乡村振兴背景下乡村传统建筑更新策略与技术途径

STRATEGIES AND TECHNICAL APPROACHES OF RURAL TRADITIONAL BUILDING RENEWAL IN CHINA’S RURAL REVITALIZATION MOVEMENT

1 背景概况

近30年来，中国的城镇化进程快速推进，同时，广袤乡村也经历了社会、经济、文化与生活方式的剧变。乡村劳动力与各类资源向大中型城市不断集聚，导致城乡两极分化日益加剧。乡村问题事关国家全局发展，又因其本身的复杂性而无法以经济或者文化的一元论视角进行简单化处理：一方面，倘若盲目效仿城市建设模式，一味注重经

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摘要

在乡村振兴的战略背景下，论文从传统乡村建筑中传统形式元素与群体风貌的保留与重塑、建造技艺的当代解读与传承、半工业化模式的引入与建造组织方式创新等方面回溯并分析了传统乡村建筑保护与更新的途径与典型案例；在此基础上，从可持续发展的研究和技术视角，提出一种更符合中国乡村实际的半工业化“微更新”传统建筑改造方式，并以江苏省兴化市戴南镇某村的“嵌院”为例加以说明，以期为未来乡村传统建筑更新与保护的应对策略、技术路径和范式提供参考。

关键词

乡村振兴；乡村传统建筑；微更新；技术途径；半工业化建造

ABSTRACT

In the context of China’s current policy-oriented Rural Rejuvenation movement, through case studies, the paper reviews protection and renewal strategies and approaches of traditional rural buildings, ranging from preservation and reshaping of traditional architectural formal elements and group characteristics, contemporary interpretation and application of traditional construction techniques, to introduction of semi-industrialized construction modes and new structural organizing approaches. Based on theoretical and technical studies of sustainability, this paper puts forward a new semi-industrialized intervention mode, called “micro-renewal,” which is more applicable for renewal practices in rural China. Finally, illustrating with an authentic micro-renewal case, the “Embedded House” in Dainan Town in Xinghua, Jiangsu Province, the paper demonstrates that this new semi-industrialized intervention offers a paradigm to strategies, techniques, and alternatives for future architectural renewal and protection in rural China.

KEY WORDS

Rural Revitalization; Rural Traditional Buildings; Micro-Renewal; Technical Approach; Semi-Industrialized Construction

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济效益与发展速度，容易造成乡村地方性文化特色的流失，导致“千村一面”；另一方面，如果一味注重文化保护而忽视乡村的物质空间建设，将致使更多人——尤其是年轻人——离开乡村，造成乡村更为严重的空心化。^[1]因此，乡村建设需在全面审视中国城乡建设的客观现状和村民生产生活需求的基础上加以积极应对。

近年来，中国乡村传统风貌与空间形态长期处于一种“亚稳定”状态，其原因在于传统的物质空间已无法适应新的乡村社会结构与产业发展需求而处于消极“停滞”的状态。中国乡村建筑的保护和更新虽然与经济的发展阶段密不可分，但总体上依然主要依托民间世代传承的建造工艺与因陋就简的建筑材料和施工技术，随着时间的推移，建筑的安全性、舒适性和适应性难免下降。

在乡村振兴的战略背景下，乡村建设需统筹兼顾地域、经济、文化等条件与需求，坚持“地域为基、文化为魂、创新为舵、设计为径、环境为果”^[2]，把握好建造工艺与技术的传承、更新与发展，实现乡村建筑的品质提升和可持续发展。目前，乡村建筑的地方性更新改造实践不断涌现，呈现出多元价值立场与实践理念。本文首先对这些项目中出现的概念、方法与技术加以梳理，将其归纳为传统符号与群体风貌的保留与重塑，以及建造技艺的解读与当代传承两个主要方面；进而探讨了基于半工业化途径的乡村建筑更新，并以“协力造屋”“内装工业化”为例加以阐释；最后，以“嵌院”作为实践检

1 Overview

In the past three decades, China has seen a rapid urbanization and its vast rural areas have also seen drastic changes in society, economy, culture, and lifestyle. Rural labors and resources are gathering toward large- and medium-sized cities, widening the gaps between urban and rural China. Rural Revitalization is one of key agendas in China, and, because of its complexity, it cannot be addressed simply in a monistic way of economy or culture. On one hand, if we blindly introduce the modes of urban construction into rural areas, or merely seek economic benefits or a fast growth, rural China's cultural identities and characteristics would be lost. On the other hand, if we only emphasize cultural protection in rural development and pay less attention to spatial construction, then more people, especially young generations, would leave their homes and migrate into cities to earn a better living, resulting in a more serious hollowing-out in rural areas.^[1] China's urban and rural construction should truly consider its reality and people's production and living needs.

