ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume X-M-2-2025
30th CIPA Symposium “Heritage Conservation from Bits:
From Digital Documentation to Data-driven Heritage Conservation”, 25–29 August 2025, Seoul, Republic of Korea

From Prototype to Originality
The Renew Design Strategy and HBIM Application of Xiamen Overseas Chinese Historical Buildings based on the Case of Shixian Villa

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Keywords: Originality, HBIM, Overseas Chinese Historical Building, Design Strategy, Culture Analysis, Xiamen.

Abstract

The application of digital technology in the renew design of historical buildings is becoming increasingly widespread. How to combine history, culture and digital technology is an important theme in the protection of historical buildings. The historical buildings of overseas Chinese in Xiamen, China, serve as a typical representative of historical buildings and are excellent research cases on both the history aspect and digital techniques aspect. This paper takes the renew design of the historical building Shixian Villa in Xiamen as an case. Based on the analysis of the heritage value characteristics of the historical buildings of overseas Chinese in Xiamen, combined with HBIM technology, it proposes the design strategy of "from prototype to originality", emphasizing the expression of authenticity as the goal, historical research as the basis, and using HBIM technology to analyze, synthesize and judge the design. And to realize the interpretation, expression and practice of the heritage value of the protection design of historical buildings of overseas Chinese in Xiamen and other similar practices.

1. Instructions

1.1 Authenticity and Chinese Historical Buildings Renew

With the deepening of China's emphasis on historical buildings, an increasing number of existing designs have brought new opportunities to architects. Xiamen City is an island city located in Fujian Province in southeastern China. A large number of overseas Chinese have settled in the city since 1900s, and it has rich historical architectural resources of overseas Chinese in southeastern China. Overseas Chinese historical buildings, as a component of Chinese history, carry abstract Chinese culture and Chinese regional architecture forms in Fujian Province. In the protection of historical buildings, the "authenticity" and "integrity" of the historical information that reflects their heritage value are particularly important. They emphasize respecting and protecting the morphological characteristics and variation processes created by the architecture culture along with the development of history (Plata et al, 2021, Sánchez et al 2016). The historical building renew design emphasized in this paper is a design process based on the existing protection conditions of historical buildings and further design methods. These kinds of projects have not only many engineering environmental restrictions but also historical and cultural restrictions. These design conditions enable the renew design of historical buildings of overseas Chinese in Xiamen to be carried out in accordance with the principles of the classical analysis theory, Systems Theory, which includes 3steps, analysis, synthesis and judgment. Among these steps, the expression of authenticity, as the guiding principle for the protection of modern historical buildings, plays an important role. Authenticity does not equal restoration. Historical building renew projects designed as urban stock, the expression of authenticity should focus more on the protection method positioning and the functional requirements(Wang, 2010).

1.2 Digital Technology and Opportunities

With digital technology coming into the historical buildings new, new technologies have brought many opportunities to the renew design of historical buildings. The renew design process of historical building protection has the following main characteristics:

1) Emphasize the digital surveying, mapping and research analysis of historical buildings. The traditional research and survey mode process relies on a lot of manual intervention. From the compilation of photos to the measurement of dimensions, a large amount of labor costs are required （Yazdi et al, 2021） . With the development of digital survey technology, the technology of digital collection has become increasingly mature. In the protection and renew project of this paper, digital technology can effectively improve the efficiency and quality of the survey and mapping of historical buildings.

2) Information integration and refined design of the building itself. Under the concept of authenticity, different historical buildings have different existing conditions and historical contexts. So the means and methods of protection are different. New concept can enhance the quality and efficiency of historical building protection plans in terms of information integration and refined design, making the renew plans and construction more refined, systematic and rational.（Osello et al, 2018）

3) Renew design process judgment and adjustment of architectural schemes. The renew project of historical buildings presents characteristics of dynamic. The process of historical building renew projects emphasizes the exchange of information during investigation and construction sites, as well as intuitive design feedback. Historical buildings has withstood the test of time. It needs to enhance its rationality through design judgment based on the comprehensive analysis of design data. On the other hand, as the investigation and analysis go further, new construction conditions and old structural remnants

This contribution has been peer-reviewed. The double-blind peer-review was conducted on the basis of the full paper.
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will be discovered on site. This requires timely adjustments to the design based on new discoveries to achieve a balance between the authenticity and practicality of the building.(Zhang et al, 2022)

With the above background, this paper, with the case of the renew project of Shixian Villa in Xiamen, proposes a strategy for the protective design of overseas Chinese historical buildings using digital technology. It takes the expression of authenticity as the goal orientation, advocates a concept called “From prototype to originality” process. It emphasizes that the protective design of historical buildings needs to be based on a full study of the cultural context development of historical buildings and the reginal building prototypes and culture. By applying digital technology to analyze, synthesize and judge design information, and understanding the characteristics and functional requirements of the historical building itself, it can realize their heritage values as cultural and historical representatives in the future. (Tian et al, 2018)

2. The Theoretical Framework of From Prototype To Originality

"From Prototype to Originality" is a theoretical path for the protection and design of historical buildings, which lies in deeply integrating architectural design with history, culture and spiritual essence, transcending the imitation of traditional forms, and emphasizing the contemporary expression of cultural "authenticity".

2.1 The interpretation of the theory "From Prototype to Originality"

This article is based on the theories of Phenomenology and the Spirit of Place, emphasizing that architecture is not only a physical space but also a container for experience. From Norberg-Schulz's "spirit of place" to Heidegger's "dwelling" philosophy, there are lots of studies showing that architecture should respond to human existence and reawaken emotional identification. This provides philosophical support for the transition from "prototype" to "originality".

