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Application of Compacted Soil Materials in the Composite Public Space of Wusutu Village

Jiaojiao Zhang

School of Art and Design, Baotou Normal University, Baotou, China,
3116275966@qq.com

Abstract. This study focuses on a proposed composite public space in Xiwusutu Village, Hohhot, and discusses the regional expression, construction adaptability and functional integration of rammed earth in rural public space. Drawing upon field surveys, questionnaire research and comparative case analysis, this paper systematically sorts out rammed-earth residential architecture distributed across the southern Yinshan foothills and Hohhot-Baotou Basin, and links this building material to local temple culture, integrated farming-nomadic collective memory, ancient apricot orchard landscapes and the spatial logic of loess terraced landforms. The design reorganizes the site's idle plots into a multifunctional public space integrating folk culture exhibitions, intangible cultural heritage workshops, study classrooms, visitor rest areas and activity spaces for local villagers. The study suggests that rammed earth can strengthen local identity and contribute to passive environmental performance, while its practical implementation still depends on soil testing, local construction training and detailed technical development.

Keywords: Rammed earth, Xiwusutu Village, Composite public space, Regional culture

1. Introduction

With the continuous promotion of national policies on rural revitalization, traditional village conservation, and green low-carbon development, the renewal of rural public spaces is required to balance functional upgrading, regional cultural inheritance and the adoption of eco-friendly building materials. However, existing studies have primarily focused on the application of rammed earth in residential architecture, with limited research exploring the integration of traditional earthen architectural techniques from the southern foothills of the Yinshan Mountains in Inner Mongolia into composite public space design [1-5]. Furthermore, research on rammed earth construction technologies and operational models suitable for cold northern regions remains limited, highlighting the need for enhanced regional specificity and practical applicability [6-11]. Against this research backdrop, this study focuses on the application of rammed earth materials in the design and construction of a new composite public space in Xiwusutu Village Considering the site conditions of the vacant land in Xiwusutu Village, this research adopts a methodology combining literature review, case study analysis, and field investigation to explore how the characteristics, construction logic, and structural strategies of rammed earth materials can be integrated into the functional organization and spatial design of composite public spaces. Theoretically, this study aims to fill the

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research gap concerning the application of rammed earth materials in composite public space design. Practically, it seeks to support the development of new public spaces in Xiwusutu Village and provide a reference design approach for the preservation and adaptation of traditional earthen construction techniques in similar villages across Inner Mongolia and other northern regions of China.

2. Scheme presentation

2.1. Summary of survey findings

The questionnaire survey revealed that the public is aware of rammed earth materials and generally recognizes their ecological advantages and regional cultural characteristics. Meanwhile, the majority of respondents indicated a need for additional public spaces and showed a preference for spaces that incorporate educational activities and cultural exhibition functions. These findings suggest that public spaces integrating cultural display, educational practice, and interactive experiences are more aligned with current community needs. Therefore, this study defines learning and educational venues and cultural exhibition spaces as the core functional components of the overall design scheme.

2.2. Design description

This design proposal is developed based on the overall concepts of courtyard enclosure, cultural integration, structural adaptation, and low-carbon operation. The buildings and courtyards together constitute a composite public space, with the overall layout forming a clear enclosed relationship along the site boundary. Systematic spatial linkages are constructed across functional zones, including the entrance plaza, folk culture exhibition areas, intangible cultural heritage workshops, educational classrooms, shared kitchens, tourist lounge areas, village activity spaces and supporting service facilities.In terms of circulation organization, the main entrance is connected to existing village roads, while visitor circulation is arranged around the central courtyard. Side entrances accommodate the daily use of local residents, and logistical service areas are sited near the site perimeter to minimize conflicts with primary visitor routes. Regarding landscape design, supplementary apricot tree planting, shallow drainage swales, permeable paving, and waterscape resting areas are incorporated to create a courtyard microenvironment that harmonizes with the surrounding Daqing Mountain landscape. In this scheme, rammed earth materials serve not only as an expression of architectural façades but also as essential elements in boundary walls, courtyard backdrops, interior partitions, and landscape features.