In recent years, the overall architectural and spatial quality of rural China is stagnant since the existing traditional physical construction can no longer support contemporary social structure and industrial development. Although the protection and renewal of rural buildings in China closely ties with its economic development, the construction of most rural buildings still mainly relies on folk techniques, locally available materials, and simplified construction methods, and the levels of safety, comfort, and applicability of buildings would decline over time.

To achieve a greater revitalization and sustainability, geographical, economic, and cultural needs should all be taken into account in rural construction. By respecting vernacular qualities, historical and cultural traditions, and indigenous construction skills and techniques, architectural design in rural areas is expected to integrate with local environmental settings with creative methods^[2]. Nowadays the number of rural architectural renewal and renovation cases is increasing, showing a rich diversity of values and concepts. First, this paper reviews related concepts, methods, and technical development by studying preservation and reshaping of traditional architectural formal elements and group characteristics, as well as contemporary interpretation and application of traditional construction techniques; then it explores the application of semi-industrialization intervention in rural building renewals by expounding two examples of cooperative house-building and industrialized interior design. In the end, the paper introduces a “micro-renewal” concept, a new semi-industrialized

验，尝试以一种半工业化“微更新”的介入方式为乡村建筑的更新与可持续发展提供参考思路。

2 基于传统建造工艺的乡村建筑更新

2.1 传统符号与群体风貌的保留与重塑

近年来，一些建筑师在乡村建筑改造实践中，不仅与时俱进地赋予建筑新的功能，还精心保留原有建筑的历史元素，使得改造后的建筑依然能够留存“没有建筑师的建筑”的地方性特征与“乡野”信息，成为一种传统文化与现代功能协调共存的载体。

张雷联合建筑事务所在浙江桐庐深澳古村的云夕深澳里书局改建项目正是这类改造的代表。为体现建筑原本的普通民宅特征，方案保留了三个室内土灶，将其改造为艺术装置，与阅读空间自然融合；原有木质楼板被保留，并在其上另附龙骨和木地板以减少震动（图1）。

此外，在保持原建筑整体架构的前提下，尽可能在其新建部分沿袭传统形式与建造工艺，也是乡村建筑更新的有效方式。例如，浙江桐庐先锋云夕图书馆改造方案（图2）在完整保留旧建筑的前提下，创造性地将原有农宅的屋架整体抬升了60cm，形成一圈高侧窗，从而大大改善了整个建筑的采光条件，层高的增加也使内部空间更符合公共图书馆的功能需求^[3]。同时，老旧的木质楼梯也被换成白色的混凝土梯段。

intervention, which is tested with an “Embedded House” case, to provide references to ideas of building renewal and sustainable development in rural regions.

2 Rural Building Renewal with Traditional Construction Techniques

2.1 Preservation and Reshaping of Traditional Architectural Formal Elements and Group Characteristics

In many recent architectural renewal projects, designers integrated historical structures and elements with new functions through careful, modest, and rustic design and interventions. The renewed buildings could remain their original vernacular qualities and better serve contemporary needs with a stronger resilience, ecologically, culturally, and socially.

The Yunxi Shen’aoli Bookstore, designed by AZL Architects, located in an ancient village in Tonglu County, Zhejiang Province, is an example of such renewals. To celebrate the regional uniqueness of typical traditional housing, three indoor earthen stoves were reclaimed into art devices and integrated into a reading space; the existing timber floor was remained and renovated with new keels and floor materials for shock-absorbing (Fig. 1).

Remaining original architectural structures and styles while renovating with minimum interventions through traditional forms and construction techniques is another approach in rural renewals. For example, in the Librairie Avant-Garde case, a bookstore renovation project in Tonglu County of Zhejiang Province (Fig. 2), the original structure of the building was well remained, and its roof truss was creatively elevated by 60 cm, forming a series of clerestory windows, which not only greatly increases daylight of the building, but also creates more interior space allowing for public library usage^[3]. In addition, the old wooden staircases were replaced by white-painted concrete stairs for functional upgrades.

1. 浙江桐庐云夕深澳里书局：保留的木雕工艺与土灶。
2. 浙江桐庐先锋云夕图书馆

1. Yunxi Shen’aoli Bookstore in Tonglu County, Zhejiang Province: preserved wood-carving artworks and earthen stoves.
2. Librairie Avant-Garde in Tonglu County, Zhejiang Province.

