WOOD RESEARCH doi.org/10.37763/wr.1336-4561/71.2.245258
e-ISSN 2729-8906
71(2): 2026 245-258 pp.

THE STUDY ON TIMBER SPECIES USED IN WOODEN COMPONENTS OF THE CULTURAL HERITAGE BUILDINGS OF SHIJIA COURTYARD, XUZHOU CITY

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(RECEIVED MARCH 2026)

ABSTRACT

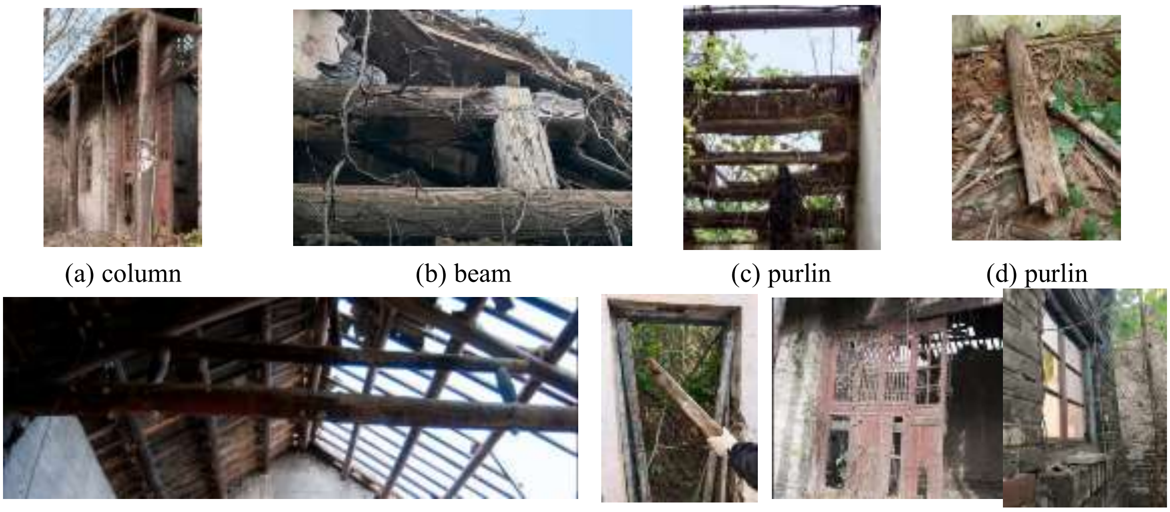
To clarify the timber species composition of wooden components in the cultural heritage buildings of Shijia Courtyard, and to provide support for the precise protection and restoration of these cultural heritage buildings, timber species were identified through microscopic observation. The results showed that the wooden components adopt typical native tree species including *Pinus bungean*a, *Cunninghamia lanceolata*, *Acer* spp., *Populus* spp., and *Ulmus* spp. This finding clarifies the timber species lineage of the building's wooden components. This study fills the gap in basic research on the timber species used in the wooden components of Shijia Courtyard. It also provides scientific guidance for the restoration of wooden components and the selection of replacement materials in Shijia Courtyard and other similar folk cultural heritage buildings of the Ming and Qing dynasties.

KEYWORDS: Cultural heritage buildings, Shijia Courtyard, wooden components, timber species identification.

INTRODUCTION

As the core material for load-bearing and decoration in ancient Chinese buildings, timber species directly determine their structural stability, durability, and artistic expression. It also reflects regional wood resource endowments, construction technology levels, and cultural integration in specific historical periods. Xuzhou is located at the junction of Jiangsu, Shandong, Henan, and Anhui provinces. As a transitional node for the integration of culture and construction technology between North and South China, Xuzhou has traditional buildings that inherit the robust and regular characteristics of northern architecture while absorbing the exquisite and flexible style of southern dwellings, forming a unique regional construction system. Shijia Courtyard, a representative ancient building complex in Gulou District of Xuzhou, was first constructed during the Hongwu reign of the Ming Dynasty (circa 1368 CE) by Shi Wang, a general who was later granted the surname "Shi" by Zhu Yuanzhang. It underwent large-scale renovation and expansion during the Jiaqing reign of the Qing dynasty (1796–1820 CE), forming a courtyard layout with three courtyards and three entrances and three exits. The complex covers a total area of approximately 40 000 m², with a construction area exceeding 5 000 m². As the largest and most well-preserved ancient folk building complex of the Ming and Qing dynasties in Xuzhou, it was listed as a cultural heritage site protected by the Xuzhou Municipal Government in 2011. It provides a valuable physical sample for studying the traditional construction techniques and material characteristics in the Huanghuai region.