Firstly, Prototype refers to a representative architectural form or spatial type that repeatedly appears in a specific culture. It is not merely a collection of architecture forms, but also embodies historical evolution, living habits, aesthetic intentions, and so on. On the other hand, Originality emphasizes the cultural spirit, essential characteristics and the unique "temperament" of the place contained behind the physical space. It is a cognition that transcends form and tends towards essence. It is an "cultural genes" of architecture which manifests as spatial order, temporal accumulation, material logic or collective memory.

2.2 The Operational Mechanism of Originality Theory: From "Historical Form" to "Modern Expression"

Firstly, Cultural Extraction: from form to meaning. Identify prototypes through modern scientific research methods and reinterpret and explore the value of the cultural semantics behind them. Secondly, Original Construction: Reproduce the spiritual structure through design. Understand the formal logic and place spirit behind the form and express them in a modern way. Thirdly, Design Transformation: Reconstruct the formal system based on the prototype logic. Under digital modeling and parameter control, the logic of the prototype space is reorganized, and a new spatial composition system is formed using new spatial design methods, thereby endowing the new architectural space with modern functional adaptability and echoing the spirit of originality.

2.3 The contemporary value of Originality Theory

It is a cultural regeneration path that transcends formal replication liberates "tradition" from the constraints of form, enabling culture to continue in a more vibrant way. Secondly, Stimulating place memory and social identity and in responding to the tension between locality and contemporaneity, "From Prototype to Originality" accommodates contemporary technology and aesthetics, serving as a bridge connecting "tradition" and "modernity". Thirdly, in response to UNESCO's logic of sustainable building renewal, compared with the simple model of demolition and reconstruction, this theory provides a sustainable evolution path for old buildings, which is conducive to resource conservation and cultural continuity.

2.4 Typical Case of From Prototype to Originality

This building renwnel project, which was completed in 2023, is the Rockbund Source Building Renewal Project in Shanghai, China. It was designed by Pritzker Prize winner David Chipperfield. The concept of the renewal project is to respect historical features, inherit culture and adapt to modern life. Therefore, first of all, the architect decided to retain the European architectural form and Asian elements of the building; Secondly, architects re-explore the culture of Shanghai and the architectural culture of concessions, and combine the functional demands of modern life to form new design concepts and cultural interpretations. Thirdly, the design team, through digital technology, reinforced the original building structure and protected and restored the building's facade. Fourth, add new architectural space within the roof areas of historical buildings to meet the needs of modern life.

Therefore, in the updated design of this project, the architect reinterpreted and formally interpreted the "prototype" of the facade and space of the buildings along the Bund in Shanghai, and carried out a new architectural design. This approach continues the architectural culture of the Bund in Shanghai, meets the needs of modern life, and restores the spirit of place. This is a typical case of the design concept and method from prototype to originality. (Figure 1)

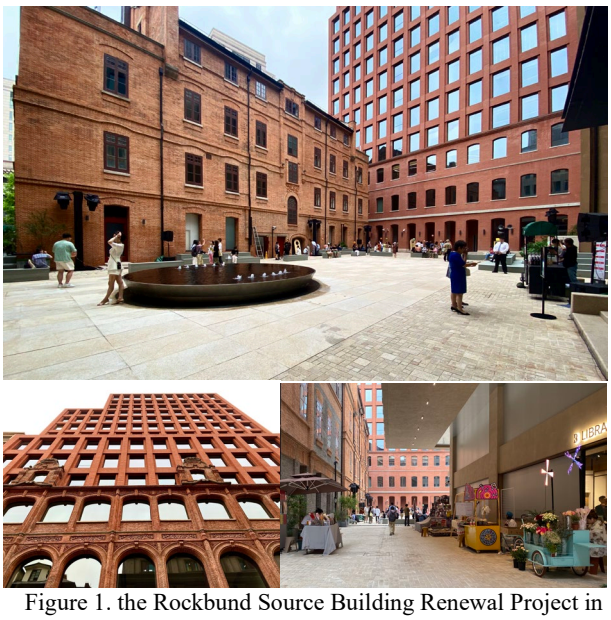

Figure 1. the Rockbund Source Building Renewal Project in Shanghai, China.

3. Project and Culture Background of Shixain Villa

3.1 Project Background

The research case of this paper, Shixian Villa, is a typical overseas Chinese historical building in Fujian province. Overseas Chinese architecture is a cultural representative with the characteristics of cultural fusion between China and foreign countries, which has been formed since late 1850s along with the communication, migrations and settlements of overseas Chinese at southeast China and abroad. It mainly includes overseas Chinese architecture and domestic architecture. The development of this cultural representative in the Chinese region has carried along "Nan Yang(south sea of China)" culture and European culture. (Wang, 2010)

Overseas Chinese residential buildings are one of the main types of overseas Chinese architecture. Its floor plan layout, facade form characteristics, decorative elements and detailed form features are quite different from the traditional Chinese architectural style in Xiamen and Minnan (South Fujian Province) area. However, there is a certain relationship in terms of functional requirements and spatial organization. The research case, Shixian Villa, is a typical representative among them. Therefore, the research on the renew project practice and conservation strategies of Shixian Villa can help understand the construction, development and evolution of overseas Chinese architecture in Xiamen. It is conducive to the study of the integration and development of traditional Chinese culture, Nanyang culture and Western culture, and responds to the international trend of cultural fusion and integration in the renew of historical buildings. It has good research value in construction, culture and history.

3.2 Renew Design Strategy Of Digital Strategy Of Shixian Villa Project

The overseas Chinese historical buildings, on the one hand, carry the cultural heritage of the resident's family, and on the other hand, they are also the memory carriers of the historical development of urban architectural culture. The protection of it should be different from the incremental design method. Design strategies should be formulated based on the principle of authenticity expression from both the perspectives of regional architecture features and historical architecture features.