江苏南京桦墅村村口农宅改造也是典型的一例，其最大限度地保持了原有建筑的体量与双坡顶木屋架体系，并以原有山墙为背景扩建了一间公共长廊，便于村民与游客休闲、驻留（图3），以激活村口广场，引发人们对乡村公共生活场景的回忆。^[4]

通过充分尊重建筑原本风格的精心修缮，以及对传统建造过程的适度调整，上述更新案例在乡村建筑的内部空间、整体风貌上实现了新、旧体系的并存与共融，凸显了地方特征，创造了更积极的空间体验，也节约了改建成本。

2.2 建造技艺的当代解读与传承

中国传统建筑的材料选型、构造工法等，一方面普遍遵循就地取材、因材施法的原则，另一方面反映出多样而独特的地理条件、地域文化、民间风俗等内涵要素。当下，由于物流交通的快速发展与高度工业化的生产方式的普及，地方材料以及传统建造技艺已逐渐失去便利性与经济性优势，但两者并非完全对立。将传统材料融入当代建造方法，不仅能进一步提高乡村建筑更新的效率与品质，也能保留传统技艺的精华。

在浙江省杭州市洞桥镇，中国美术学院的师生探索了具有乡土特征的夯土墙、抹泥墙、杭灰石墙等作为建筑表皮的可行性（图4），实现了地方材料再利用、工匠技艺传承与乡村建筑现代化改造的结合。

Another example is the housing renovation project in the Huashu Village, Nanjing City, Jiangsu Province, in which the building's volume and its wooden double-side sloping roof structure were remained, and, by reclaiming the existing gables, a public gallery was created as a gathering and recreational place for both local villagers and tourists (Fig. 3), helping activate the village common and recall collective memories of rural public life.^[4]

With a respect of buildings' original styles and characteristics, the above three cases integrate the old with and the new with meticulous renovations and modest interventions in interior and overall design, shining into regional identity and uniqueness, forming more dynamic space, and helping cost saving.

2.2 Contemporary Interpretation and Application of Traditional Construction Techniques

The material selection and construction techniques of China's traditional buildings not only depends on local availability and material performance, but also is defined by geographical, cultural, historical, and social varieties. Today, due to the rapid development of logistics industries and high industrialization, local materials and traditional construction craftsmanship have gradually been replaced by more convenient and economical methods and products. However, a combination of traditional materials and contemporary construction methods would not only improve the efficiency and quality of rural renewal, but also help revitalize traditional craftsmanships.

In Dongqiao Town, Hangzhou City, Zhejiang Province, faculty and students of China Academy of Art explored the diversity of architectural facades made of local materials, such as earth-rammed walls, mud-plastered walls, and marble-stone walls (Fig. 4), demonstrating a combination of reuse of local materials, development of craftsmanship and techniques, and modern concepts of rural architectural design. In this project, the design of new farm-houses employed a reinforced concrete structure

3. 江苏南京桦墅村村口建筑改造效果
4. 浙江杭州洞桥镇改造农宅
3. The renovated Hall of Huashu Village, Nanjing City, Jiangsu Province.
4. Renovated farm houses in Dongqiao Town, Hangzhou City, Zhejiang Province.

新建农宅以钢筋混凝土为基础，墙皮包裹材料则为附近乡村建筑拆除后留下的可再利用部分。旧建筑上那些原本并不起眼的碎石、瓦片和砖块通过重新设计与组合，不仅使新建建筑外观焕发出丰富、立体的乡村特色，还提高了建筑本身的坚固性与墙体性能，延续了村落的风貌，兼顾了对现代生活品质的追求和乡村历史信息的重塑与传达，受到了当地村民的认可。然而，这类“表皮化”建造工艺的实施难度较高，需要专门训练当地工匠，并且需要设计师将较多时间投入到现场监工中，所需的人力成本与时间成本不亚于现代建筑工业化的建造过程。因此，该模式较难在短期内大范围铺开，但仍具有一定的示范意义。

3 基于半工业化途径的乡村建筑更新

传统乡村建筑的建造通常依托家庭成员及邻里互助等方式完成。在当前乡村日益老龄化、劳动力逐渐紧缺的社会背景下，人工成本持续增加，传统模式开始失去优势。随着预制装配等工业化技术愈加成熟，半工业化、工业化乡村建设模式的边际成本持续降低，逐渐成为更加经济、可行的选择。近来，已经有一部分建筑师尝试将传统建造方式与当代工业化生产体系下的结构材料系统相融合，以提高建造效率、节省用工成本，并激发村民的自主性。