However, affected by temperature and humidity fluctuations and biological erosion, the existing wooden components of Shijia Courtyard have suffered widespread deterioration (Fig. 1). The bases of load-bearing columns and beams show severe decay, with partial decay depth exceeding one-fourth of the component diameter. Obvious signs of infestation by wood-boring insects can be observed. These deteriorations not only alter the anatomical structure of wood (Kiliç 2025), degrades its chemical composition (Kiliç 2025; Chu et al. 2025; Alfredsen et al. 2025), and impairs its physical and mechanical properties, but also impairs the structural integrity of component (Felle et al. 2026), ultimately endangers the overall structural safety of buildings (Wang et al. 2021). The identification of timber species used in ancient building components is a fundamental scientific work. Accurate species information provides a core basis for diagnosing component diseases, matching restoration materials, selecting anti-corrosion and anti-insect measures, and implementing long-term preventive protection. It is also a prerequisite for following the principles of minimum intervention and restoration to the original condition as specified in GB/T 50165 (2020).



(a) column (b) beam (c) purlin (d) purlin

(e) beam, purlin and rafter (f) door frame (g) door (h) window

Fig. 1: Current status of the cultural heritage buildings in Shijia courtyard.

Consequently, this study will systematically conduct accurate identification of timber species used in wooden components of Shijia courtyard. The results will not only fill the gap in research on the timber species used in Shijia courtyard and enrich the database of traditional building materials in the North-South transitional zone of China, but also provide scientific guidance for the restoration of its wooden components and the selection of replacement materials. Additionally, these results will offer a reference for the protection and practice of wooden components in similar cultural heritage buildings in Xuzhou.

MATERIAL AND METHODS

The samples were collected from the wooden components of the cultural heritage buildings at Shijia Courtyard, Xuzhou, with geographic coordinates of 117.15° E and 34.34° N. These samples covered core load-bearing wooden components (CLBWCs) of columns and beams, secondary load-bearing wooden components (SLBWCs) of purlins and rafters, and enclosure-decorative wooden components (EDWCs) of doors, window frames, and lattice strips (Fig. 1). In the present study, the tree species of wooden components were first classified and identified using the macroscopic visual observation method, followed by targeted sampling and identification of the wooden components. Detailed information is shown in Tab. 1.

Tab. 1: Sampling information of wooden components.

Sample	Sampling location	Component type	Sample	Sampling location	Component type
No.1	door	EDWCs	No.10	column	CLBWCs
No.2	window frame	EDWCs	No.11	beam	CLBWCs
No.3	lattice strip	EDWCs	No.12	beam	CLBWCs
No.4	rafter	SLBWCs	No.13	beam	CLBWCs
No.5	rafter	SLBWCs	No.14	column	CLBWCs
No.6	purlin	SLBWCs	No.15	column	CLBWCs
No.7	purlin	SLBWCs	No.16	column	CLBWCs
No.8	column	CLBWCs	No.17	beam	CLBWCs
No.9	column	CLBWCs	No.18	beam	CLBWCs

Preparation of wood sections

The preparation of wood sections was carried out with reference to GB/T 29894 (2013) and the wood sectioning techniques described by Yang et al. (2024,2025). The entire preparation process followed the four steps including sectioning, dehydration, degreasing and clearing, and mounting and preservation. In the sectioning step, a Leica HistoCore Autocut microtome was used to prepare three types of sections (transverse, radial, and tangential) of the wood samples. Each of these sections was prepared with a thickness ranging from 10 to 15 μm to ensure clear observation of the internal structure of the wood. After sectioning, the sections were subjected to gradient dehydration in 50%, 75%, 95%, and 100% ethanol solutions, respectively. The sections were kept in each concentration of the ethanol solutions for 10 min to ensure that the water in the sections was gradually removed. Once dehydration was completed, the sections were transferred to xylene for degreasing and clearing. The sections were immersed in xylene for 3 to 5 min. This process served to remove any grease or other impurities present in the sections. Finally, the cleared sections were taken out, placed on clean glass slides, and then one to two drops of neutral balsam were added to them, followed by placing a coverslip on top. The prepared slides were then placed in a well-ventilated area to air-dry.

Observation and identification of timber species

To observe the prepared wood sections, a Nikon Eclipse Ni-U biological microscope equipped with objective lenses with different magnifications (4×, 10×, 20×, and 40×) was used. Anatomical characteristics were described in accordance with the *IAWA List of microscopic features for softwood identification* (Richter et al. 2004) and the *IAWA List of microscopic features for hardwood identification* (Wheeler et al. 1989). Comparisons were made with anatomical illustrations from Atlas of Chinese woods (Cheng et al. 1992), and the commercial names of the timber species were determined in accordance with GB/T 16734 (1997).

RESULTS AND DISCUSSION

Through microscopic anatomical observation and standard comparison of 14 wooden component samples, it was found that the timber species used in the cultural heritage buildings of Shijia Courtyard mainly belong to 5 families including Pinaceae, Taxodiaceae, Aceraceae, Salicaceae, and Ulmaceae (Tab. 2).

