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To cite this article: A Sabil *et al* 2022 *IOP Conf. Ser.: Earth Environ. Sci.* **1022** 012007

The Application of Photogrammetry in Architecture Historical Documentation: The measured drawing of Tanjung Sembrong Mosque and Teratak Selari Bonda

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Abstract. Architectural measured drawings refer to the process of on-site constructed building documentation in the form of presentable set architectural drawings. The drawings are produced by executing the on-site measurement before converting it into an appropriate architectural drawing scheme. Traditionally, the process begins by obtaining the measurement of the building wholly with the aid of standard measurement tools. With this method, there are issues and challenges identified in obtaining accurate measurement. The process is complicated due to human limitations in getting the measurement on the highest peak of the building. With the assistance of geomatics tools, the photogrammetry method assisting in obtaining such measurements, specifically the roof of the building. This publication explains the integration process of the traditional measurement method and photogrammetry through the measured drawing exercise of Tanjung Sembrong Mosque and Teratak Selari Bonda located at Parit Raja, Johore. The procedure involves the common measurement technique using standard measurement tools integrated with the photogrammetry methods with UAV usage to capture the coordinated aerial image of both buildings.

1. Introduction

Architectural measured drawing referring to the systematic procedure in documenting and understanding the characteristics of built environment, specifically on-site constructed building [1]. The outcome of documentation is generally represented by visual communication illustration and literature as part of educational tools in understanding the buildings' context and significant cultural values [1], [2]. The procedure of documentation involves multiples series of qualitative and quantitative data collection. It includes the physical building components measurement, supported by the oral and literature documentation that represent the narratives historical background of the buildings. The measurement data plays an essential role in determining the actual record and condition of the building before being translated into comprehensive architectural documents in the form of two-dimensional (2D) and three-dimensional (3D) drawings [3].

2. The Importance of Architecture Measured Drawings

As a way to preserve the valuable built heritage, architecture measured drawings are considered as one of the predominant components in historical architecture documentation. The role of historical documentation is widely known as the main medium in conserving and recording the intrinsic and

extrinsic values of built heritage [4]. Department of National Heritage made a lot of effort in conserving the values by initiating the conservation projects and documenting selected heritage buildings, specifically on the extrinsic values of the monuments. Although the initiative was extensively attempted, numerous heritage monuments remain intact at the site non-documented, and some are left abandoned unmaintained. [5].

Apart from documenting, the Department of National Heritage initiated the act, which gazettes some of the selected heritage buildings and gone through under controlled conservation project. But there are problems aside. Rasdi [6] stated that most people are not aware of this National Heritage initiative due to its not wide publicly promoted in the mass media. Besides that, some people are not interested in nominating their building as one of the National heritage gazettes due to the difficult process and procedure before and after the gazetting process. Apart from that, some of the citizens who are their house have been gazetted facing difficulties when they intend to renovate or sell their building. It's because they are restricted by the National Heritage act. Contrary to the avoided gazette procedure that regulatory immersed, most of the owners willingly allowed their buildings to undergo measured drawing procedures. Due to its significant importance, the measured drawing procedures should be evolved with the current techniques and methodology.

3. The Practices of Architecture Measured Drawings in Undergraduates Architecture Curriculum

Aside from being practiced by professional consultants, the measured drawing exercises are embedded with the curriculum in the undergraduate architecture program in most Malaysian higher education institutions [7-9]. University Technology Malaysia commemorates the works of completed students' measured drawing documentation with the establishment of the Centre for The Study of Built Environment in The Malay World (KALAM) in 1996 [10]. On the other side, some of the institutions publically published the students' measured drawing report online, which has been initiated by Taylor's University.

In standard practices, measuring building components are the primary activity of the measured drawing procedures. The main tools being used in this activity include the standard measuring tape and digital devices such as laser distance measuring devices. The measuring tape is mainly used in the accessible part or area of the building. The digital laser measuring devices are used to measure higher components such as the column height and the inclination degrees of the roof. The devices allow the user to measure the inaccessible parts or areas by mere human capability, despite being limited to the components that are only visible to the user's eyesight [11].