The building façades employ modern rammed earth materials primarily composed of locally sourced loess, thereby continuing the earthen construction traditions and cultural memory of Xiwusutu Village. Rammed earth walls should not be placed directly in contact with the ground; instead, stone or concrete plinths, damp-proof layers, and drainage slopes should be incorporated to enhance durability and moisture resistance. Flexible sealants and metal connectors should be applied at the interfaces between timber, glass, and rammed earth components to accommodate differential thermal expansion and contraction and prevent cracking. In terms of seismic performance, the design complies with rural residential seismic safety standards by adopting structural measures such as ring beams, structural columns, tie reinforcements and steel-timber composite frame systems to strengthen the overall structural integrity and stability of the building [12-14].

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2.2.1. Design deduction

The architectural form is derived from the traditional courtyard dwelling prototype, and its development can be divided into four stages. First, the site boundaries, main entrance, and central courtyard are defined. Second, the building mass is subdivided according to functional requirements, including exhibition spaces, educational areas, leisure facilities, and service areas. Third, the building volumes are adjusted in response to solar orientation, prevailing wind conditions, and borrowed landscape views, allowing major public spaces to be organized around the inner courtyard. The final stage shapes the solid-void spatial relationship by integrating rammed earth enclosures, glass openings, semi-outdoor transitional spaces and connecting corridors.

The building volumes adjacent to the primary arrival area accommodate entrance identification and exhibition guidance functions, while those facing the inner courtyard support social interaction, recreation, and gathering activities. The external façades employ a combination of massive rammed earth walls and strategically placed transparent openings, creating a spatial character that conveys both stability and openness. To enhance the rigor and legibility of the design derivation process, Figure 1 will be further supplemented with iterative design sketches, volumetric scale analysis and façade opening refinement processes in the final drawing set (Figure 1).

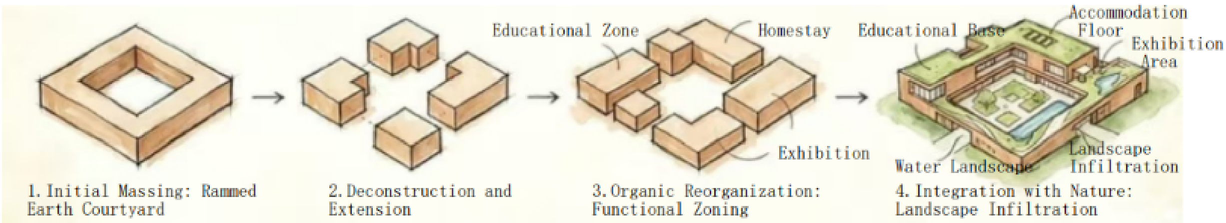

Figure 1. Architectural massing evolution diagram (source: drawn by the author)

2.2.2. Master plan

The master plan adopts an enclosed layout strategy, with buildings arranged along the site boundaries to create a public activity space centered around the courtyard and water features. The main entrance is prominently positioned along the southern road frontage, with a dedicated entrance gathering and buffer zone arranged on the entry site. Internally, pedestrian circulation is organized around the central courtyard, connecting key functional spaces including the folk culture exhibition hall, educational classrooms, intangible cultural heritage workshops, leisure tea areas, and shared kitchen facilities.

The site's grading should work with the existing topography by incorporating drainage slopes of 0.3%–0.5%. Shallow drainage swales and permeable paving should be installed along the courtyard edges to minimize the impact of seasonal rainfall and prevent water accumulation around the base of the rammed earth walls. Further refinement of the master plan should include the addition of a scale bar, north arrow, key dimensions, site boundaries, entrances and exits, fire access and service circulation routes, as well as room labels and area annotations, thereby ensuring that the drawings provide sufficient technical information to support the implementation of the proposed design.