Tab. 2: Timber species identification results of wooden components.

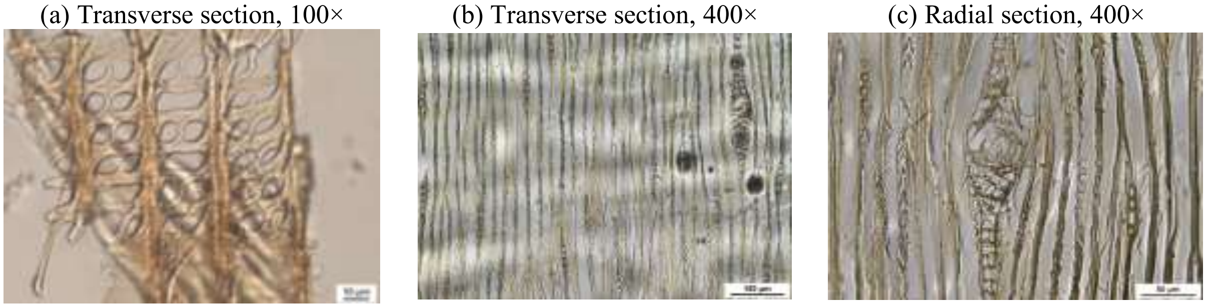
Wood	Sample	Family	Genus/Subgenus	Tree species
Group I	No.1–No.3	Pinaceae	*Pinus* subg. *Haploxylon*	*Pinus bungeana*
Group II	No.4–No.7	Taxodiaceae	*Cunninghamia*	*Cunninghamia lanceolata*
Group III	No.9, No.11	Aceraceae	*Acer*	*Acer Mono, Acer oliverianum, Acer truncatum*
Group IV	No.8, No.10, No.12–No.14	Salicaceae	*Populus*	*Populus Simonii*, *Populus canadensis*, *Populus nigra* var. *italica*
Group V	No.15–No.18	Ulmaceae	*Ulmus*	*Ulmus Macrocarpa*, *Ulmus pumila*

Group I wood: *Pinus bungeana*

Key anatomical characteristics

This group corresponds to door, window frames and lattice strips (No.1-3), whose key anatomical characteristics are shown in Fig. 2. Growth rings slightly distinct, with a gradual transition from earlywood to latewood tracheids (Fig. 2a); earlywood tracheids with thin walls and latewood tracheids with thick walls (Fig. 2a,b); tracheid pitting in radial walls in earlywood only predominantly uniseriate, helical thickenings in longitudinal tracheids absent (Fig. 2c,d); axial parenchyma absent (Fig. 2a,b); wood rays of two types including uniseriate (5–15 cells high) and fusiform (2–3 cells wide, 3–12 cells high) (Fig. 2e,f); ray cells comprising ray tracheids and ray parenchyma cells, inner cell walls of ray tracheids micro-dentate with wavy outer edges (Fig. 2c,d); cross-field pittings between ray parenchyma cells and earlywood tracheids Pinoid-type, usually 1–2 per cross-field (Fig. 2c,d); both of axial intercellular canals (Fig. 2a,b) and radial intercellular canals (Fig. 2e,f) present.

(a) Transverse section, 100× (b) Transverse section, 400× (c) Radial section, 400×



(d) Radial section, 400× (e) Tangential section, 100× (f) Tangential section, 200×

Fig. 2. Anatomical structure of Group I wood (Pinus bungeana): (a) Growth rings slightly distinct, gradual transition from earlywood to latewood tracheids, axial intercellular canals; (b) axial intercellular canals; (c) and (d) ray cells comprising ray tracheids and ray parenchyma cells, inner cell walls of ray tracheids micro-dentate with wavy outer edges; cross-field pittings between ray parenchyma cells and earlywood tracheids Pinoid-type, usually 1–2 per cross-field; (e and (f) wood rays of two types including uniseriate and fusiform, radial intercellular canals.

