COMPANY

Architectural Services Department, HKSAR

PROJECT

Heritage Building Information Modelling for Cultural Heritage Conservation at Tai Fu Tai Mansion

LOCATION

Wing Ping Tsuen, San Tin, Yuen Long

TYPE

Facility Management

SCHEDULED TIME OF COMPLETION

August 2021

New Era of Heritage Conservation with Adoption of Heritage Building Information Modelling

"Tai Fu Tai Mansion is the first government owned Chinese style monument in testifying the use of BIM on heritage conservation in Hong Kong and is one of the pilot projects for the purpose of building up the as-built BIM inventory for Architectural Services Department. In echoing government's support of innovation and technology, we hope to establish a comprehensive database together with HBIM models for managing conservation information to facilitate effective facilities upkeep of historic buildings in future."

—**Alan Sin**
Assistant Director (Property Services), Architectural Services Department, HKSAR

—**Liny Lau**
Senior Maintenance Surveyor/ Heritage, Architectural Services Department, HKSAR

—**Ken Ma**
Senior Property Services Manager/ SD32, Architectural Services Department, HKSAR

BIM PARTNERS

WSP Hong Kong Limited

Revival Heritage Consultants Limited

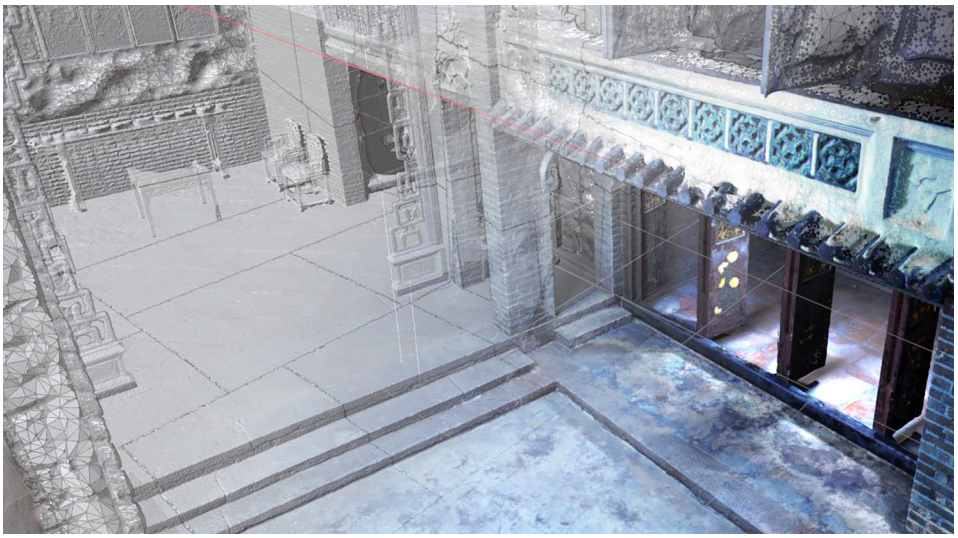
AUTODESK PRODUCTS USED

Autodesk® BIM 360® Docs

Autodesk Forge®

Autodesk® ReCap® Pro

Autodesk® Revit®



3D Photogrammetry Scanning VS Existing Conditions
Image Courtesy of Architectural Services Department, HKSAR (ArchSD)

Project Background

Tai Fu Tai Mansion is a two-storey grey brick mansion with delicate design and rich embellishments in around 1865 in the fourth year of the Tongzhi Reign of the Qing Dynasty. It is a rare example of traditional Chinese residence in Hong Kong built by an eminent gentry (Man Chung-luen) who received the imperial title of Tai Fu. As such, the residence is named as Tai Fu Tai. The main building of Tai Fu Tai is a two-hall, three-bay structure with side chambers flanking the courtyard. There is a one-bay ancillary building on each side of the main building. It was declared a monument in 1987.

The project is about developing a Heritage Building Information Model (HBIM) for the Tai Fu Tai Mansion to augment conservation and facilities upkeep of the historic fabrics. The project lasted for 7 months and was completed in August 2021.

Objective of HBIM

By the adoption of 3D photogrammetry scanning and historical research, the existing environment and historic merits could be accurately collected for building up the BIM model and also the phasing

Revival of Tai Fu Tai Mansion through HBIM
Image Courtesy of ArchSD

InstaPro 360 Degree Camera & Tripod for conducting 3D scanning works
Image Courtesy of ArchSD

of architectural changes from 1865 to 2021 to illustrate the historic evolution of the site and its context. The HBIM for Tai Fu Tai Mansion is developed as an interface and platform to visualize, share and navigate the heritage information available on the dimension and state of conservation of the historic building for bettering of heritage conservation and facilities upkeep. The as-built BIM models allow easy extraction and dissemination of data and information for the production of architectural drawings with detailing of Character-defining Elements (CDEs) such as artworks including painting, carving, ceramic and plaster figurines, murals and mouldings.