The renew design strategy for the Shixian Villa can be summarized as a process “from prototype discovery to originality renew design”. The main process goes through three major stages: cultural research, digital integration, and design expression, corresponding to the three main processes of Systems Theory, analysis, synthesis, and judgment. The prototype refers to the analysis and synthesis of design conditions based on the historical materials, environmental evolution, survey data and other contents of historical buildings. This is to obtain the prototype characteristics behind the buildings, including culture, form, function, etc. Originality renew design refers to the use of contemporary technology based on prototype analysis, in accordance with functional requirements, design status and other conditions, to make design judgments on historical buildings. Meanwhile, on the basis of ensuring the expression of its architectural cultural characteristics, a practical and creative renew design is carried out. This renew design process exploring the intrinsic value of existing historical buildings on the basis of authenticity as the main principle, and conducting protective design through reasonable analysis, synthesis and judgment with the help of modern digital technology methods. (Figure 2)

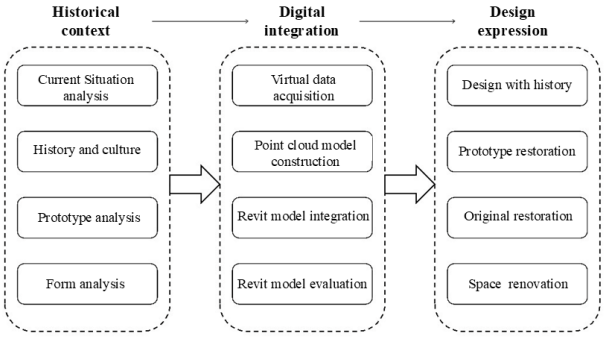

Figure 2. Renew Design Strategy Of Digital Strategy Of Shixian Villa Project.

3.3 Culture basis and analysis

The historical buildings of overseas Chinese in Xiamen are different from the traditional ancient buildings of southern Fujian in the local area. They not only have architectural symbols with typical traditional Chinese architectural cultural connotations in southern Fujian, but also integrate a large number of "Nanyang" and Western architectural elements. The fundamental reason for this change is closely related to the social background from 1850s to 1950s, which is connected with the traditional concept of hometown complex of overseas Chinese. The prototype of the Shixian Villa is similar to the Villa that was popular in Europe at the end of the 19th century (Figure 3). Its main construction materials are brick, stone, wood, concrete and glass. Influenced by the cultures of Southeast Asia, Europe and China, these buildings’ form, space, plan, elevation, decoration and details reflect a mixed style of Chinese, Southeast Asian and European. The building structure is brick and concrete, with concrete columns, beams and floor as the main load-bearing components. These structures enable the internal building space to be free and open. In terms of architectural form, the building can show the characteristics of simplicity and restraint. The style of the pillar is in the style of European flowers and plants, symbolizing peace and harmony. The interior walls are decorated with lace and the floor tiles are simple, plain and elegant. The flower-form windows are made of stained glass with a sense of texture. (Figure 3)In terms of architectural function, Shixian Villa is a typical city residence building for overseas Chinese in Xiamen. The entire building condition is well-preserved. Its floor plan is different from the traditional form of residential buildings in Fujian and generate suitable living spaces for small families. The main living Spaces are divided into living rooms, dining rooms, bedrooms, etc. Modern living Spaces such as bathrooms and kitchens are set up, and large terraces, balconies and other spaces are attached. In terms of building materials and masonry techniques, this building shows both of the expression model of traditional local architecture in southern Fujian and overseas architecture. It uses the unique “smoked red bricks” of the southern Fujian region. This material makes the building more distinctive in the region. (Figure 4)

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Figure 3. Shixian Villa history, present and prototype.

Figure 4. Details of Shixian Villa before renew design.

4. Digital strategy of Shixian Villa Project

4.1 HBIM Background and Shixian Villa Application

New technologies have brought new opportunities for the renew of historical buildings. In the renew design project of Shixian Villa, HBIM was adopted as the main technical support. HBIM technology was proposed by Murphy in 2009 to protect historical buildings using BIM technology, namely “the Historic/Heritage Building Information Model” method. The objective of HBIM technology is to take advantage of the BIM technology in combination with the inherent characteristics of historical buildings or architectural heritage, and introduce multiple digital technologies including survey, information integration, modelling, and engineering management platforms, to assist in the renew design and engineering construction of historical buildings with an information-based and digitalized approach. (Yang et al, 2020)

The characteristics of HBIM can effectively assist historical buildings in completing the entire design process, including mapping, analysis, information integration, modelling, and drawing output. In the Shixian Villa renew design project, the application of HBIM involves three main processes:
(1) Digital survey, (2) model establishment and information integration, (3) Accuracy verification and digital archiving. (Pocobelli et al, 2018)

4.2 Digital Survey of Shixian Villa

The digital survey process of Shixian Villa adopted LiDAR 3D scanning technology, which has the advantages of high accuracy, convenient information collection and high efficiency. The use of 3D scanning technology can transform the architectural form and material characteristics of the overseas Chinese buildings in Shixian Villa into visual data, achieving the conversion from physical space to virtual space.

