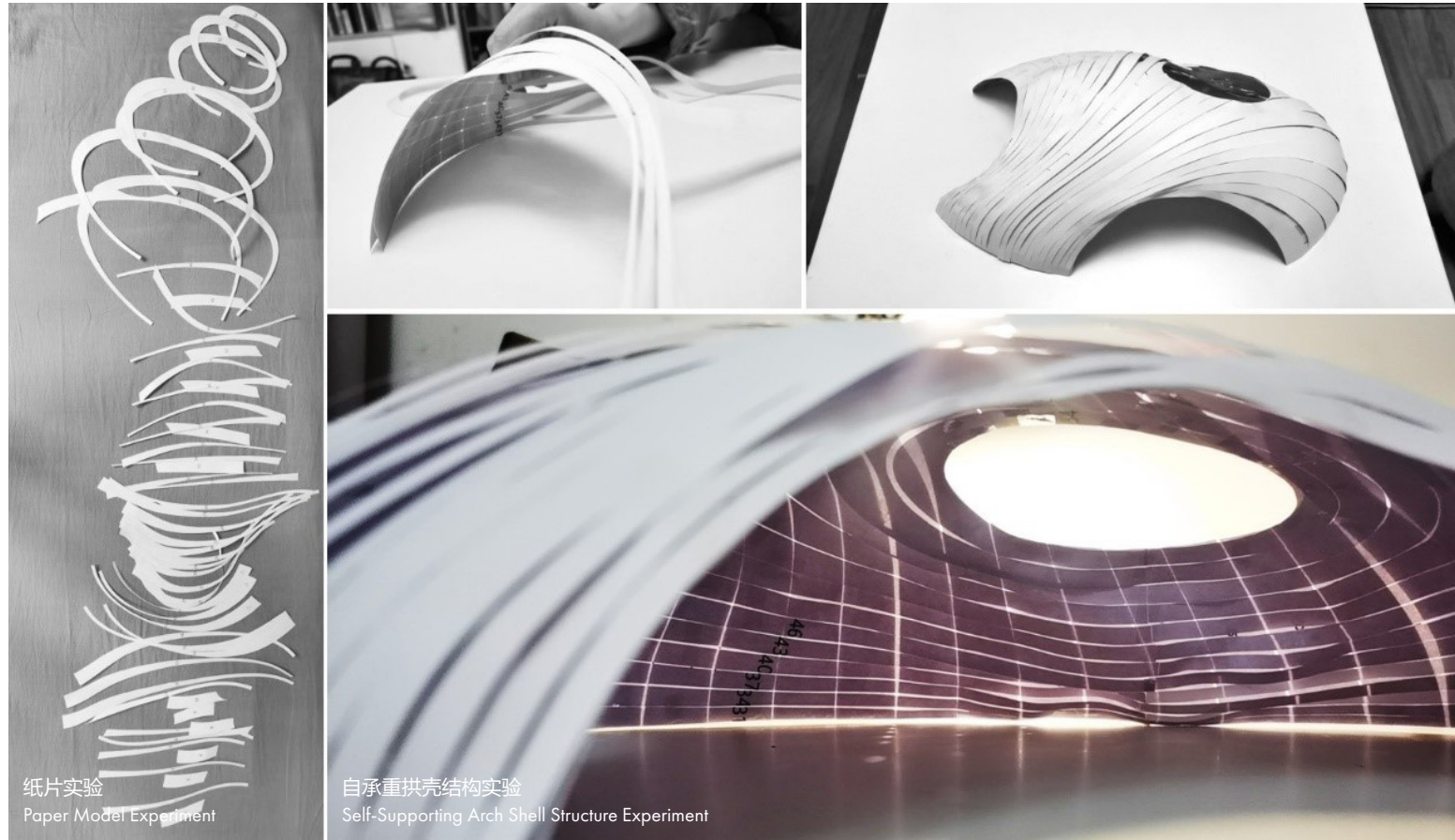
通过采用这种综合的数字方法，极大幅减少了人力成本的消耗，又提高了工艺水准，很好地呈现了双曲面顺滑柔和的视觉效果。

3. EASY-TO-BUILD DIGITALLY CONSTRUCTION

A dedicated application was programmed for curvature analysis, deformation calculation and surface subdivision. The entire hyperboloid structure is divided into 469 bespoke metal segments of varying sizes. Through the digital design and fabrication process, these segments are specifically designed to fit together precisely, ensuring easier and more efficient processing.