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Figure 2. Site plan (source: drawn by the author)

Figure 3. Functional layout plan (source: drawn by the author)

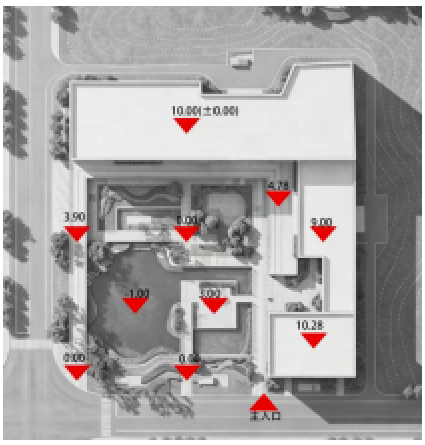

Figure 4. Elevation analysis diagram (source: drawn by the author)

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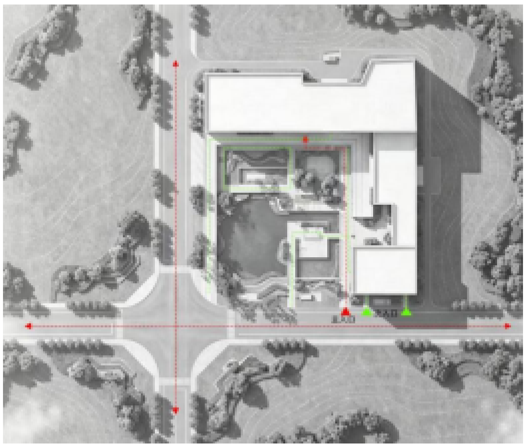

Figure 5. Road network analysis diagram (source: drawn by the author)

2.2.3. Functional analysis

The functional organization of the proposed scheme follows a sequence of entrance guidance, cultural exhibition, workshop experience, courtyard interaction, leisure services, and supporting facilities. The folk culture exhibition hall is designed with a unidirectional circulation route. The entrance exhibition zone interprets local village history, the cultural connotation of regional temple architecture, and the historical heritage of centennial apricot orchards. The intermediate exhibition spaces display traditional earthen dwellings, agricultural tools, and local handicrafts, while the exit area is connected to cultural and creative products as well as local agricultural product displays.

Educational classrooms are designed to accommodate small groups of 30–40 participants, supporting activities such as rammed earth material education, hands-on craft workshops, and nature observation programs for primary and secondary school students. Intangible cultural heritage workshops are planned to accommodate 10–20 participants simultaneously, facilitating activities including clay sculpture making, rubbing techniques, and apricot product packaging experiences. Adjacent to the central courtyard, the shared kitchen and leisure lounge serve as daily gathering venues for local villagers, and can be converted into tourist-oriented leisure and consumption spaces during holidays and peak tourism seasons.The floor plans of the proposed scheme are presented in Figures 6 and 7, while the circulation analysis diagrams are illustrated in Figures 8 and 9.

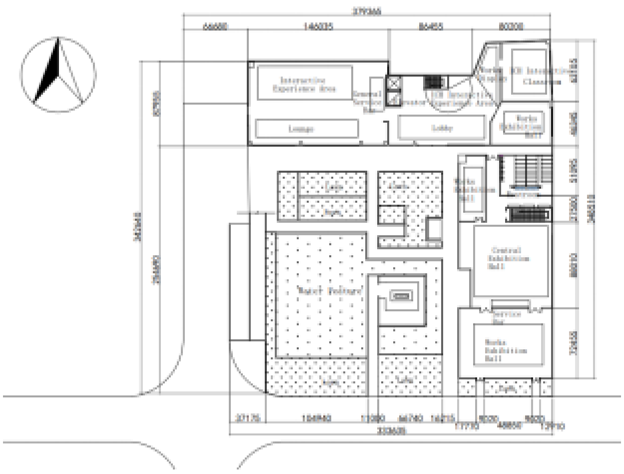

Figure 6. First floor plan (source: drawn by the author)