The measurement data will be recorded accordingly and translated into the brief vignette and sketches before producing an appropriate architecture drawing scheme [11]. In the early days, the sets of drawings are produced by manual draughting technique before the Computer-Aided Design software have been used widely. Generally, the drawing consists of plans, elevations, sections, and numbers of detailed drawings that show the ornaments and construction. With the limitation of technology and human capacity, the whole procedures are time-consuming in the range of a week to a month, depending on the size of the building. Apart from that, the accuracy of the measurements is debatable, where some of the non-measurable buildings' components are often assumed by using the drawing scale and proportion techniques.

With the recent technological and knowledge advancement, unmanned aerial vehicles (UAVs), commonly known as drones, are integrated as tools for measuring activities. With the ability to capture the image from desired coordinate and height, drone usage assists in collecting the measurement data and determining the roof profile of the building with photogrammetry. Photogrammetry referring to techniques of measuring by using photographs. The photogrammetric process is intended to derive accurate information from aerial photographs and generate the photographic image from which all errors have been removed [12]. With the integration of standard measurement techniques and photogrammetry, the collected measurement data ascertain higher accuracy.

4. Measured Drawing Procedures at Masjid Tanjung Sembrong and Teratak Selari Bonda

The integration of standard measurement and photogrammetry procedures are explained through the measured drawing exercise at Masjid Tanjung Sembrong and Teratak Selari Bonda. The buildings were chosen by representing two different building typologies based on their usage and construction material. The whole procedure is divided into two phases, started by the documentation of the historical background of the building, follows by the series of measurings activities in obtaining the exact measurement for final drawing production.

4.1. Background of the Buildings

The first building is Tanjung Sembrong Mosque, also known as Tunku Mahkota Ismail Mosque. It is one of the earliest mosques built in Tanjung Sembrong near Parit Raja, Batu Pahat. The site of this mosque was founded in 1932 by the earliest village head descended from the royal family of Jambi, namely Raden Yassin bin Hamzah who is also a Vice Kadi appointed by the Johore Islamic Religious Council. The mosque was entirely constructed in 1935 with funding from the Johore government and donations from the public. At the moment, the number of users reported decreasing, and the mosque itself is potentially abandoned if left without appropriate maintenance. It is caused by the migration of local communities to the cities, resulting in the small size of the current population using the mosque. While the building remains intact on-site, the documentation approach is necessary to record the extrinsic elements of this valuable heritage.

The second building, Teratak Selari Bonda, is a homestay located in Kampung Parit Tengah. It is a homestay suitable for tourists who want to experience staying in a typical Johor's rural environment. The house is owned by a group of eight siblings where it is led and managed by the eldest child, Tuan Haji Yatani Bin Sameran. The construction process of Teratak Selari Bonda started in 2010 and was completed in 2012. Twenty carpenters were involved in the construction, where each of them has their job specialization and was led by a carpenter from Jepara, Indonesia. The house's architectural features are heavily influenced by Indonesian construction and architecture style. In total, 60 tonnes of Cengal and Belian have been used as the house's main structure. It's imported from Sarawak and joint without using any nails. Instead, it is connected by a hybrid mortise system. The buildings are heavily occupied with numerous characters of ornamentation and portray the long gone precedent traditional construction system, which is essential to be documented for future references.

4.2. The Integrated Measurement Process

The measurement process is conducted through two integrated techniques. The first technique is measuring the accessible areas and components of the building physically by using standard measuring tools. The second technique relies on the photogrammetry techniques in generating the complete physical exterior information of the building by using captured coordinated images.

For physical measuring activity, the standard tools used include measuring tape and laser distance meter. As shown in the Figure 1, the steel measuring tape is used to measure all the reachable parts of the building, such as the doors, stairs, columns, and windows. On the other side, nylon measuring tape is used for non-linear building components such as arches and columns due to its bendable properties. The laser distance meter is used in measuring the unreachable building components. The device's triangle measurement features are used to determine the length of rafters and beam underneath the roof structure of the buildings. The collected measurement data are recorded through on-site sketches and vignettes to produce the final set of architectural drawings.