3.1 协力造屋

自1999年始，中国台湾建筑师谢英俊一直秉持将工业化技术方法应用于经济落后地区的理念，力求将房屋建造的主动权归还给当地居民，开展具有启迪意义的乡村建筑营造^[5]。他将现代轻钢结构简化，教会村民运用简单的钢结构连接方法自行营造家屋。该模式不仅能大大减少人力成本，也与乡村的社会组织方式相吻合。

在中国台湾日月潭地区邵族安置社区的震后重建项目中，谢英俊团队充分结合少数民族集体组织方式实行“以工代赈”，让少数民族以自组织形式参与到社区营建中。同时，新建筑采用高度工业化的轻钢结构与环保材料，而非当地材料作为围护结构，基本依靠人力进行建构，通过最质朴的陡坡顶建筑语言，还原了少数民族的人文生态。^[6]

在四川省汶川“5·12”震后重建中，面对人均可支配收入有限的村民，以及生态敏感、文化保护标准高、建成时间短等限制条件，谢英俊突破标准化、规格化的城市建筑工业化建造模式，提出了一套适应乡村建筑现实的、切实可行的“非整体工业化轻钢结构体系”。该体系中，只有抗震设计、结构计算、原型构架生产等涉及建筑学与结构工程学的专业内容由专业人员与工厂完成，其余部分均由村民自建。谢英俊的实践以开放性的结构体系与建造工艺，将现代技术与地

that was wrapped by rescued materials collected from nearby demolishing sites. Ordinary gravels, tiles, and bricks from old buildings are now remixed as new facade materials to highlight rich native fabrics and features and help reinforce the building, while improving its thermodynamic performance. This project has been soundly recognized by local villagers for its role in improving locals' living condition and keeping the historic sense and values of the village. However, such practice requires a high-level craftsmanship and a long-term on-site instruction by architects. Beside its demonstrative significance, compared with modern industrialized construction methods, this renewal approach does not see an advantage in labor or time cost, making difficulties for a broader application in a near future.

3 Renewal of Rural Buildings through Semi-Industrialized Methods

Traditionally, a rural family's housing construction is usually aided by other family members or neighbors. However, it is no longer suitable for today's situation, especially given the increasingly aging and hollowing-out social structure of rural areas. Meanwhile, proven modern technologies such as prefabrication and assembly construction are reducing the marginal cost of semi-industrialized and industrialized construction, offering more economical and feasible options for rural renewal. In the past few years, architects have attempted to integrate traditional construction modes with advanced industrialized structural products to improve construction efficiency, save labor costs, and encourage villagers' proactivity.

3.1 Cooperative House-Building

Since 1999, architect Hsieh Ying-Chun has been putting his efforts into practicing industrialized techniques in less-developed areas of Taiwan, China, to help enhance local villagers' proactivity in housing construction with a number of demonstrative projects^[5]. By simplifying modern light-steel structures, he has trained villagers to build their own houses in a low-tech way. Such practice could sharply reduce labor cost and work well with today's social organizing patterns in rural areas.

In the post-earthquake reconstruction project of the Shao settlements in the Sun Moon Lake area in Taiwan, China, by respecting the unique social structure of Shao community and motivating locals' "welfare-to-work" in post-earthquake reconstruction, Hsieh's team used highly industrialized light-steel structures and environmentally-friendly materials — instead of locally collected materials — for building enclosures. Most newly built structures were constructed manually. The humanistic context of the Shao community was restored by reintroducing

5. 众建筑“内盒院”（5-1）
与旅舍室内（5-2）
5. The Courtyard House
Plugin designed by
People's Architecture
Office (5-1) and the
interiors of the hostel
(5-2).

方材料和传统建造工艺糅合起来，实现了工业化的高效性与乡村建筑的地域性的融合。

3.2 内装工业化

早在20世纪中叶，荷兰与日本就先后提出了将支撑体（Skeleton）与填充体（Infill）作为两个独立体系来考虑的开放建筑体系（SI），其中支撑体具有坚固、永久的特征，填充体则具有足够的灵活度。在此基础上，内装工业化理念则是基于填充体的功能发展而来。其依托工业化生产体系进行预制建造，具有通用性与标准化特性，有别于一般的“室内装修”，能够承载更多的建筑功能。