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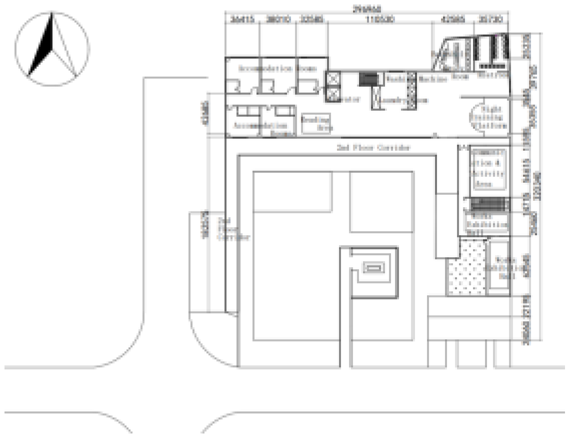

Figure 7. Second floor plan (source: drawn by the author)

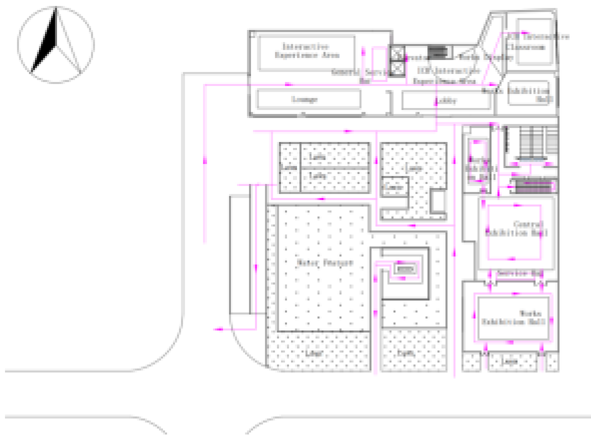

Figure 8. First floor circulation diagram (source: drawn by the author)

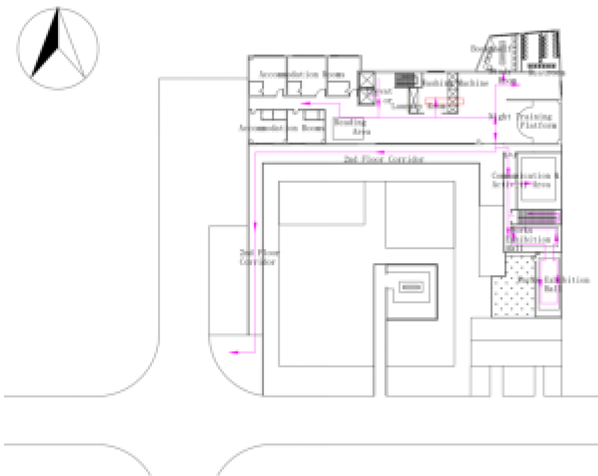

Figure 9. Second floor circulation diagram (source: drawn by the author)

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2.2.4. Facade analysis and rammed earth material application

The façade design primarily utilizes rammed earth wall surfaces, complemented by glazed openings, localized stone plinths, and timber elements to create visual depth and material variation. The road-facing elevation focuses on architectural integrity and site recognition, forming a distinct sense of place via continuous rammed earth enclosure surfaces. In contrast, the courtyard-facing elevation incorporates additional window openings and semi-outdoor transitional spaces to strengthen the visual connection between interior functions, including exhibitions, educational activities, and leisure spaces, and the external courtyard environment.

In the subsequent elevation drawing optimization, comprehensive technical parameters will be supplemented, including structural grid sizes, key elevation elevations, wall thicknesses, window scales, material legends and standard construction detail annotations. This will ensure that the drawings provide adequate technical support for the design proposal rather than functioning solely as representational renderings lacking construction-based evidence (Figure 10).