Conservation Management Plan (CMP)

Built over a century ago, Tai Fu Tai Mansion has witnessed many human activities and experienced various alterations. Design information, drawings and construction records of heritage buildings are usually missing or lost. In order to retain the tangible and intangible heritage values, an extensive research on its architectural merit, historical interest, social values and maintenance requirements was conducted. Interview with academics, Antiquities & Monuments Office and local villagers were carried out to verify the information. The aim of Conservation Management Plan is to examine the heritage values, identify the CDEs of the site, assess their significance as well as opportunities and constraints so as to develop a Practical Conservation Policy. Information of research findings would be integrated with Building Information Modelling (BIM).

Data Collection by Photogrammetry

3D photogrammetry scanning has been utilized for many years to record and model the geometric features of buildings and environments. These technologies can be used to perform Heritage Building Information Modelling to digitally restore valuable artifacts and spaces. This 3D scanning solution allows the creation of high quality photorealistic 3D models. The diversity and complexity of the close range objects allow us to confirm the feasibility of the processing to archive high quality virtual outputs either in 2D drawings or in 3D models and objects. Furthermore, true dimensional BIM objects with realistic texture can be quickly generated or converted from photorealistic 3D models to enhance the visualization and quality of as-built BIM models.

Character-defining Elements (CDEs)

According to the Standards and Guidelines for the Conservation of Historic Places, character-defining elements mean “the materials, forms, location, spatial configurations, uses and cultural associations or meanings that contribute to the heritage value of a historic place, which must be retained in order to preserve its heritage value”. Tai Fu Tai Mansion, with many exquisite and colourful timber-carved elements, plaster motifs and sculptures, Shiwan ceramic figurines, wall paintings, etc. demonstrates a high level of craftsmanship, architectural and aesthetical values of the building. It is essential to identify, record the CDEs of the monument and their level of significance in the BIM model to justify any future treatment to CDEs.

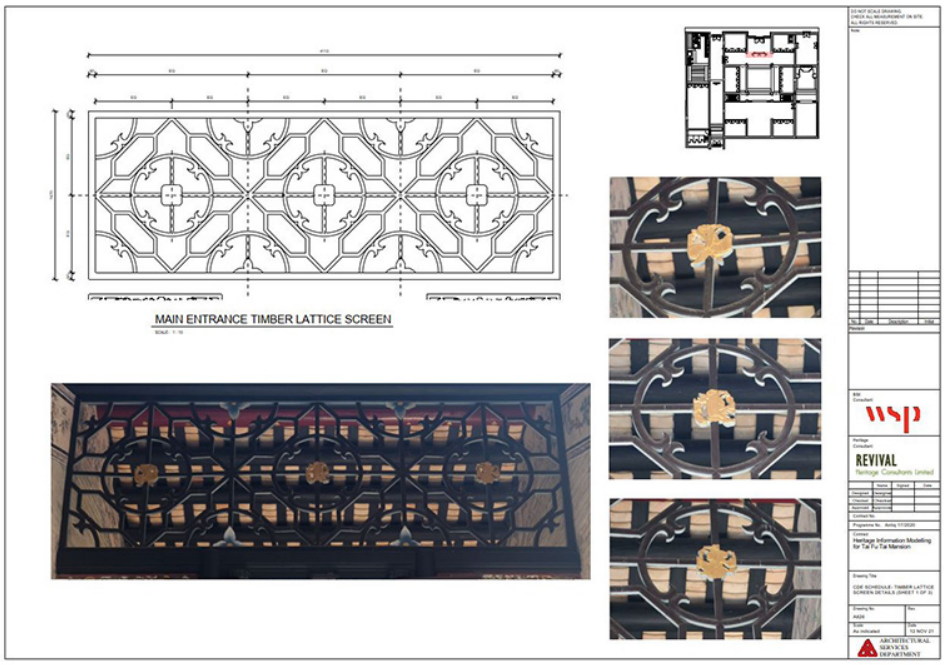
Development of HBIM

The HBIM model is developed as an interface and platform to interlink, visualize, analyze and navigate the heritage information available on the dimension and state of conservation of the monument, including:
Storyboard - Illustrative images recorded significant changes of Tai Fu Tai Mansion in 6 Phases from 1865 to 2021.

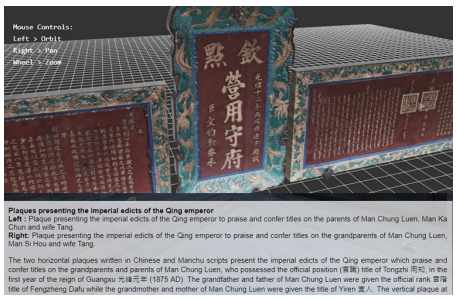
Virtual Tour - Formed with seamless 360-degree spherical panoramic images, key plans, information tags with historical information and images, interactive 3D objects which enable project team or potential user to navigate and visualize the building anytime even when the site is closed or far away from town.