Species identification and adaptability analysis

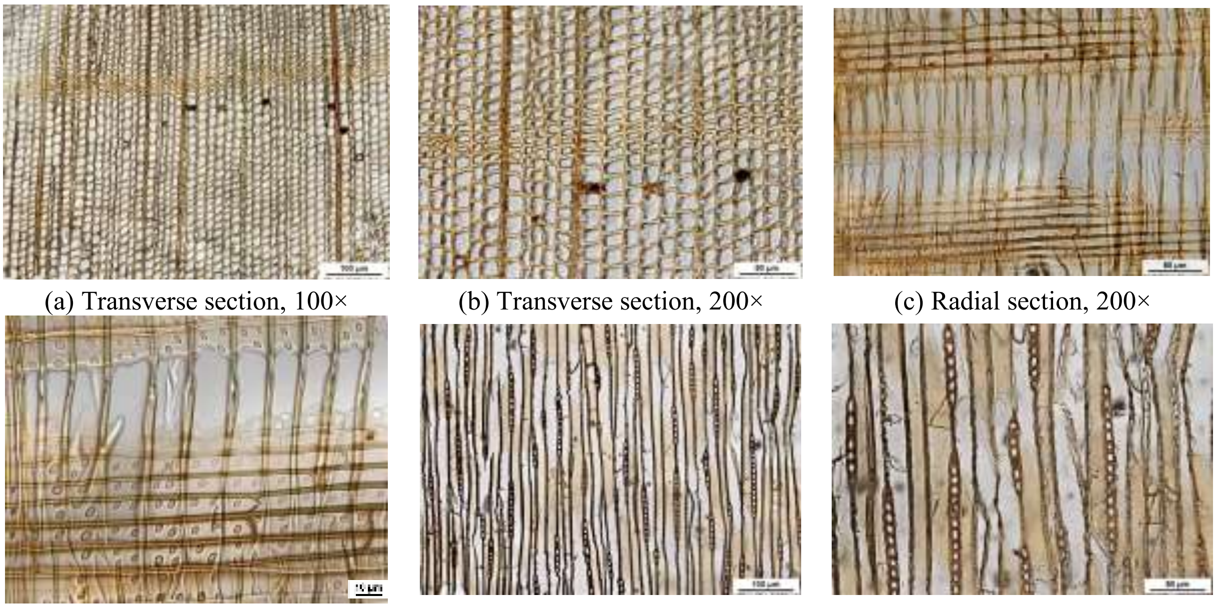
The genera of the Pinaceae family including *Pinus*, *Picea*, *Larix*, *Pseudotsuga*, and *Cathaya* possess both axial and radial intercellular canals. However, Pinoid-type cross-field pittings stand out as the core diagnostic feature that distinguishes *Pinus bungeana* from other species within the *Pinus* genus (Yang et al. 2024,2025; Cheng et al. 1992). By comparing these characteristics of tracheids, wood rays, cross-field pittings, and intercellular canals, it was determined that Group I wood belongs to *Pinus bungeana* classified under the subgenus *Haploxylon* of the genus *Pinus*. In accordance with GB/T 16734 (1997), the commercial name assigned to this wood is lace-bark pine.

From the perspective of wood properties, lace-bark pine is characterized by its light weight, soft texture, and fine grain structure that collectively endow it with excellent machinability (Cheng et al. 1992). While its mechanical strength is relatively low, it is highly suitable for non-load-bearing decorative components such as doors, window frames, and lattice strips. From a geographical perspective, lace-bark pine has a specific natural distribution range and cultivation history. It is naturally distributed in regions such as Shanxi Province, western Henan Province, and the Qinling Mountains in Shaanxi Province. Additionally, it has a long-standing cultivation history in areas such as Suzhou and Hangzhou (Cheng et al. 1992; GB/T 16734-1997; Editorial Committee of Flora of China 1978). Xuzhou is adjacent to the cultivation and natural distribution areas of *Pinus bungeana*, providing convenient access to these local resources. This ease of resource access aligns with the material procurement logic commonly followed in folk buildings constructed during the Ming and Qing dynasties, in which utilizing locally available materials was a common practice to reduce costs and ensure construction efficiency.

Group II wood: *Cunninghamia lanceolata*

Key anatomical characteristics

This Group corresponds to purlins and rafters (No.4–No.7), whose key anatomical characteristics are shown in Fig. 3. Growth rings boundaries distinct (Fig. 3a), with a gradual transition from earlywood to latewood tracheids (Fig. 3a); earlywood tracheids with thin walls and latewood tracheids with thick walls (Fig. 3a,b); tracheid pitting in radial walls in earlywood only predominantly uniseriate, helical thickenings in longitudinal tracheids absent (Fig. 3c,d); axial parenchyma abundant, mainly diffuse and tangential banded (Fig. 3a,b); wood rays usually uniseriate, rarely biseriate, 5–10 cells high (Fig. 3e,f); only ray parenchyma cells and no ray tracheids (Fig. 3c,d); cross-field pittings Taxodioid-type, usually 2–4 per cross-field (Fig. 3c,d); intercellular canals absent (Fig. 3a,b,e,f).



(a) Transverse section, 100× (b) Transverse section, 200× (c) Radial section, 200×

(d) Radial section, 400× (e) Tangential section, 100× (f) Tangential section, 200×

Fig. 3. Anatomical structure of Group II wood (Cunninghamia lanceolata): (a) Growth rings slightly distinct, gradual transition from earlywood to latewood tracheids, axial parenchyma diffuse and tangential banded; (b) axial parenchyma diffuse and tangential banded; (c) and (d) Radial section: only ray parenchyma cells; cross-field pittings between ray parenchyma cells and earlywood tracheids Taxodioid-type, usually 2–4 per cross-field; (e) and (f) wood rays usually uniseriate.