The pavilion is a welding-free construction, with all shell segments pre-fabricated using CNC machinery, numbered, and then delivered to the site for precise assembly. This method does not require extensive positioning keel and shape finding formwork. A small team of craftsmen is sufficient to assemble the entire structure efficiently.

By employing this integrative digital approach, labor costs are reduced, and the caliber of craftsmanship is elevated, ensuring the doubly curved geometry boasts a visually fluid and gentle appearance.



4. 装配式与可移动

在建设过程中，传统的手工焊接技术被螺栓对位和高精度铣削所取代。这个技术被采用以完成从基础组装到结构主体的整个施工过程。

这种方法的优点在于每个可拆卸螺栓都是数字设计并验证的，以确保最终形态的准确性。这防止了传统手工制造中常见的找形错误，如人工定位的累积误差和薄板的焊接热变形。

此外，这种方法赋予了亭子灵活性，可以轻松更换组件，甚至整体拆装移动。所有建筑模块都设计为可拆卸，并可以在不同地点重复使用，从而增强了项目的可持续性，并赋予了亭子时空上的延续性与永久性。

该亭子首次组装落地于 2020 年，随后在 2023 年完整搬迁并重新组装落地，以适应项目从临时的展示目的到永久使用的过渡需求，最终节约了大量的新建成本，减少了建筑材料的浪费。

4. ASSEMBLY AND FLEXIBILITY

During the construction, traditional manual welding techniques were replaced with the use of bolts for point-to-point alignment and high-precision milling. This technique was adopted to complete the entire construction process, encompassing everything from the assembly of the foundation to the main body of the structure.

The advantage of this approach is that each removable bolt is digitally designed and verified to ensure the accuracy of the final form. This prevents the form-finding errors commonly arise in traditional manual manufacturing, such as cumulative errors from manual positioning and welding heat-induced deformation of thin plates.

Furthermore, this method imparts flexibility to the pavilion, allowing for easy replacement of components or even relocation of the entire structure. All building modules are designed for disassembly and reuse at different sites, thereby enhancing the project's sustainability and giving the pavilion a sense of continuity and permanence.

First assembled in 2020, the pavilion was subsequently reassembled and relocated in 2023 to transition from a temporary exhibition purpose to permanent use. As a final benefit, considerable cost savings on new builds were achieved, alongside a reduction in material waste.





鸟巢数字编织薄壳景亭旨在为城市居民提供一个远离喧嚣的冥想空间，营造一个促进内心平和的氛围。

The Thin-shell Metal Woven Pavilion is designed to provide urban dwellers a tranquil space for contemplation, away from the hustle and bustle of city life. It fosters an atmosphere that promotes meditation and inner peace.

项目信息表

项目正式名称：	鸟巢数字编织薄壳景亭
项目地点：	中国安徽省合肥市，阳光城檀悦
开发商：	合肥阳光城
尺寸：	11 米 x 8 米
设计及建造：	喜随设计
主设计师：	胡一昊
项目经理：	彭阳
结构顾问：	翼扬（北京）建筑设计有限公司
供应商：	上海洲杰金属装饰工程有限公司 上海展晶建设工程有限公司
项目领域：	景观装置
预算：	人民币 1,000,000 元
初次建成时间：	2020 年 10 月 1 日
迁移重装时间：	2023 年 4 月 20 日
摄影师：	胡一昊，刘佳，繁玺视觉摄影工作室

DATA SHEET

Official Project Name:	Thin-Shell Metal Woven Pavilion
Location:	Hefei City, Anhui Province, China
Client:	Yango Group Co., Ltd. Hefei
Size:	11 by 8 meters
Design & Build:	XISUI Design
Chief Designer:	Yihao Hu
Project Manager:	Yang Peng
Structural Consultant:	Spiring Achitectural Design
Suppliers:	Shanghai ZhouJie Metal Decoration Engineering Co., Ltd. Shanghai Zhan Jing Construction Engineering Co., Ltd.
Project Sector:	Landscape Installation
Budget:	CNY 1,000,000
First Completion Date:	October 1, 2020
Relocation Completion Date:	April 20, 2023
Photographer:	Yihao Hu, Jia Liu, Fancy Images