Figure 10. Architectural elevation analysis diagrams (source: drawn by the author)

Rammed earth serves as the core material of this design proposal. Different rammed earth finishes are used on different surfaces for varied expression. Layered rammed earth is employed for exterior boundary walls and entrance areas to reinforce the texture and visual character of the loess landscape at the foothills of the Yinshan Mountains. Smoother rammed earth finishes are used for selected interior partition walls to reduce surface wear caused by frequent contact. Landscape elements, including seating, planting beds, and low courtyard walls, may incorporate rough rammed earth surfaces or rammed earth-textured concrete to enhance the tactile experience of public spaces. The application of rammed earth is no longer confined to building facades, but is extended to paving boundaries, landscape installations, interior partitions and exhibition backgrounds, forming multi-layered material presentations adapted to varied spatial scenarios (Figure 11).

From a construction perspective, rammed earth walls are recommended to adopt a system consisting of an elevated foundation, damp-proof layer, layered rammed earth construction, and top capping protection. Stone or concrete plinths with a height of 300–450 mm should be installed at the base of the walls, with a damp-proof course incorporated between the plinth and the rammed earth wall. Before determining the final proportioning scheme, the soil mixture undergoes particle screening, moisture regulation and compressive strength testing of prefabricated sample blocks. Where necessary, appropriate amounts of aggregates, lime, or cement stabilizers may be added to reduce the risk of shrinkage and cracking. Additional reinforcement, such as tie connectors or structural columns, should be incorporated at door and window openings, wall corners, and long wall segments. Ring beams constructed from timber, steel, or reinforced concrete should be installed at the top of the walls to enhance structural integrity. Furthermore, roof overhangs, protective coping elements, or drip edges should be provided above exterior walls to minimize long-term erosion

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caused by rainwater exposure. All aforementioned construction techniques will be further visualized and refined in subsequent construction detail drawings and technical illustrations.

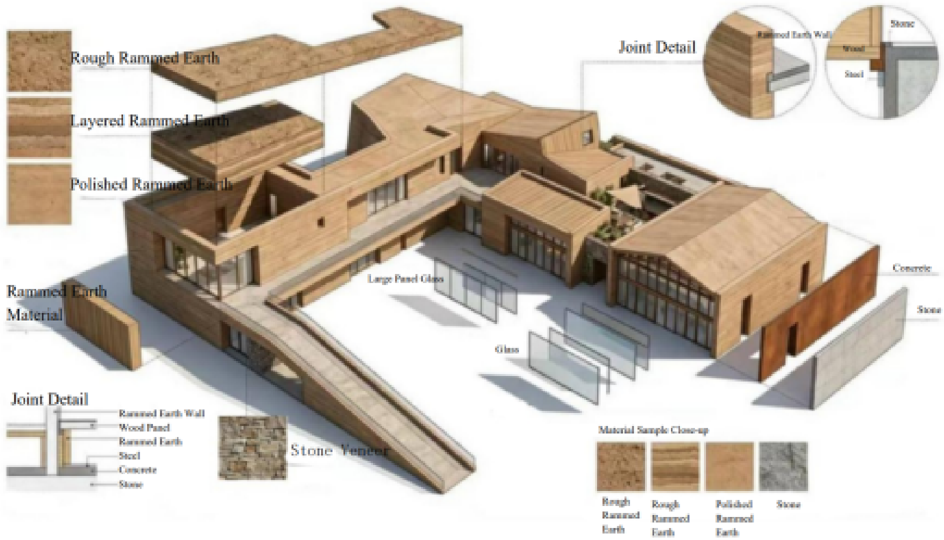

Figure 11. Building materials analysis diagram (source: drawn by the author)

2.2.5. Analysis of energy conservation and environmental friendliness

This analysis of energy conservation and environmental performance is conducted based on Hohhot's regional climatic characteristics and the spatial layout of the design scheme. Hohhot is characterized by long, cold, and dry winters, relatively concentrated summer precipitation, and significant diurnal temperature variations during autumn [14]. Therefore, the energy-saving strategy of this proposal should not rely solely on the thermal mass effect of rammed earth walls but instead establish an integrated system consisting of thermal storage through thick walls, courtyard buffering, south-oriented day lighting, summer shading, natural ventilation, and rainwater management.