众建筑在2014年北京大栅栏更新计划中展示的“内盒院”预制模块建造系统（图5-1）即是内装工业化理念的表现形式之一。模块盒体由预制板材拼接而成，并将结构、水电线路、设备管井等集成于一体，内嵌于老旧房屋之中，可以有效延长其使用寿命并提升舒适性，具有突出的快捷性与集成优势，是对内装型改造的有益探索。中国建筑师何崴及其团队在浙江省松阳县平田村也开展过类似实践：将一栋木结构夯土旧宅的整体结构和外部形态完整保留，在二层植入三个由阳光板围合而成的“盒子”，用作旅社客房。植入的“盒子”采用聚碳酸酯材料，呈现半透明的现代性特征，老宅质朴的木穿斗屋架也得以还原，使新、旧内部装饰体系能够明晰区分（图5-2）。插入的盒体尺度适宜居住，并能根据需要进行水平移动，提高了空间利用的灵活性。^[7]

5-1
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5-2
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vernacular steep-slope roofs.^[6]

In the post-earthquake reconstruction of Wenchuan County, Sichuan Province in 2008, due to the limited budget and time frame, high ecological vulnerability, and demanding cultural protection, Hsieh and his team proposed a practicable means that adopts a partly-industrialized light-steel structure, rather than a standardized and high-industrialized system usually employed in urban construction. Through this new approach, technical frameworks, including seismic design, structural engineering calculation, and prototype modeling, are developed by architectural professionals and suppliers, while the rest are all determined and built by villagers. Hsieh's practice combines modern technologies with local materials and traditional techniques through an open structure and construction system, meeting both requirements of high construction efficiency and vernacular qualities.

3.2 Industrialized Interior Design

As early as the middle of the 20th century, Dutch and Japanese architects started to consider dealing with a building's skeleton and its infill as two separate parts and developed a Skeleton-Infill (SI) System, in which skeleton is a permanent structure with a great loadability and the infill can allow for adjustments over time. On this basis, an industrialized interior design can be regarded as a kind of infill, which, compared with interior decoration, is under standardized prefabrication to better support architectural functions.

The prefabricated modular system “Courtyard House Plugin” (Fig. 5-1) designed by People's Architecture Office for the 2014 Beijing Dashilar Project was an example of industrialized interior design. Made up with prefabricated panels, this plugin design integrates a skeleton, wiring and plumbing system, equipment wells, etc. into the existing building to prolong its service life and improve users' experience. In this project prefabrication showed an outstanding flexibility and integration, proving a valuable exploration on interior renovation. Chinese architect He Wei and his team have carried out a similar practice in Pingtian Village, Songyang County, Zhejiang Province. The existing wooden structural framework and external forms of an old earth-rammed house were completely preserved, and three “boxes” made with translucent polycarbonate panels were installed on the second floor to serve as guest rooms of a hostel. Its interior design outlines both the old and the new systems by contrasting the modern materials and fabrics with the rustic wooden column-and-tie skeleton (Fig. 5-2). The plugin boxes are designed in a livable size and can be moved horizontally as needed, allowing for a higher flexibility of spatial use.^[7]

4 基于内装工业化的乡村建筑更新与技术整合^[8]

根据对当下乡村建筑基于“文脉”与“技术”的多种更新模式的整体研究，本文尝试对内装工业化“微更新”技术进行进一步深化与实践应用。近年来，笔者所在课题组^①以江苏兴化戴南镇某村一典型农宅（图6）为例，提出了一种建筑原型——“嵌院”，分别从建筑体系、空间构成、结构强化、墙体优化、设备优选的角度研究了内装工业化在乡村建筑更新中的具体工程应用。

老宅建于20世纪90年代，原为三开间朝南的院宅，北墙为另一户的南院墙，无法开窗。2000年初，屋主在院南侧加建辅助用房并将院子改造成合院，原本的三开间仅剩中间堂屋可以自然采光，天井成为进出各个房间的必经之路，在大风、下雨等天气条件下使用不便。在本次改造中，屋主希望在拓展有效使用面积的同时，解决采光不足的问题，并改善堂屋的居住品质。

4.1 建筑体系生成

基于SI建筑体系，原有农宅可被视为一种具有时间属性的表皮骨架，其立面材料具有一定的历史与文脉信息，属于村落风貌的基本组成要素。然而，该骨架也存在性能短板，其结构安全、保温、防水与隔音性能无法满足现代生活需求。因此，有别于将填充体完全作为标准化构件来实现功能灵活性的SI建筑体系，“嵌院”尝试将填充体作为骨架短板的补充，从空间、结构、围护、设备等角度实现整座农宅的功能升级（图7）。

4.2 平面空间重构

“嵌院”基于对空间多义性与开放性的思考，对既有传统旧宅的空间构成进行了调整与优化。现状农宅是由一栋三开间坡顶屋与一组

4 Rural Building Renovation and Technical Integration through Industrialized Interior Design^[8]

Based on an overall study of current renewal modes of rural buildings rooted in local cultural context and technical upgrades, this paper further explores the application of micro-renewal technologies in industrialized interior design. A research group^① studied on a typical farm house in a village in Dainan Town, Xinghua City, Jiangsu Province (Fig. 6) and developed an architectural prototype, “Embedded House,” to examine its engineering application in rural building renewals from aspects of architectural structure, spatial composition, structure reinforcement, wall optimization, and equipment improvement.