Species identification and adaptability analysis

The core diagnostic features of *Cunninghamia lanceolata* belonging to the Taxodiaceae family include diffuse and tangential banded axial parenchyma, the absence of intercellular canals, wood rays composed entirely of parenchyma cells, and Taxodioid-type cross-field pittings (Yang et al. 2024; Cheng et al. 1992; Luo et al. 2008; Shao et al. 2003; Pan et al. 2013; Liao et al. 2016; Giachi et al. 2017; Bao 2020; Yang et al. 2022; Gao et al. 2023; Zhang et al.

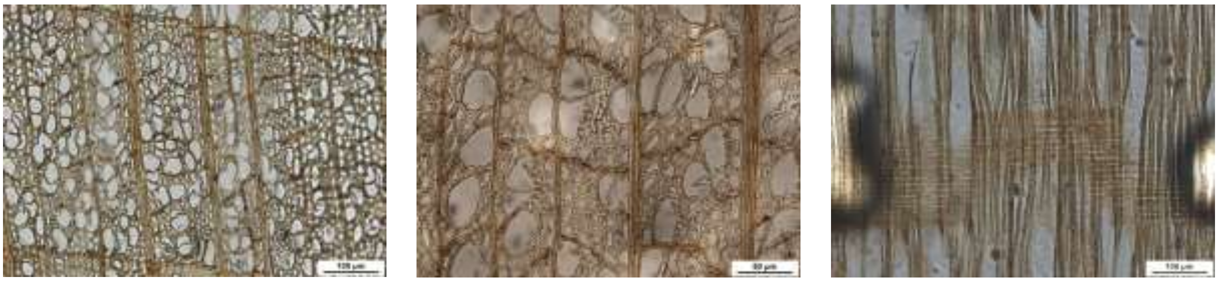
2024; Yang et al. 2024; Wang et al. 2025a;b; Wang et al. 2010). Through observation of the anatomical structure of Group II wood, it was found that these characteristics all fully match those of *Cunninghamia lanceolata*. In accordance with GB/T 16734 (1997), the commercial name of this wood is Chinese fir.

From the perspective of geographical distribution, Chinese fir is a dominant cultivated tree species in the Yangtze River Basin and the areas south of the Qinling Mountains. It has abundant resources and relatively low acquisition costs. Xuzhou is located in the northern-southern climate transitional zone of China, and the southern part of Xuzhou is directly adjacent to the main distribution area of Chinese fir. This geographical advantage enables Xuzhou to fully follow the traditional architectural principle of local material sourcing (Cheng et al. 1992; GB/T 16734-1997; Editorial Committee of Flora of China 1978). In terms of the adaptability between wood properties and wooden component functions, Chinese fir has properties such as light weight, soft texture, and a small shrinkage coefficient, which makes it less prone to deformation or cracking with changes in environmental temperature and humidity. Moreover, it contains natural aromatic compounds that exert significant inhibitory effects on microorganisms such as fungi and bacteria, thereby endowing Chinese fir with excellent natural decay resistance (Cheng et al. 1992). These characteristics are highly compatible with the functional requirements of purlins and rafters, which need to have light weight characteristics to effectively reduce the overall load of the roof and avoid excessive pressure on the core load-bearing structure, and also need to have good decay resistance to extend their service life.

Group III wood: *Acer* spp.

Key anatomical characteristics

This Group corresponds to columns and beams (No.9, No.11), whose key anatomical characteristics are shown in Fig. 4. Growth rings boundaries slightly distinct (Fig. 4a); wood diffuse-porous, vessels oval to elliptical with slightly polygonal outlines (Fig. 4a,b); vessels exclusively solitary (90% or more), a few vessels in radial multiples of 2-4 and vessel clusters (Fig. 4a,b); vessels in randomly distributed pattern (Fig. 4a,b); simple perforation plates (Fig. 4c,d,e,f); intervessel pitting alternate (Fig. 4c,d,e,f); helical thickenings in vessel elements present (Fig. 4c,d,e,f); axial parenchyma in marginal or in seemingly marginal bands (1–2 cells wide), and a few of vasicentric and diffuse axial parenchyma (Fig. 4a,b); fibres thin- to thick-walled with simple to minutely bordered pitting; wood rays of two types containing rays uniseriate and larger rays commonly 2- to 6-seriate (Fig. 4a,b,e,f), all ray cells procumbent, containing gum, no specialized cells (Fig. 4c,d); intercellular canals absent (Fig. 4a,b,e,f).