This paper adopts a three-dimensional scanning method for Shixian Villa, which involves setting up a group of triangular base stations around the villa and inside the rooms to obtain the point cloud data of the building. It is planned to set up 39 scanning base stations. According to the actual situation, 16 more stations are added, and finally 55 scanning base stations are set up. Subsequently, the point cloud data was organized using the Cyclone software (Figure 6). Compared with traditional models, the point cloud model has the advantages of accuracy and completeness, and can also greatly reduce the time cost of data collection and analysis in the early stage. Through the observation of the point cloud model, the project team conducted a detailed analysis of the villa at the architectural space level and the architectural detail level, and summarized the spatial layout characteristics and decorative features of the overall building. Through the overall observation and slice observation of the point cloud model, it can be seen that the overall building is in a symmetrical form, and the local functions have been adjusted. For instance, the position of the walls on the third floor has shifted, and there are also structural changes in the bathroom section on the south side and the corner room section, etc. More important, based on the analysis of the culture material on the buildings of overseas Chinese in those specific historical period, it can be determined that the building originally had a courtyard on the south side. However, with the passage of time and changes of occupants, the courtyard has disappeared. This information can be observed intuitively through the point cloud model, enabling the subsequent design to better judge and analyze the architectural prototype.

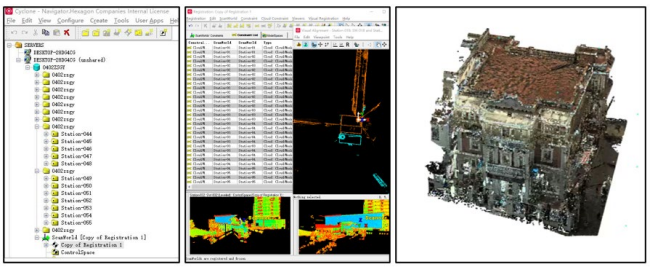


Figure 5. 3D scan and data processing of Shixian Villa.

4.3 HBIM Model Creation of Shixian Villa

Although the point cloud model has the complete architectural information, it still lacks a unified and integrated model information processing platform. The BIM model can not only conduct unified and integrated processing of architectural data information, but also convert the historical information of Shixian Villa into parameter forms. The conversion of point cloud models to BIM models can better support the data operability of architectural models and the multi-disciplinary collaborative expression in the later stage of renew design. Since BIM models associate two-dimensional drawings with three-dimensional models, compared with point cloud models, they can update the models in real time and promptly according to subsequent design requirements. Figure 5 shows the data integration of the BIM model of Shixian Villa in Revit software. In the early stage of visualizing the overall basic data, the visible components and materials of each facade were added.

When building a BIM model, establishing the corresponding BIM family library is important to increase the fineness of data visualization. This paper divides the BIM model family of Shixian Villa into “component family” and “wall family”. For decorative columns, railings and Windows, their general shapes remain unchanged, but the specific dimensions are slightly different. The component family library is established using the BIM family function and named in the format of "South 1F – Column AB". The enclosed structures such as walls and floor-to-ceiling windows also establish other family libraries based on the point cloud model data. Figure 7 shows the BIM model component database of Shixian Villa, among which the column family library contains 13 types of column style family

components. The window family library contains 26 types of window style family components. The other family libraries contain three types of door style family pieces. Through the integration and summary of family documents, it can be demonstrated that Shixian Villa has cultural and historical value as a typical example of overseas Chinese residence architecture in Xiamen. And through BIM model transformation, the architectural detail styles are transformed into model with variable data, facilitating the subsequent design expression and real-time update of the model.

To analyze the historical and cultural value of the digital model of Shixian Villa, after integrating the BIM model and family components, this research conducts another round of comparison between its model and the point cloud model as well as the current status of the building. This is to visualize the historical information of Shixian Villa with the BIM model, such as the old and damaged conditions of the building columns and the local defects of the floor tiles. The research team conducted analysis and comparison of various parts of the existing building by using the point cloud model and BIM platform, and then formed the architectural survey and survey drawings of the Shixian Villa, expressing the current situation of the physical space in an engineering way in the virtual space to assist in the subsequent detailed design. (Figure 8) The introduction of cultural and restoration information in BIM not only enhances the historical and cultural value, but also serves as a reference and prompt for engineering design.

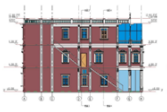
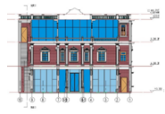
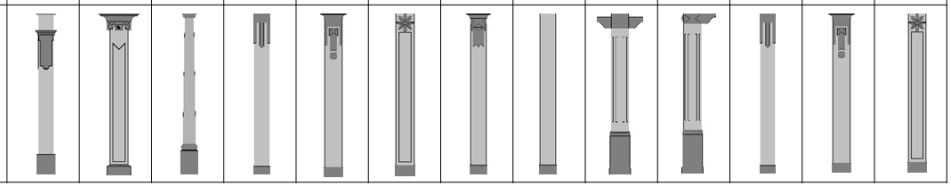
Category	East elevation	South elevation	West elevation	North elevation	Axial chart 1	Axial chart 2
Effect picture						
Visual family components	①East 1F - Pillar D ②East 1F/2F/3F - Pillar E ③East 3F - Pillar F; ④East 1F - Window V ⑤East 1F - Window W ⑥East 2F - Window X ⑦East 3F - Window Y ⑧East 3F - Window Z ⑨1F/3F-Glass curtain wall ⑩1F/2F/3F-Red brick wall ⑪3F/Roof - Vase Railing	①South 1F/2F/3F - Pillar G ②South 1F/2F/3F - Column H ③South 2F - Pillar I ④South 3F - Pillar J ⑤South 1F/3F - Window O ⑥South 1F - Window P ⑦South 2F - Window Q ⑧South 2F - Window R ⑨South 2F - Window S ⑩South 3F - Window T ⑪South 3F - Window U ⑫1F/2F/3F - Red brick wall ⑬1F/2F/3F - Marble wall ⑭South 2F - Double doors ⑮South/North 3F - Double doors ⑯2F/3F/ Roof - Vase railing	①West 1F - Pillar D ②West 1F/2F/3F - Pillar E ③West 3F - Pillar F ④West 1F - Window F ⑤West 1F - Window G ⑥West 1F - Window H ⑦West 2F - Window I ⑧West 2F - Window J ⑨West 3F - Window K ⑩West 3F - Window L ⑪West 3F - Window M ⑫West 3F - Window N ⑬1F/2F/3F - Red brick wall ⑭3F/ Roof - Vase Railing ⑮1F/3F-Glass curtain wall	①North 1F/3F - Pillar A ②North 2F - Pillar B ③North 1F - Pillar C ④North 2F - Window A ⑤North 2F - Window B ⑥North 2F - Window C ⑦North 3F - Window D ⑧North 3F - Window E ⑨North 1st Floor - Double embedded glass doors ⑩1F/3F - Glass curtain wall ⑪1F/2F/3F - Red brick wall ⑫3F/Roof -Vase Railing	For details, please refer to the visible components on the north elevation and the west elevation	For details, please refer to the visible components on the south elevation and the west elevation
Material	①Red brick ②Concrete ③Liu LI ④Glass ⑤Wood ⑥Steel structure	①Red brick ②Marble ③Concrete ④Liu LI ⑤Glass ⑥Wood ⑦Steel structure	①Red brick ②Concrete ③Liu LI ④Glass ⑤Wood ⑥Steel structure	①Red brick ②Concrete ③Liu LI ④Glass ⑤Wood ⑥Steel structure	For details, please refer to the visible components on the north elevation and the west elevation	For details, please refer to the visible components on the south elevation and the west elevation