During winter, the thermal inertia of rammed earth walls can be utilized to moderate indoor temperature fluctuations, while south-facing openings maximize solar heat gain. Semi-outdoor transitional spaces at entrances are introduced to reduce the direct infiltration of cold air into interior spaces. In summer, courtyard ventilation mechanisms, waterscape evaporative cooling, pergola shading facilities and operable windows jointly boost natural air circulation and indoor heat dissipation. During the rainy season, stormwater runoff can be mitigated through roof rainwater harvesting systems, shallow drainage swales, and permeable paving surfaces.

In subsequent design stages, if energy simulation conditions are accessible, comparative analysis will be carried out between rammed earth building envelopes and traditional brick-concrete enclosure systems to compare disparities in winter heating loads and summer indoor thermal fluctuations. Such analyses would enable the transition of the energy performance assessment from qualitative descriptions to quantitative validation, thereby providing more robust evidence for the environmental benefits of the proposed design (Figure 12).

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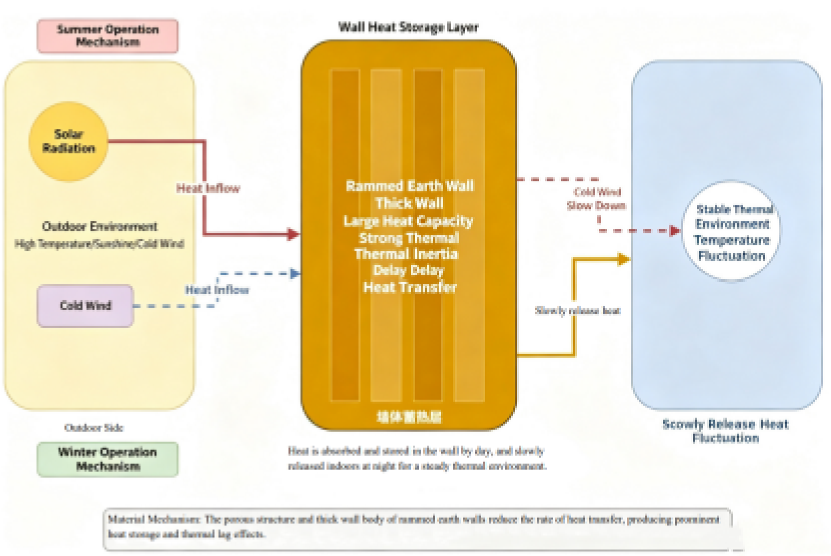

Figure 12. Schematic diagram of the thermal storage and insulation mechanism of rammed earth walls (source: drawn by the author)

3. Conclusion

This design is grounded in the actual site conditions and rural contextual characteristics of Wusutu Village, treating rammed earth as a key medium that integrates architectural form, courtyard space, landscape environment and local regional culture.. Preliminary surveys indicate that the site possesses the basic conditions for organizing a composite public space, though it also presents issues such as intersecting circulation routes, insufficient resting facilities, unclear platforms for cultural display, and weak drainage and vegetation systems. The scheme adopts courtyard enclosure as its basic spatial framework, integrating folk exhibition, intangible cultural heritage workshops, research and study classrooms, a shared kitchen, visitor rest areas, and villager activities into a single public space system, allowing tourist experiences and villagers' daily use to coexist across different time periods.