Generate 3D scan model from data collected on site
Image Courtesy of ArchSD

Heritage Building Information Modelling of Tai Fu Tai Mansion
Image Courtesy of ArchSD

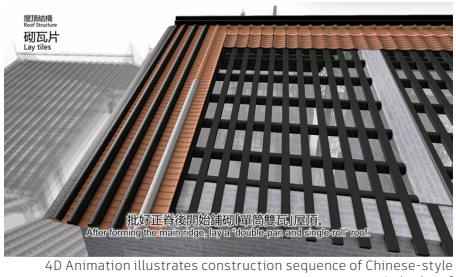


BIM-generated as-built record drawings
Image Courtesy of ArchSD

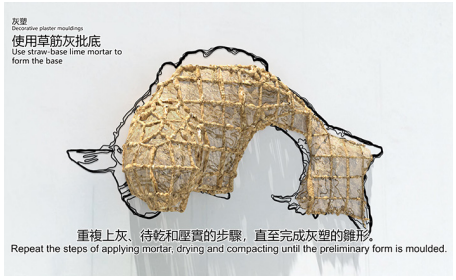


3D Objects converted from 3D Scan Model and Historical Information
Image Courtesy of ArchSD

records, animations and essential building information. Production of 4D animations enable maintenance personnel for visualization of the construction sequence of selected CDEs (the laying of Chinese-style pitched roof structure, timber bracket support, decorative plaster moulding, operation of screen door and brick laying) and helps preserving our valuable heritage to our next generation.



4D Animation illustrates construction sequence of Chinese-style pitched roof
Image Courtesy of ArchSD



4D Animation illustrates construction sequence of plaster moulding
Image Courtesy of ArchSD

Web-based 3D Model - User friendly, fast, full of features, easy to control and software free for daily navigation and operation i.e. sectional box, dimensioning, zoom & selection, data entries.

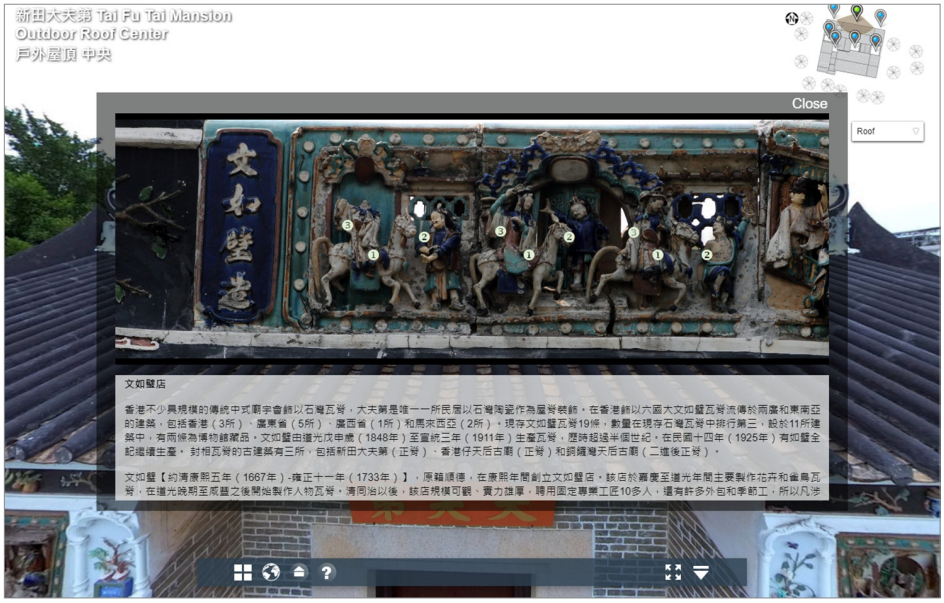
4D Animated Video - Simulated the construction sequence or techniques of this monument to enhance the understanding of traditional construction techniques for maintenance personnel.

Application of Innovative Technology

High-resolution 3D mesh model may have trouble being handled in 3D software, therefore a lower-resolution mesh model are required for daily operation. The objective is to make the lower-resolution mesh looks as similar as possible to the high-resolution mesh by generating a normal map using photogrammetry technique. This technique allows UV Map application which is the process of projecting a 2D image to a 3D model's surface for texture mapping. UV texturing permits polygons that make up a 3D object to be painted with colour from an ordinary image. The image is called a UV texture map. When the scene is rendered, each triangle will map to the appropriate texture. This process is known as UV unwrapping. The mesh optimization is performed to reduce unnecessary geometry complexity keeping the look same as the original one.

Facilities Upkeep and Maintenance

The production of accurate as-built BIM models is set according to ArchSD Building Information Modelling (BIM) Guide for Facilities Upkeep. It also demonstrates the potential of using BIM for facilities upkeep and heritage conservation, especially the use of timeline function to illustrate the contextual development of the site and the storage of archival records by means of CDEs schedule, photographic



Virtual Tour
Image Courtesy of ArchSD

建築署
Architectural Services Department

Timeline development of Tai Fu Tai Mansion
Image Courtesy of ArchSD

About Architectural Services Department, HKSAR

Architectural Services Department (ArchSD) was found in 1986 serving as one of the works departments under the Development Bureau of the HKSAR Government for the development and upkeep of public facilities. Our aim is to provide efficient and cost-effective professional and project management services for the design, construction, maintenance and refurbishment of government buildings and facilities. We also provide professional and technical advice to the Government and quasi-government organizations. Our mission is to serve and care for our community by enriching the living environment through high quality professional services; and to promote best practices in the building industry.

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