Figure 6. HBIM model and information integration.

Category	North Side 1F/3F Pillar A	North Side 2F Pillar B	North Side 1F Pillar C	West side 1F Pillar D	West side 1F/2F/3F Pillar E	West side 3F Pillar F	South side 1F/2F/3F Pillar G	South side 1F/2F/3F Pillar H	South side 2F Pillar I	South side 3F Pillar J	East side 1F Pillar D	East side 1F/2F/3F Pillar E	East side 3F Pillar F
Graphic													

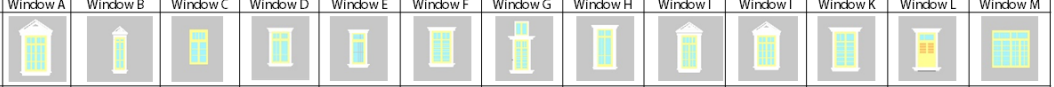
Category	North 2F-Window A	North 2F-Window B	North 2F-Window C	North 3F-Window D	North 3F-Window E	West 1F-Window F	West 1F-Window G	West 1F-Window H	West 2F-Window I	West 2F-Window J	West 3F-Window K	West 3F-Window L	West 3F-Window M
Graphic													
Category	West 3F-Window N	South 1F/3F-Window O	South 1F-Window P	South 2F-Window Q	South 2F-Window R	South 2F-Window S	South 3F-Window T	South 3F-Window U	East 1F-Window V	East 1F-Window W	East 2F-Window X	East 3F-Window Y	East 3F-Window Z
Graphic													

Figure 7. Some of the variable family components of Shixian Villa.

Number	Size	Window sash material	Damage condition
C43	1360*1850	Wooden blinds outside, glass flower window inside, Moldings window frame	The window sash and wooden window frame are severely rotten, the frame is cracked, the window frame moldings are missing and the plastering has fallen off
C44	800*1850	Wooden blinds outside, glass flower window inside, Moldings window frame	The window sash and wooden window frame are well-preserved, but the glass part is missing. The window frame with moldings is severely soiled
C45	1000*1850	Wooden blinds outside, glass flower window inside	The window sash and wooden window frame are well-preserved, but the glass part is missing
C46	1000*1850	Wooden blinds outside, glass flower window inside	The window sash and wooden window frame are well-preserved, but the glass part is missing
C47	1360*1850	Wooden blinds outside, glass flower window inside, Moldings window frame	The window sash and wooden window frame are severely rotten, the frame is cracked, the window frame moldings are missing and the plastering has fallen off
C48	1110*1850	Wooden blinds outside, wooden sliding window inside, Moldings window frame	The outer wooden blinds were later artificially dismantled and modified. The inner window sashes and wooden window frames were well-preserved, while the moldings and window frames were severely soiled
C49	1360*1850	Wooden blinds outside, wooden sliding window inside, Moldings window frame	The window sash and wooden window frame are well-preserved, but the glass part is missing. The window frame with moldings is severely soiled
C50	880*1890	Wooden blinds outside, glass flower window inside, Moldings window frame	The window sashes and wooden window frames are severely decayed. The moldings of the window frames are missing and the plastering has fallen off
C51	1360*1850	Wooden blinds outside, wooden sliding window inside, Moldings window frame	The window sashes and wooden window frames are severely decayed. The moldings of the window frames are missing and the plastering has fallen off
C52	700*1850	Wooden blinds outside, glass flower window inside	The window sash and wooden window frame are well-preserved, but the glass part is missing
C53	700*1890	Wooden blinds outside, glass flower window inside	The window sash and wooden window frame are well-preserved, but the glass part is missing

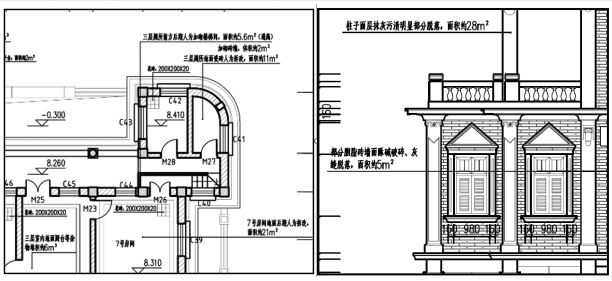


Figure 8. Detail information which setup in HBIM model.