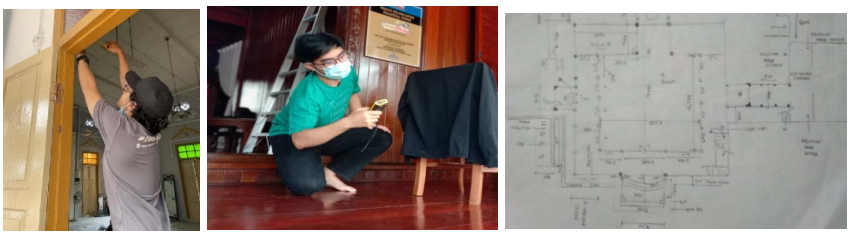

Figure 1. Physical measuring activities by using the standard measuring tape and laser distance meter (left and middle). The data recorded into appropriate on-site sketches (right)

Contrary to the physical measuring technique, the photogrammetry technique relies on the usage of the devices and software. As shown in Figure 2, two types of drones were used, including the mini size drone for low altitude and short-range flight. Followed by a medium-size drone for higher and distant range fly capability and equipped with a high-resolution GPS camera. The DJI Tello (mini drone) was used to capture close and focus images of unreachable building components, such as ornamentation at top parts of the building as shown in Figure 3. On the other side, the DJI Phantom 4 Pro (medium size drone) was used to capture the desired coordinated points of aerial image in generating a 3D model drawing of the building.

Figure 2. DJI Tello mini drone (left) and DJI Phantom 4 Pro medium size drone (right)

Figure 3. The static images of ornaments profile located at the top part of the building, interiors and exteriors captured by using DJI Tello

The photogrammetry process started by planning the flight route for DJI Phantom 4 Pro before the measuring works at the site. As shown in Figure 4, the mobile application Pix4Dcapture use by creating the 'mission' and set up the drone flight route, together with the specified coordinate point for capturing the aerial images of the building (Figure 5 and 6). The 'grid' route and 'circular' route missions are subsequently used to get overlapping coordinated images in generating more accurate, informative, and detailed 3D drawings. Aside from that, the flight altitude is set within the range of 20m-30m above the ground. For more visible building images, the degree of the camera's gimbal is set with angles 10° and 30°. During the measuring day, the drone will fly according to the mission as been set in Pix4Dcapture.

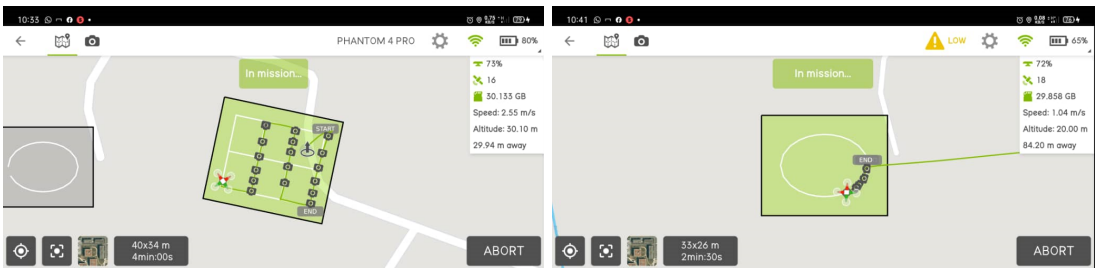

Figure 4. In 'mission' drone flight by grid route (left) and circular route (right) as in Pix4Dcapture

Figure 5. Aerial coordinated images of Tanjung Sembrong Mosque (different gimbal angle) captured by DJI Phantom 4 Pro

Figure 6. Aerial coordinated images of Teratak Selari Bonda (different gimbal angle) captured by DJI Phantom 4 Pro

4.3. Drawing Production -Documentation

The collected data from physical measurement and photogrammetry are converted partially into 2D CAD drawings and 3D models drawings. 2D CAD drawings are generated from the on-site sketches by each measured component of the building. All necessary detailed drawings, such as ornaments and construction details, are produced separately. On the other side, the first 3D drawings are generated by the output of photogrammetry. In total, around 150 aerial coordinated images are captured for each building. The captured image is then converted into a 3D drawing in Agisoft Metashape Professional software as shown in Figure 7 and 8. The aerial coordinated images transformed into the point cloud, based on the GPS coordinate and altitude of images captured on the flying drone. Based on the point cloud, Agisoft Metashape Professional processes all the images into a 3D model drawing that is readable in various 3D drawing software, such as Autodesk Revit and Google Sketch Up.