(a) Transverse section, 100× (b) Transverse section, 200× (c) Radial section, 100×

(d) Radial section, 200× (e) Tangential section, 200× (f) Tangential section, 400×

Fig. 4. Anatomical structure of Group III wood (Acer spp.): (a) growth ring boundaries slightly distinct; wood diffuse-porous; vessels exclusively solitary (90% or more), a few vessels in radial multiples of 2-4 and vessel clusters, vessels in randomly distributed pattern; axial parenchyma in marginal or in seemingly marginal bands, and a few of vasicentric and diffuse axial parenchyma; (b) vessels exclusively solitary (90% or more), a few vessels in radial multiples of 2-4 and vessel clusters, vessels in randomly distributed pattern; axial parenchyma in marginal or in seemingly marginal bands, and a few of vasicentric and diffuse axial parenchyma; (c) and (d): intervessel pitting alternate; helical thickenings in vessel elements present; all ray cells procumbent; (e) and (f): intervessel pitting alternate; helical thickenings in vessel elements present; wood rays of two types containing rays uniseriate and larger rays commonly 2- to 6-seriate.

Species identification and adaptability analysis

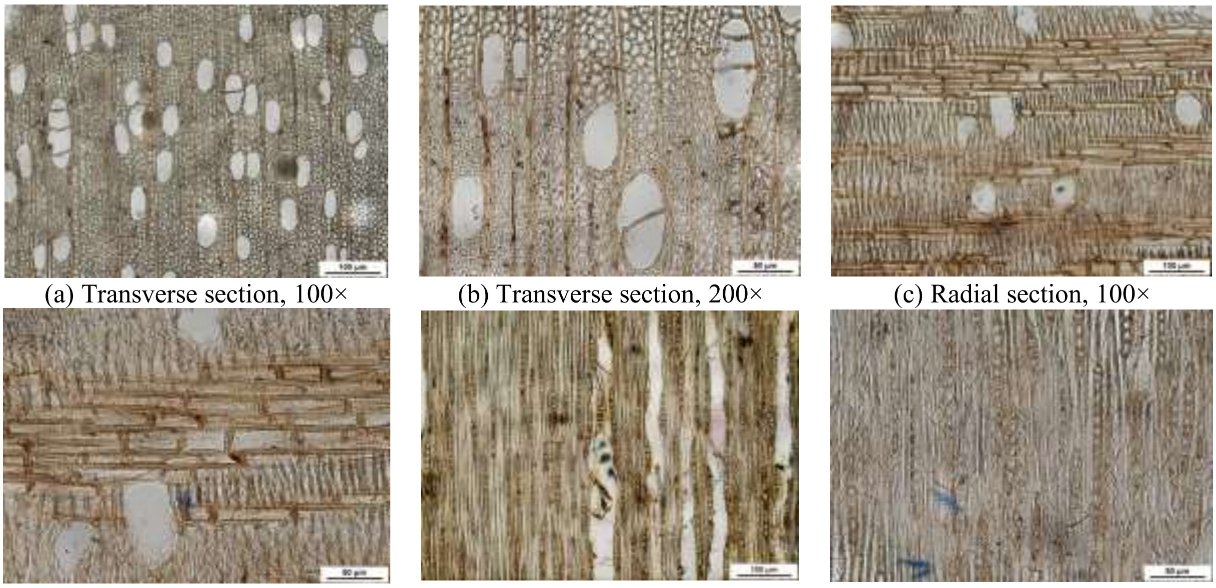
The genus *Acer* within the Aceraceae family exhibits typical anatomical features including diffuse-porous wood, the presence of helical thickenings in vessel elements, axial parenchyma arranged in marginal or seemingly marginal bands, and the presence of both uniseriate and larger wood rays (Cheng et al. 1992; Wang et al. 2019). By examining the vessel morphology and ray structure of wood samples No.9 and No.11, it was concluded that Group III wood belongs to *Acer* spp., such as *A. mono*, *A. oliverianum*, and *A. truncatum*. In accordance with GB/T 16734 (1997), the commercial name of this group is hard maple.

Hard maple has a series of favourable properties, such as uniform structure, high hardness, and excellent wear resistance. Additionally, it exhibits medium to high levels of axial compressive strength and bending strength (Cheng et al. 1992). These properties perfectly align with the functional requirements of the CLBWCs such as columns and beams. Such components are required to bear vertical and horizontal building loads over an extended period, which require high mechanical strength and structural stability. From a geographical distribution perspective, *Acer* species such as *A. truncatum* and *A. mono* are widely distributed in Jiangsu Province (Cheng et al. 1992; GB/T 16734-1997; Editorial Committee of Flora of China 1979). In Xuzhou and its surrounding areas, these species are abundant, ensuring sufficient resource availability. This abundance is in line with the traditional practice of local material sourcing in folk building construction. This practice not only reduces transportation costs and logistical burdens but also reflects the adaptation of local construction practices to available natural resources, which is a key characteristic of traditional folk architecture.