4.4 Accuracy Verification of BIM Model

The digital information collection of Shixian Villa is not only an auxiliary improvement for the design, but also of good significance in the engineering archiving of the villa. To meet the requirements of the refined design and digital archiving of Shixian Villa, the research team conducted an accuracy verification. The research team conducted quality assessment and error calculation on the BIM simulation 3D model based on the point cloud model and data to verify the accuracy and completeness of the BIM model. This method takes the point cloud mapping data as the reference value, the BIM 3D model data as the test value, and refers to the collection of standards and norms on architecture survey results in China. The error calculation formula for the final inspection data obtained by sampling and collecting data bits is as follows (1).

$$M = \pm\sqrt{\frac{\sum_{i=1}^{n}\Delta_i^2}{2n}} \qquad (1)$$

where M = error in the outcome
n = the total number of detection points (edges)
Δi = statistical error

To verify the deviation of BIM model data from point cloud model data and the error between BIM model and real building data, the research team conducted a quality inspection of the mapping results of the overall model of Shixian Villa to confirm that the BIM model has the value of authenticity, reference value and storability. The research team took the length, width and height data of the BIM model as the test values and the corresponding data of the point cloud model as the reference values for formula calculation. Then, the group sampling error calculation was conducted on the BIM model family components of Shixian Villa. Two column families (Column A and Column G), three window families (Window A, Window H and Window Y) from the column family library, and one family component (Bottle railing) from other family libraries were selected. The length, width and height data of each family were used as the test values for formula calculation. By referring to the standards and norms on architecture survey results in China , the corresponding M_0 (V_1=0 for high-precision detection) can be obtained and substituted into the allowable result error stipulated in the relevant regulations. The digital data evaluation grades of the Shixian Villa can be classified as: BIM overall model M=3.54 - Good; BIM Column family library M=1.96 - Good; BIM Window Family library M=1.19 - Excellent; BIM Other family libraries M=1.66 - Good. According to the calculation results, the quality of the BIM digital model of Shixian Villa is good and above. It accurately restores the current prototype of Shixian Villa, enabling the classification and preservation of the building component prototypes of the Minnan overseas Chinese residence buildings, and providing corresponding assistance for subsequent design and research. (Figure 9)

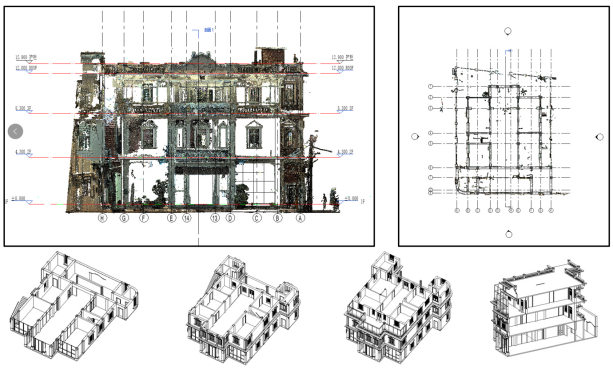


Figure 9. Accuracy Verification of BIM Model.

5. Renew design strategy of Shixian Villa

The point cloud model of Shixian Villa has realized the analysis from the overall space to the detailed design by using the survey model. The subsequent BIM survey model organically combines cultural information with model information to form an information integration platform and a data family library. Based on the two models, the research team carried out the renew design of Shixian Villa.

5.1 Architectural Restoration: The authenticity of Shixian Villa

In terms of the exterior design of Shixian Villa, the research team followed the prototype of the integration of Chinese and Western elements excavated from the research on the historical context of the Xiamen and Fujian area, and formulated the design strategy in combination with the principle of authenticity expression. The owner of Shixian Villa possesses the cultural customs and connotations of overseas Chinese merchants. Therefore, in terms of architectural form, the basic form of the overseas culture integrated style should be followed. What’s more, as a historical building of overseas Chinese in Xiamen area, Shixian Villa should also respond to the local regional culture, architecture characteristics, and climatic conditions of Xiamen city. It also needs to coordinate with the contemporary architectural facade features of Xiamen in the present day. Therefore, the building should still maintain the use of red bricks as the main material with regional characteristics. In the original building, the materials of some walls were changed, turning them into white-painted walls with relatively weak integrity. Therefore, in this renovation, efforts were made to restore the exterior walls to red brick walls as much as possible. In addition, the existing exterior windows and decorative components are relatively well-preserved. In addition, the exterior windows and decorative components of the building are relatively well-preserved. Therefore, in this renew design,

efforts are made to retain its original form as much as possible, and only material restoration is carried out on the basis of the original status research. In this way, on the one hand, the prototype of the architectural details is preserved; on the other hand, the durability of the architectural details is enhanced. For the form of these doors and windows that need to be restored, the research team follows their old style definitions. Through the door and window family library of the HBIM system, the matching door and window styles can be quickly formed and designed, which can greatly improve the design efficiency. In addition, by taking advantage of the directness of the BIM model, design judgments can be made by the help of 3D model while designing the drawings, ensuring the real-time update of design information. This not only meets the requirements of design drawings but also those of engineering drawings. (Figure 10)

Figure 10. Façade restoration and some detailed design.