Built in the 1990s, the old house consisted of three south-faced rooms with a courtyard. Because its northern wall was shared with another household, there was no window on that wall. In early 2000, the house owner built an additional room to the south and enclosed the house into a courtyard. Afterwards, only the middle room (the living room) could get sun-lit, and the open-air patio became a hub connecting all rooms, which caused inconvenience in windy or rainy days. Designers were expected to increase daylight of the house, improve the comfort level of the living room, and optimize spatial usage.

4.1 A New SI System

Based on a SI system, the existing house can be regarded as a surface of skeleton that evolves over time and its facades present historic and cultural traces, as a basic element of vernacular styles and characteristics. However, the skeleton had a low loadability and poor performance in structural stability, thermal

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6. 农宅总平面图（左）与现状农宅轴测图（右）
7. SI住宅体系与内装工业化体系对比
8. 平面改造前后分析
6. Site plan of the farm house (left) and an axonometric drawing of the existing farm house (right)
7. A comparison between the SI System and an industrialized interior decoration system
8. Before and after embedding the core module

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平顶屋围合成的口字型院落。由于旧宅南侧加建的附属建筑遮挡了东侧厢房的采光，所以进行局部拆除；在原有天井中置入了一个核心模块，将中庭式的空间构成转变为边院式，形成一个并联式平面空间，加强了南北空间的直接衔接（图8）。这种“嵌入式”的微小介入并未伤及旧宅筋骨，还将原有的堂屋面积扩大了一倍。该嵌入模块的内装改造并未覆盖整个空间，而是采用架空地面、双层墙体的构造，可将所需的设备供电系统集成其中。通过核心模块的带动，其余房间因宅院中间区域的品质提升被激活。

4.3 整体结构加强

针对乡村住宅的构件特征，课题组总结了表层蒙皮、连接包裹、梁柱包裹、框体包裹的旧建筑结构加固手段。在“嵌院”中，填充体作为同时优化空间构成与结构的介入要素，被定义为盒子一样的内胆，用于框体包裹，即在原有围护结构的内层附加一层框架龙骨，通过墙面节点连接框架龙骨与旧建筑，使得既有建筑结构变形时产生的

insulation, and water and sound proofing. Unlike other SI systems that adopt infill as individual standardized components for a better functional flexibility, the design of Embedded House uses infill to complete its skeleton to upgrade the space, structure, enclosure, and equipment of the house in a holistic way (Fig. 7).

4.2 Reorganization of Spatial Layout

Taking spatial multi-functions and openness into consideration, the spatial layout is reorganized and optimized. The existing enclosed courtyard was shaped by the double-side sloping roof in the north and several flat roofs in the south. The added structure in the south is partially demolished to increase daylight of the eastern wing. To reconnect the north and the south, a core module is embedded in the open-air patio, forming a parallel layout of the house while creating a side yard (Fig. 8). This micro-scaled embedded intervention does not need any transformation of the existing skeleton but doubles the size of the living room. Instead of an entire renewal, its interior design adopts a sub-framing floor and dual-layer walls, where wiring systems and other necessary equipment are integrated inside. This core module improves the comfort and spatial usage of the house.

4.3 Reinforcement of Overall Structure

The research group found that in architectural renewals of rural buildings, reinforcement methods, such as surface enveloping and wrapping of joints, beams, columns, or frames. In the case of Embedded House, the core module, as the infill, is used for optimizing both spatial layout and structure, like an inner tank inside a box. Technically, this frame wrapping adds

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应力可以传递至框架龙骨，以有效延缓老建筑结构的变形破坏，同时最大限度地保证了室内空间的安全性。为了验证这种结构优化策略的可行性，课题组利用有限元分析（FEA）工具对既有农宅结构与经过框架龙骨加固后的农宅结构进行了模拟分析。从图9分析结果的对比可知，在一定重力载荷与风力（侧向力模拟）的影响下，既有农宅的结构系统存在一个变形趋势值（图9-1）；若既有结构与框架龙骨“嵌体”组合受力，整个结构系统的变形明显下降（图9-2）。