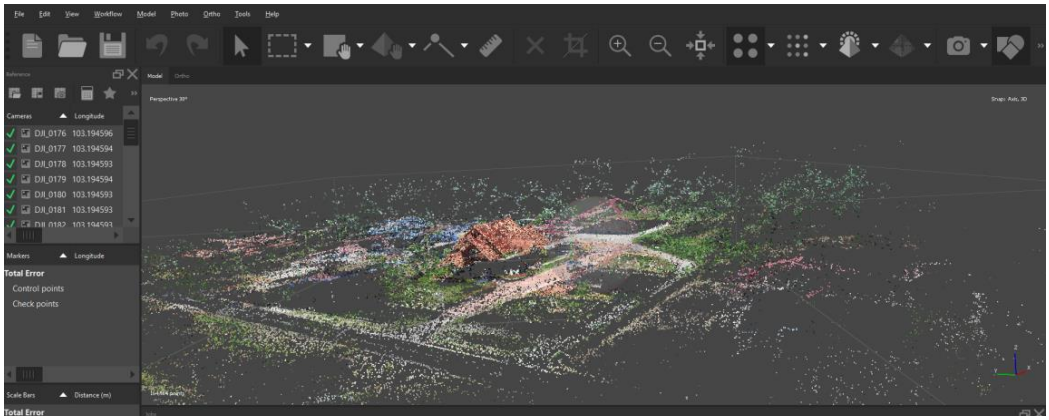

Figure 7. The Agisoft Metashape Professional software generating the 3D model drawings of Teratak Selari Bonda from point cloud

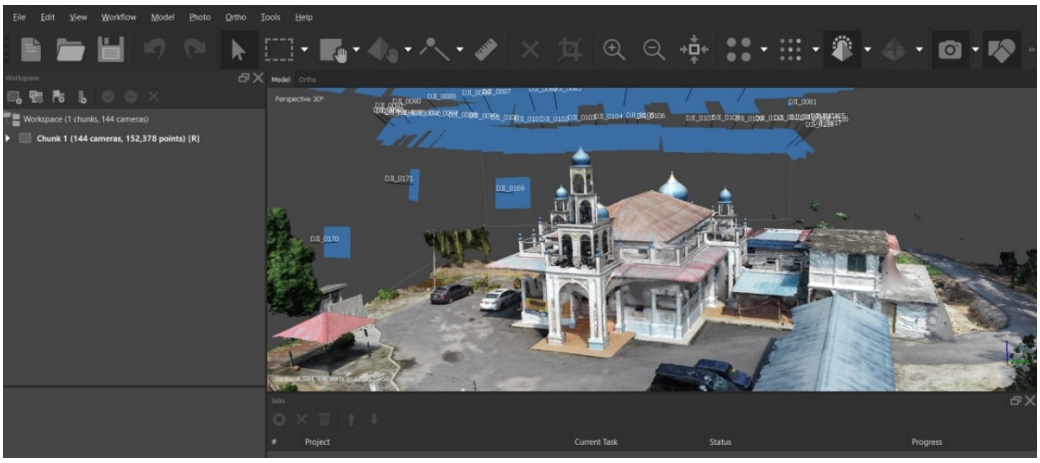

Figure 8. Generated 3D drawing of Tanjung Sembrong Mosque in Agisoft Metashape Professional software

The generated 3D model from Agisoft Metashape Professional occupied with the actual scale of the building dimension and measurement. By that, the total size and dimensions of buildings are identified horizontally and vertically. The exact height of the building was recorded, specifically on the roof profile for both of the buildings, since it was unreachable by physical measurement. All of the collected measurement data from physical measurement and photogrammetry are verified by one another to ensure the accuracy of the building dimension. The complete set of drawings is then produced by combining all of the partial components and detailed drawings into a set of elevations (Figure 9), sections,3D drawings (Figure 10) and floor plans (Figure 11).