Group IV Wood: *Populus* spp.

Key anatomical characteristics

This Group corresponds to columns (No.8, No.10, No.12-14), whose key anatomical characteristics are shown in Fig. 5. Growth rings boundaries indistinct (Fig. 5a); wood diffuse-porous, numerous vessels, vessels oval to elliptical (Fig. 5a,b); vessels solitary and a few vessels in radial multiples of 2-4 (Fig. 5a,b); vessels in radial pattern (Fig. 5a,b); simple perforation plates (Fig. 5c,d); intervessel pitting alternate (Fig. 5e); helical thickenings absent (Fig. 5c,d); axial parenchyma axial parenchyma scarce, mostly marginal, rarely diffuse (Fig. 5a,b); fibres very thin-walled with simple pitting; wood rays non-storied, only uniseriate (Fig. 5a,b,e,f), all ray cells procumbent (Fig. 5c,d); intercellular canals absent (Fig. 5a,b,e,f).



(a) Transverse section, 100× (b) Transverse section, 200× (c) Radial section, 100×

(d) Radial section, 200× (e) Tangential section, 100× (f) Tangential section, 200×

Fig. 5. Anatomical structure of Group IV wood (Populus spp.): (a) growth ring boundaries indistinct; wood diffuse-porous; vessels solitary and a few vessels in radial multiples of 2-4, vessels in radial pattern; axial parenchyma axial parenchyma scarce, mostly marginal, rarely diffuse; (b): vessels solitary and a few vessels in radial multiples of 2-4, vessels in radial pattern; axial parenchyma axial parenchyma scarce, mostly marginal, rarely diffuse; (c) and (d) simple perforation plates; all ray cells procumbent; (e) and (f) intervessel pitting alternate; wood rays non-storied, only uniseriate.

Species identification and adaptability analysis

Core diagnostic features of the genus *Populus* within the Salicaceae family include diffuse-porous wood, vessels arranged in a radial pattern, and uniseriate wood rays (Yang et al. 2024, 2025; Cheng et al. 1992; Luo et al. 2008; Dong et al. 2017a, 2017b; Cao et al. 2019). By conducting an examination of the vessel morphology and ray structure of the Group IV, it was confirmed that this Group belongs to *Populus* spp., including locally common species such as *P. simonii*, *P. canadensis*, and *P. nigra* var. *italica*. In accordance with GB/T 16734 (1997), the commercial name of this group is poplar.

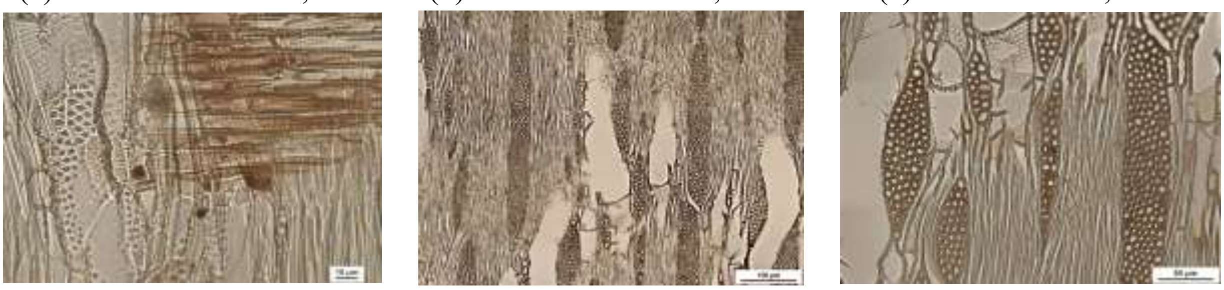
From the perspective of wood properties, poplar exhibits properties of light weight and soft texture, relatively low axial compressive strength and bending strength, and also has poor natural resistance to decay and wood-boring insects (Cheng et al. 1992). During the on-site survey, obvious spiral cracks were observed on the cell walls of the poplar wooden components (Fig. 5e, f). These spiral cracks are presumably associated with insufficient mechanical strength and long-term load-bearing. Based on these inherent properties, poplar is not considered ideal materials for load-bearing components in traditional wooden structures, as they may fail to meet the long-term structural stability requirements of such components. However, *Populus* spp. such as *P. simonii* and *P. canadensis*, have distinct advantages in geographical distribution and economic practicality. They are widely distributed throughout the Xuzhou region, have a fast growth rate, and have relatively low acquisition costs (Cheng et al. 1992; GB/T 16734-1997; Editorial Committee of Flora of China 1979). Such characteristics make poplar a commonly used economical wood species in folk buildings (Yang et al. 2021,2024,2025; Dong et al. 2017a,b).