Design analysis with model, history, culture and the prototype result is also very important. An example is the renovation of the first and third floors of the villa. The current status of the first and third floors on the north side of the original building is simple metal exterior windows. However, through the sorting out of historical photos and materials and the comparison with other historical buildings of overseas Chinese in the same period, these windows are not the original window forms of the building. So in the renew design, the current glass windows were removed to restore the original form of this part of the space. In addition, to restore the shape of the courtyard on the north side of the villa, the research team recreated the style of the entrance gate through the search of historical photos and culture materials. (Figure 11)

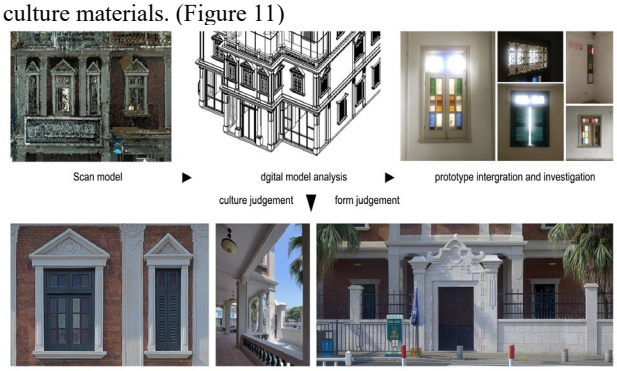


Figure 11. Design judgement according to HBIM model, history material, and prototype analysis.

For the south part of building, after comparing the terrain and the original structure of the villa, the walls were removed to restore the original courtyard. When the floor was removed, a well buried underground was discovered. The research team immediately added this information to the BIM model and revised the design plan of the courtyard. After the south side of the building was demolished and turned into a courtyard, the overall building not only increased ventilation and lighting, but also greatly improved the richness of the space (Figure 12).

Figure 12. Restoration design of south courtyard.

In the interior of the first floor, through structural investigation and 3D model comparation, it was found that the original arched structure was rebuilt. Therefore, following the principle of authenticity, the arched structure was removed and restored to the original structure to enhance the integrity and symmetry of the space. Also, by the on-site investigation, it was determined that the floor of the main lobby was raised on the the original floor, with the aim of creating an elevated layer for dampness prevention. Therefore, modern waterproof treatment was utilized and the original floor can emerge again. Traditional Fujian floor material, Doudi Bricks, are applied to showcase traditional regional culture. (Figure 13)

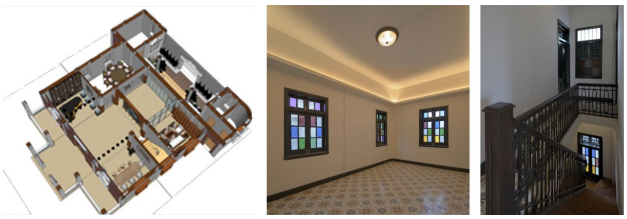
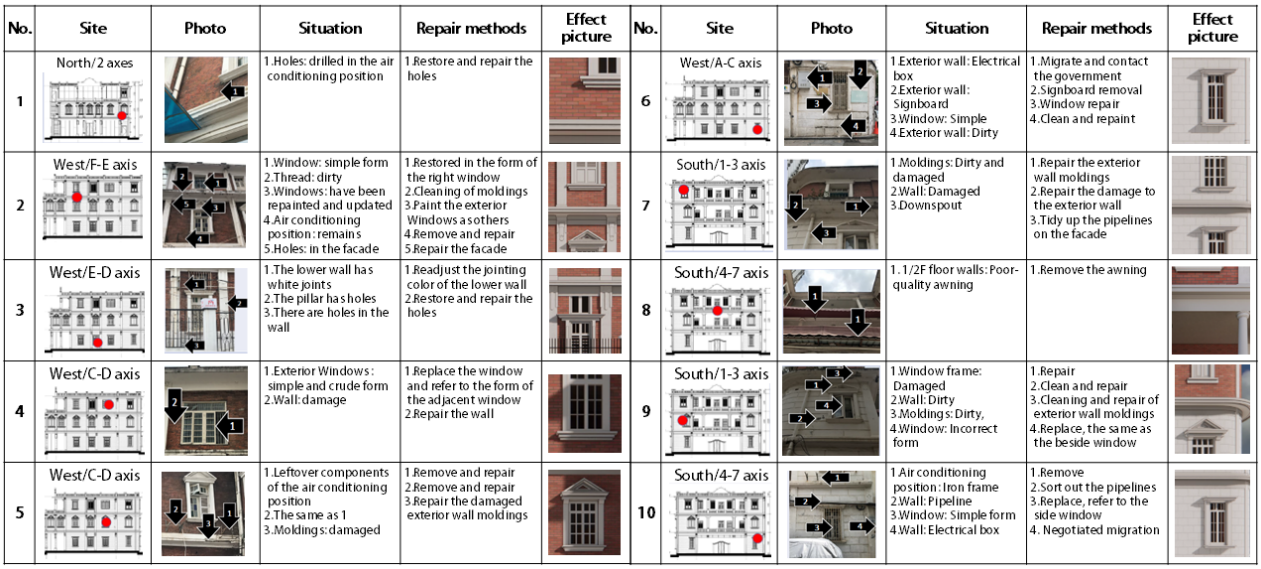


Figure 13. Interior restoration design.

5.2 Building Renovation: Performance Requirements

The protection of Shixian Villa also needs to emphasize the position of people, and it needs to express the connotation and value system of Nanyang culture and overseas Chinese culture. Through analysis, synthesis and judgment process, reasonable design ideas are proposed in view of the current situation. For building exterior components that should not be retained, conditional removal are selected, such as air conditioning panels and exposed wires that pose certain safety hazards. At the same time, for the staircase on the east side of the building, due to its long-term disrepair and significant impact on the functional requirements of the first floor, it is replaced by a modern steel plate staircase. This not only meets the structural requirements but also meets the daily ventilation and lighting needs of the rooms on the first floor. Based on the characteristics of various regions and components, the research team made design judgments on the basis of cultural analysis and formulated repair methods for different components to meet the performance requirements of the building and the requirements of historical and cultural expression. (Figure 14)