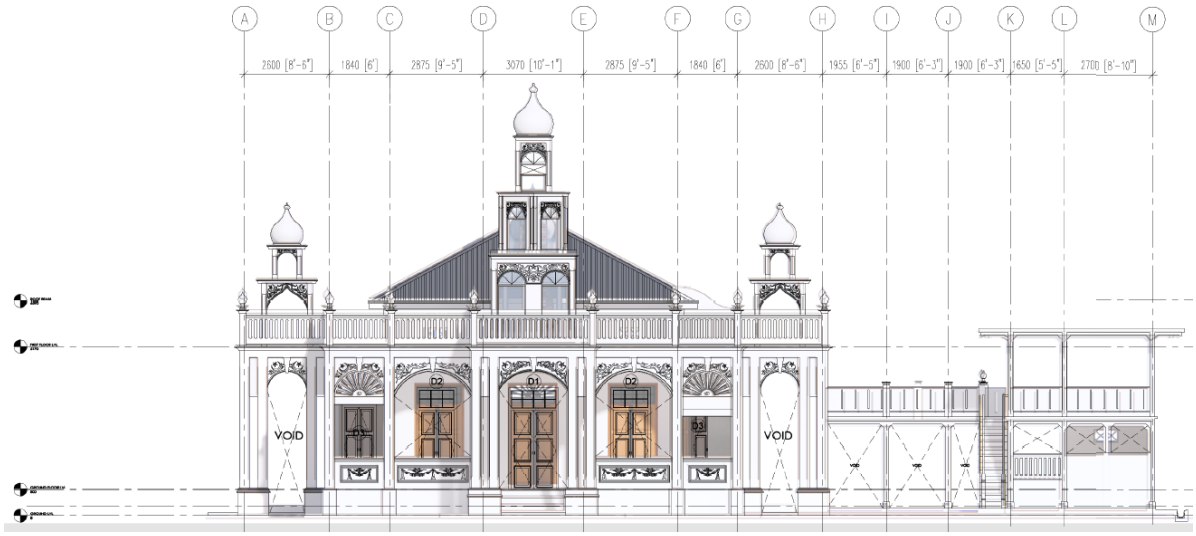

Figure 9. The front elevation drawing of Tanjung Sembrong Mosque

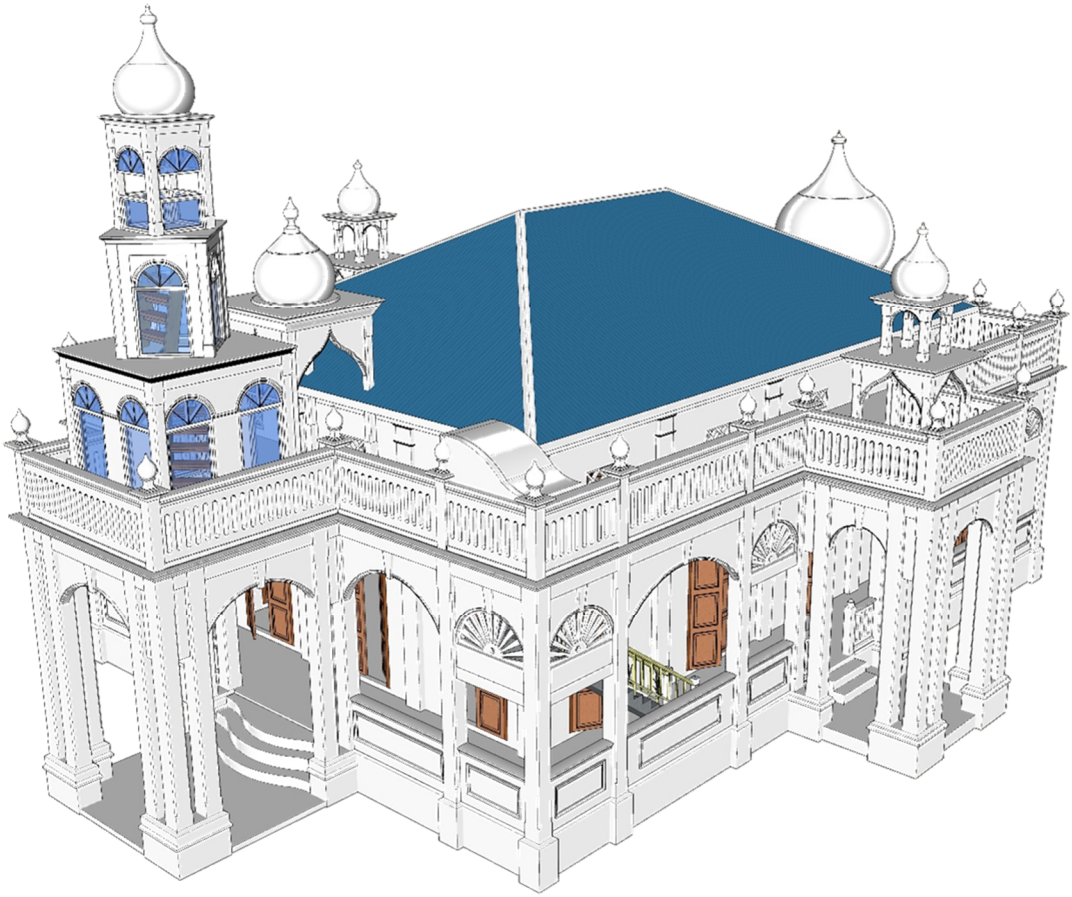

Figure 10. The 3D drawing of Tanjung Sembrong Mosque

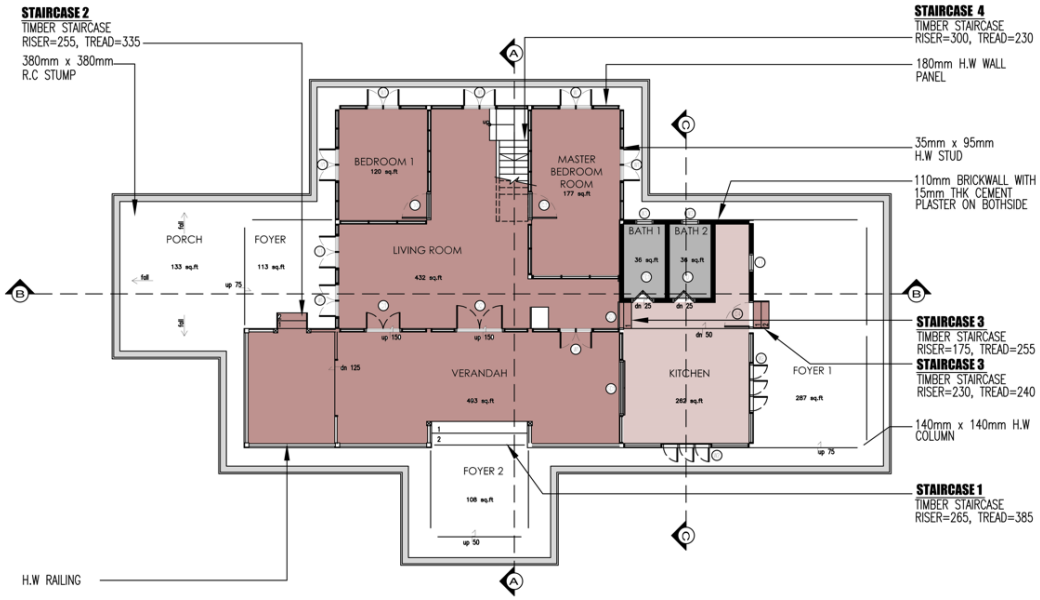

Figure 11. The floor plan drawing of Teratak Selari Bonda

5. Conclusion

The importance of architectural measured drawings is undeniable in its contribution to the body of knowledge, not merely as historical records, but as a resource in developing future architecture design ideas that reflect the nations' roots. Previously, the measured drawing process was tedious, demanding, and even hazardous in obtaining the measurement from the highest peak of the building. The integration of photogrammetry not only moderates the whole process but also contributes additional data to verify the physical measurement outcome. At the end of the process, accurate architectural drawings are essential as valuable historical documentation of built heritage.

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Acknowledgments

This study was supported by University Tun Hussein Onn Malaysia through Tier 1 Research Grant' (Code: H748) for the research project *A Study of Gamification Method to Increase Student Performance of Design in Architectural Studio Based Learning*. The authors also acknowledge the support of the Architecture Department, University Tun Hussein Onn Malaysia, Focus Researh Group Asia Design, Architecture and Research Study (ASDARS), University Tun Hussein Onn Malaysia and WARIS Research Group, University Putra Malaysia.