The findings show that the value of applying rammed earth in Wusutu Village is reflected mainly in three aspects.First, its warm yellow hue and layered texture inherit the local spatial and cultural memory embedded in piedmont terraces, traditional earthen dwellings and courtyard enclosures. Second, the thermal mass of thick walls, courtyard buffering, and natural ventilation help improve the comfort of public spaces in cold, dry regions. Third, the use of locally sourced materials and low processing energy responds to the demands of low-carbon rural construction.

Compared with the initial design scheme, this proposal further integrates local temple culture, farming-nomadic collective memory and centennial apricot orchard landscape with modern public service functions. In this regard, rammed earth functions not only as a façade decorative material, but also as a core design thread that runs through spatial narrative, functional layout and structural tectonic logic.The limitations of this study lie in the absence of complete soil material testing, energy consumption simulation, detailed construction drawings, and cost estimation; the scale, elevations, detail indexes, and material legends in the drawings also require further refinement in subsequent development. Future research could focus on waterproofing and crack prevention for rammed earth walls, seismic reinforcement, training of local construction teams, low-cost

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maintenance, and seasonal operation models, in order to enhance the feasibility and long-term value of the proposed scheme.

References

[1] CPC Central Committee, State Council. (2024, February 3). Opinions on learning from and applying the experience of the "thousands of villages demonstration, ten thousands of villages renovation" project to effectively promote the comprehensive revitalization of rural areas [EB/OL]. [2026-03-23].

[2] CPC Central Committee, State Council. (2025, January 22). Comprehensive rural revitalization plan (2024-2027) [EB/OL]. [2026-03-23].

[3] Huang, Ziyao, & Li, Ruijun. (2022). Practice and exploration of renewal design of traditional dwellings in Ningxia - Taking the renewal design of traditional dwellings in Zhongwei City, Ningxia as an example. *Beauty and Times (City)*, (4), 1-4.

[4] Shi, Yuyan. (2020). *Ecological research and application design of earthen cave dwellings - Taking the architectural design of Qikou Ancient Town, Linxian County as an example* [D]. Taiyuan University of Technology.

[5] Song, Jingying, & Kong, Jing. (2022). Research on the characteristics and development issues of earthen dwellings in the Yellow River Basin of Inner Mongolia. *Architecture and Culture*, (5), 124-126.

[6] Yanyang Design Studio. (2019). South Bank·Zhongwei: Transformation of rural architecture on the banks of the Yellow River. *Interior Design and Decoration, 2019*(05), 64–67.

[7] Dadi Rural Residence Team. (2022). Modern regeneration of rural memories and ethnic aesthetics in Chulechuan - Design practice of Dadi Rural Residence·Chulechuan architectural cluster. *Rural Tourism Research, 8*(2), 45–51.

[8] Wang Tianqi, et al. (2022). Regeneration and application of rural elements in rural architectural design. *Modern Horticulture, 2022*(04), 152–154.

[9] Chen Yijie, Wang Wei, & Wang Xiaoyan. (2020). Timber frame and joint construction technology of traditional dwellings on the southern slope of Yinshan Mountain in Inner Mongolia. *Urban Architecture, 17*(24), 68–70.

[10] Ma Xuechun, & He Long. (2023). Sensitivity analysis of passive energy-saving design factors for rural houses in Inner Mongolia—taking Wusutu Village, Hohhot as an example. *Building Energy Conservation (Chinese and English), 51*(4), 26–32.

[11] Fathy, H. (1973). *Architecture for the poor: An experiment in rural Egypt*. University of Chicago Press.

[12] Rudofsky, B. (1964). *Architecture without architects: A short introduction to non-pedigreed architecture*. Museum of Modern Art, New York.

[13] Heringer, A. (2013). *Building with clay: Sustainable architecture in Burkina Faso*. Prestel Publishing, Munich.

[14] Ministry of Housing and Urban-Rural Development. (2011, July 25). *Basic requirements for seismic safety of rural dilapidated housing renovation (trial)*. Retrieved May 16, 2026, from [EB/OL].