4.4 双层墙体优化

乡村住宅的墙体以砖石墙、夯土墙、木板墙为主。经过长期使用，建筑墙体因地基不均匀沉降、材料冷热变形开裂、风化腐蚀等原因，逐渐失去其基本的防水保温性能。但是传统建筑的立面又因其所具有的历史文化价值，需加以精心保护与利用。在“嵌院”中，对于部分已经出现严重变形或墙面凹凸肌理明显的建筑墙体，常规的找平法难以修复。课题组在构造层与原始墙体间用防腐木龙骨隔开并穿孔留出100mm厚的空气层，在此基础上再进行框架龙骨复合墙体的安装。这种方式简化了墙体施工难度，同时也充分保持了墙体的原有状态。

4.5 建筑设备选型

乡村住宅的设备优化可以明显提升室内生活的舒适性。“嵌院”主要针对采光系统、通风系统与卫浴系统进行优化。由于旧宅在设计建造之初未考虑建筑设备空间，所以现状的水电、空调、照明管线皆为明露式，不仅与旧宅室内风格格格不入，也留有安全隐患。“嵌

a layer of frame keels inside the existing structure with joints on walls, so that the stress caused by building deformation can be transferred to the frame keels that would effectively reduce the stress on the old building and greatly improve its safety. The research group simulated and compared the stress deformation of the house before and after the reinforcement by a Finite Element Analysis (FEA). As shown in Figure 9, under a given gravity load and wind force (lateral force), the deformation of the existing frame of the three rooms in the north (Fig. 9-1) is considerably reduced after the core module embedded (Fig. 9-2).

4.4 Optimization of Dual-Layer Walls

Among most rural traditional buildings, materials used to build walls include masonry, rammed earth, and plank. Their performance would decline over time in waterproof and thermal insulation due to uneven subsidence of foundation, deformation or cracking, and weathering. Meanwhile, these walls should be well protected, reused, and revitalized for their historic and cultural values. In Embedded House, some walls have seen serious deformation or obvious damages that cannot be restored by conventional leveling methods. As a solution, before the reinforcement, anticorrosive wood keels are installed first between the existing walls and the newly embedded structure, leaving a 100 mm ventilation layer with air-holes. This method not only simplifies on-site construction but also protects the existing walls.

4.5 Improvement of Household Equipment

Equipment improvement would greatly increase the living comfort level of rural houses. The systems of daylighting and ventilation, as well as toilet and bathroom equipment, of the

9. 利用FEA在侧推力作用下的建筑墙体及杆件内力，来检验农宅改造前后的结构变形趋势。红色表示局部内力为压力，蓝色为拉力，白色为无内力。
10. “嵌院”建筑采光优化设计
11. “嵌院”建筑通风优化设计

9. Simulations of structural deformation before and after the reinforcement by a FEA through a lateral thrust test. Red: tension; Blue: pulling; White: no internal force detected.
10. Daylight improvement of the Embedded House
11. Ventilation improvement of the Embedded House

院”充分利用了旧宅坡屋顶与嵌入模块之间的三角形屋架夹层，将设备终端（例如空调设备的送风口与室外机风口）安装于此。同时，夹层的尺度恰好适合维修人员从吊顶进入，为后期的设备维护与更新预留了空间。

由于旧宅的天井尺寸较小，堂屋室内光线昏暗，在植入核心模块后，“嵌院”分别在原中庭的顶端与堂屋正北向的吊顶处进行了采光优化设计：在原中庭部分开启一扇电控天窗，与侧向的边院形成一个开放的半室外空间，使自然光尽可能多地进入室内（图10）；此外，在堂屋北侧屋顶置入一组导光筒，它们穿过设备夹层直至吊顶，将原本昏暗的空间照亮，使室内在白天可以完全实现自然照明（图11）。当电控天窗关闭时，天窗下的明亮空间与设有导光筒的堂屋合并成一个40m²的“无影”起居空间。天窗的设计同时也是基于对自然通风的

Embedded House are improved. Because there is no room for household equipment improvement, all existing wiring, plumbing, air-conditioning, and lighting systems were installed outside the walls, mismatching the traditional style of the old house and leaving safety hazards. The design installs equipment terminals (for example, the air outlet and tuyere of air-conditioner) in the mezzanine between the existing triangular truss and the newly embedded structure. At the same time, the mezzanine is large enough for future maintenance and renewal operations.