Group V wood: *Ulmus* spp.

Key anatomical characteristics

This Group corresponds to columns and beams (No.15-No.18), whose key anatomical characteristics are shown in Fig. 6. Growth rings boundaries distinct (Fig. 6a); wood ring-porous, earlywood vessels 1–3 cells wide with the shape of round, oval, or elliptical, tyloses and deposits in vessels common, and latewood vessels irregular polygonal (Fig. 6a,b); latewood vessels in tangential bands (Fig. 6a,b), latewood vessels clusters common and occasionally short radial multiples (Fig. 6a,b); simple perforation plates (Fig. 6e,f); intervessel pitting mainly alternate (Fig. 6c,d,f); helical thickenings only in narrower vessel elements (Fig. 6c,d,e); axial parenchyma abundant, mainly paratracheal axial parenchyma including axial parenchyma vasicentric in earlywood zone, and axial parenchyma bands more than three cells wide in latewood zone (Fig. 6a,b); fibres very thick-walled with distinctly bordered pitting; larger rays commonly 4- to 10-seriate (Fig. 6a,b,e,f); all ray cells procumbent (Fig. 6a,b,c,d); intercellular canals absent (Fig. 6a,b,e,f).

(a) Transverse section, 20× (b) Transverse section, 100× (c) Radial section, 200×



(d) Radial section, 400× (e) Tangential section, 100× (f) Tangential section, 200×

Fig. 6. Anatomical structure of Group V wood (Ulmus spp.): (a) growth ring boundaries distinct; wood ring-porous; latewood vessels clusters common, and in tangential bands; axial parenchyma mainly paratracheal axial parenchyma including axial parenchyma vasicentric in earlywood zone, and axial parenchyma bands more than three cells wide in latewood zone; (b) latewood vessels clusters common, and in tangential bands; axial parenchyma mainly paratracheal axial parenchyma including axial parenchyma vasicentric in earlywood zone, and axial parenchyma bands more than three cells wide in latewood zone; (c) and (d) helical thickenings only in narrower vessel elements; intervessel pitting mainly alternate; all ray cells procumbent; (e) and (f) simple perforation plates; intervessel pitting mainly alternate; helical thickenings only in narrower vessel elements; larger rays commonly 4- to 10-seriate.

Species identification and adaptability analysis

The genus *Ulmus* in the Ulmaceae family exhibits distinct core anatomical features such as wood ring-porous, latewood vessels in tangential bands, helical thickenings only in narrower vessel elements, larger rays commonly 4- to 10-seriate (Yang et al. 2021, 2025; Cheng et al. 1992; Dong et al. 2017a,b; Giachi et al. 2017; Macchioni et al. 2023; Zhang et al. 2025; Mayinuer et al. 2025). By examining the vessel morphology and ray structure of the wood samples in Group V, it was concluded that this Group belongs to *Ulmus* spp., including common local species such as *U. macrocarpa* and *U. pumila*. According to GB/T 16734 (1997) the commercial name assigned to this wood is elm.

Elm exhibits a range of favourable properties, including high hardness, excellent wear resistance, superior compressive strength along the grain, strong bending strength, and attractive wood grain patterns (Cheng et al. 1992). These properties make elm an ideal material for CLBWCs such as columns and beams, which are required to bear both vertical and horizontal loads over extended periods, and its mechanical performance fully meets these functional demands. From the perspective of geographical distribution, *U. macrocarpa* and *U. pumila* are widely distributed in Jiangsu Province (Cheng et al. 1992; GB/T 16734-1997; Editorial Committee of Flora of China 1979). The wide distribution of these elm species in the Xuzhou region aligns with the traditional principle of local material sourcing in ancient architecture.

CONCLUSIONS

To clarify the timber species composition of the wooden components in the cultural heritage buildings of Shijia Courtyard in Xuzhou, this study performed microscopic anatomical observation and comparison on wooden component samples. It was confirmed that the wooden components of Shijia Courtyard use typical native tree species from 5 families and 5 genera. These species are *Pinus bungeana* from Pinaceae, *Cunninghamia lanceolata* from Taxodiaceae, *Acer* spp. from Aceraceae, *Populus* spp. from Salicaceae, and *Ulmus* spp. from Ulmaceae. This result clarifies the timber species lineage of the Shijia courtyard, filling the gap in basic research regarding the timber species, and also providing a scientific basis for the restoration of wooden components.

ACKNOWLEDGMENTS

This work was supported by the Natural Science Foundation Project of Henan Province (252300420061), the Key Research and Development and Promotion Project of Henan Province (242102320293), the Key Research Project of University in Henan Province (24A560017), and the Research Fund Project for College Students of Nanyang Institute of Technology (NGDJ-2024-58).

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