No.	Site	Photo	Situation	Repair methods	Effect picture	No.	Site	Photo	Situation	Repair methods	Effect picture
1	North/2 axes		1.Holes: drilled in the air conditioning position	1.Restore and repair the holes		6	West/A-C axis		1.Exterior wall: Electrical box 2.Exterior wall: Signboard 3.Window: Simple 4.Exterior wall: Dirty	1.Migrate and contact the government 2.Signboard removal 3.Window repair 4.Clean and repaint	
2	West/F-E axis		1.Window: simple form 2.Thread: dirty 3.Windows: have been repainted and updated 4.Air conditioning position: remains 5.Holes: in the facade	1.Restored in the form of the right window 2.Cleaning of moldings 3.Paint the exterior Windows as others 4.Remove and repair 5.Repair the facade		7	South/1-3 axis		1.Moldings: Dirty and damaged 2.Wall: Damaged 3.Downspout	1.Repair the exterior wall moldings 2.Repair the damage to the exterior wall 3.Tidy up the pipelines on the facade	
3	West/E-D axis		1.The lower wall has white joints 2.The pillar has holes 3.There are holes in the wall	1.Readjust the jointing color of the lower wall 2.Restore and repair the holes		8	South/4-7 axis		1. 1/2F floor walls: Poor-quality awning	1.Remove the awning	
4	West/C-D axis		1.Exterior Windows: simple and crude form 2.Wall: damage	1.Replace the window and refer to the form of the adjacent window 2.Repair the wall		9	South/1-3 axis		1.Window frame: Damaged 2.Wall: Dirty 3.Moldings: Dirty, 4.Window: Incorrect form	1.Repair 2.Clean and repair 3.Cleaning and repair of exterior wall moldings 4.Replace, the same as the beside window	
5	West/C-D axis		1.Leftover components of the air conditioning position 2.The same as 1 3.Moldings: damaged	1.Remove and repair 2.Remove and repair 3.Repair the damaged exterior wall moldings		10	South/4-7 axis		1.Air conditioning position: Iron frame 2.Wall: Pipeline 3.Window: Simple form 4.Wall: Electrical box	1.Remove 2.Sort out the pipelines 3.Replace, refer to the side window 4. Negotiated migration	

Figure 14. Some of the building renovation method using HBIM model and design model.

5.3 Building Renew: Functional Requirements

In the renew design of Shixian Villa, modern renovations should also be carried out on the basis of conforming to the traditional architectural features to meet the needs of modern people's lives. The renew concept is based on level distribution strategy. All the building components include façade, plan and decoration elements, etc, are reconsidered during the design process. Some of new design and new facilities are applied according to the redesign level judgement. (Figure 15)

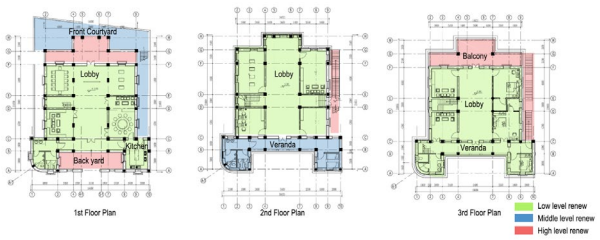


Figure 15. Renew plan and level distribution strategy.

The research team designs green plant landscapes on the outer side of the north courtyard near the main urban road, enhancing the aesthetic appeal while reducing the noise from the main road. In the decoration of interior buildings, the original isomorphic elements are selected and repeatedly applied on the walls and columns to form a certain sense of rhythm and unity. In the interior design of the building, the original grid beam structure is retained and certain decorations are added to the structure. New wood wainscots and trunkings are also applied. What’s more, to meet the air conditioning and ventilation requirements of the rooms, the research team redesign the ceilings of each room and hidden the air duct in them. The ceiling is equipped with lighting facilities such as spotlights, strip lights and ceiling lights. These practices are to endow modern functions within the traditional framework, enabling the interior of the building to restore the original living function of the building while ensuring the style characteristics of the building prototype.

6. Discussion

"From prototype to originality" is a cultural cognitive path and design thinking method. It calls on designers to start from the depth of culture and apply digital technology methods to achieve a real dialogue between architecture and time, culture and space. Between history and the present, it offers an enlightening and creative path. Meanwhile, the application of HBIM has brought positive effects to the successful completion of the project: it has shortened the time for historical building research, analysis and other work, improved the efficiency of team collaboration, and reduced the errors in the design cooperation of different project drawings. Of course, the "originality theory" has currently completed the integration of theory and digital design, but a complete evaluation system has not yet been established. In subsequent research, it is necessary to establish a framework for assessing the rationality of "originality expression" to avoid subjective abuse. In addition, the development of modern technologies such as AI, VR/AR has also provided the possibility for further exploring the evolution logic and modern expression of "originality".

7. Conclusion

In the design strategies for the protection of historical buildings of overseas Chinese, “From prototype to originality” is a design strategy that emphasizes authenticity. In the protection project of Shixian Villa, the client hopes to restore the original function through the renewal process. Based on this, the research team conducted an in-depth analysis of the external form and internal space of the existing historical building, deeply restored the architectural features according to its historical materials. Meanwhile, the research team carried out minimally invasive local renovations based on the functional requirements of the client. Under the premise of avoiding a large number of innovative designs, research team used digital technology combined with cultural analysis to conduct a secondary design of the building, which also echoed the historical and cultural value of the historical building itself. After the building completion, the Shixian Villa renew design project has become a representative case of the protection of overseas Chinese historical buildings in Xiamen, providing a reference for design

This contribution has been peer-reviewed. The double-blind peer-review was conducted on the basis of the full paper.
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strategies for other overseas Chinese historical buildings in the same area. This case can also become a representative example of historical building protection under the HBIM concept.

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