Considering the small size of the existing open-air patio and the poor daylight of the living room, the design opens a motor-controlled skylight at the top of the patio to form an semi-open space together with the side yard (Fig. 10). In addition, installed through the mezzanine, a light guide tube is introduced on the northern ceiling of the living room, through which the room would not need an additional lighting in daytime (Fig. 11). When the skylight is closed, the patio and the living room together form a 40-square-meter “shadow free” space, where it is still bright enough in daytime. The skylight also helps improve

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考虑，由于旧宅北侧与他户毗邻，无法形成南北向的穿堂风，天窗为整个长平面添加了一个气孔，提供了可调节的自然通风（图12）。

旧宅原本没有独立的卫浴系统，使用西北角红砖砌筑的旱厕。而在SI建筑体系中，整体式卫浴技术已经相对成熟且普遍应用，早在2008年，美国莱斯大学就设计了可吊装的集成卫浴系统^[9]。区别于需要进行防水闭水测试等工序的传统厕所，此类卫浴系统只需解决与外部综合管网的衔接问题。在“嵌院”中，整体卫浴系统被安装在南侧辅助房间内，因为此处紧邻预埋了市政管网的村道，便于卫浴下水系统与其

natural ventilation: given there is no south-north ventilation paths, the skylight serves as an important air hole for natural circulation of the whole house (Fig. 12).

Given there is no toilet-bathroom plumbing system in this house, a brick dry toilet in the northwest corner is used. In a SI System, technologies of integrated toilet-bathroom system is sophisticated and widely applied. In as early as 2008, Rice University in the United States designed a hoisting toilet-bathroom system^[9], which can be easily connected to a house's existing pipe network, no need of waterproofing tests. In Embedded House, an integrated toilet-bathroom system is installed in one of the rooms in the south, where it is closer to village's sewerage network. The Embedded House project

12. “嵌院”建筑综合剖面

12. Section of the Embedded House

衔接。“嵌院”尝试从工业化预制构件市场化的背景中思考乡村建筑设备优化的渠道，并针对乡村农宅中普遍的设备现状、房屋问题提出具有参考意义的解决方案。

目前，“嵌院”处于样品试制阶段，样品由南京旭建新型建材股份有限公司生产制作，出厂价约为1 100元/m²，但工厂与项目场地之间的运输费用较为昂贵，增加了不少成本。假以时日，待该产品能够在当地规模化生产、建造后，其成本将进一步降低，产品竞争力会大大提升。

5 结语

近年来，中国乡村普遍陷入经济衰退、人口流失与老龄化的困境，传统建造工艺与技术的传承日渐式微；另一方面，农村劳动力成本也在持续上升。因此，探寻一种改善性或替代性的乡村建筑更新技术路径势在必行。^[10]在乡村振兴战略背景下，乡村建筑更新除了以传统风貌维系与特色塑造为目标外，还应因时、因地、因材料而异，尽可能选择经济且适用的材料、技术和建造模式，既保留“传统的由世代因袭相传和实效性带来的建筑建造方式”^[2]，也须将营造工程的时间、经济成本纳入考量，并充分利用工业化的规模经济优势平衡机会成本。内装工业化“微更新”途径兼顾了上述两方面目标，可在一定程度上减少乡村建筑更新对劳动力的密集需求，也能推动村民参与工业化生产，为乡村转型发展提供难得的机遇。**LAF**

ponders over the paths of equipment improvement of rural buildings in an era of high-industrialized prefabrication, demonstrating an alternative solution to rural housing renewals.

At present, the Embedded House is in a trial production by Nanjing Asahi New Building Materials Co., Ltd. The ex-factory price is approximately RMB 1,100 per square meter; an average transporting expense from Nanjing to Xinghua is high, largely increasing the total cost. In the future, local manufacturing and construction of this product would considerably reduce its production cost.

5 Conclusion

In recent decades, on one hand, accompanying with societal problems like economic recession, labor loss, ageing of population, rural China has seen a dwindling in the development of modes and technologies of rural traditional construction. On the other hand, the rise of labor cost is challenging architects to explore a technical alternative of rural building renewal with minimum improvement or replacement.^[10] In the context of Rural Revitalization, China’s rural building renewals should not only protect vernacular qualities and identities, but also consider selection of local materials, techniques, and methods, as well as cost and time-period assessment. In other words, contemporary rural architectural renewals are expected to preserve the effective traditional construction methods, knowledge, and experience, which are passed down by generations^[2], while using industrialized products for a higher efficiency, a greater performance, and a more economical approach. As an example of such practice, micro-renewal of industrialized interior design would require a lower demand for labor force and facilitate villagers’ engagement into industrialized production, providing an opportunity for a true rural revitalization. **LAF**

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