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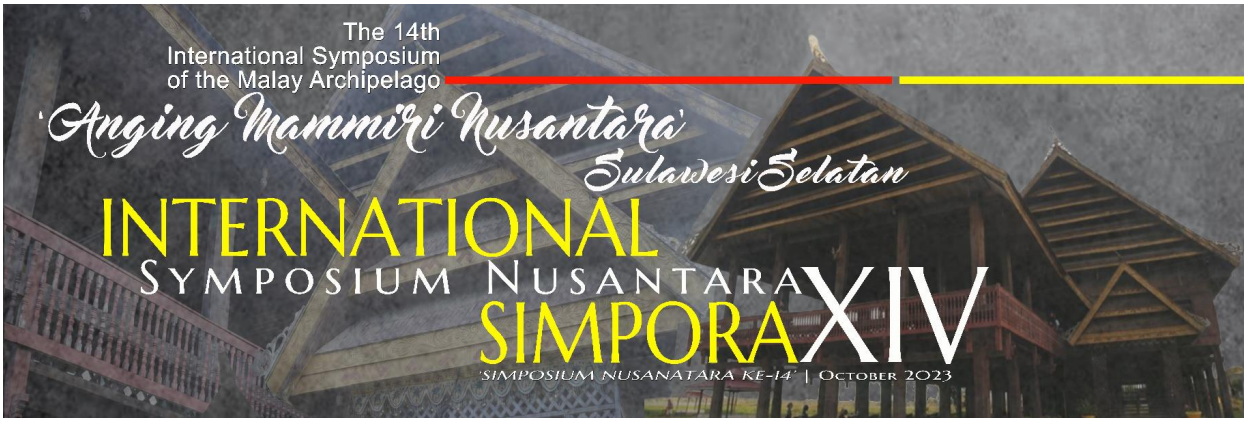

PRESERVATION OF MEANING IN MOSQUE ARCHITECTURE USING HERITAGE BUILDING INFORMATION MODELING (HBIM): A CASE STUDY OF THE ICONIC AL-HILAL KATANGKA MOSQUE, GOWA, SOUTH SULAWESI, INDONESIA

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Abstract: This research aims to document the meanings of building elements in digital applications. Building Information Modeling (BIM) helps researchers and architects collect information on the meanings and values of old building elements in 3-dimensional models. The architectural elements of the Al-Hilal Katangka Gowa Mosque are the characteristics that reinforce the historical significance and pride of the Gowa district. However, the meanings and values are not integrated into a single object. On the other hand, mosque buildings have the potential to be maintained with the HBIM digital platform. This research uses a content analysis method with a rationalistic paradigm. The research results show that every meaning and value can be understood when accessed through a three-dimensional model. Augmented reality projects 2D and 3D virtual models that can be interactively and effectively projected in real time. ArchiCAD software is used to collect the meanings of roofs, walls and columns into a single 3-dimensional model.

***Keywords*:** Preservation, Meaning of Mosque Construction, Iconic Architecture, HBIM, Virtual Reality

INTRODUCTION

The preservation of cultural heritage is documented in three dimensions so that it can become a potential tourist attraction and contribute to the country's foreign exchange through the non-oil and gas economic sector (Syafar et al., 2023). In architecture, three-dimensional models have developed rapidly since government regulations implemented Building Information Modeling (BIM) for buildings. Additionally, Heritage Building Information Modeling (HBIM) opens up alternatives in architecture, both as a theory and research method. By keeping pace with technological developments, people can access historical information quickly, not only through HBIM but also through virtual tour technology. Several historical building elements were detected, such as wall reliefs, artefacts and monuments. The documentation system for ancient objects uses an interactive visualization approach, which is helpful for interactive learning media.

Virtual Reality (VR) is an important technology that benefits the real world. The historical values identified are included in the architectural digital platform. Many studies produce qualitative data, presenting information and knowledge in descriptive form. Space's meaning is significant in formulating old building objects into cultural heritage buildings. The architects preserve the building by assessing its significant aspects before rehabilitating it. With BIM-based 3-dimensional models for heritage buildings, architects save more time conducting studies because information on the building's significance is already embedded in the 3-dimensional model. Even in its development, virtual reality offers an approach known as VRP (Virtual Reality Photography).

Conservationists must retain non-digital methods even though they have found digital methods. The latest government regulations emphasize that buildings suspected of being cultural heritage must be treated as such until the assessment process is complete. Even cultural heritage buildings that have been demolished can be reconstructed with digital assistance. Technological developments can utilize the results of fundamental research as a basis for reconstructing cultural heritage buildings. .

1.1 Issues and Problems Statement

This research aims to collect and record the historical value and meaning of ancient mosque buildings, which were identified as the iconic buildings in South Sulawesi at that time. Researchers have difficulty finding historical evidence of the arrival of Islam in Sulawesi because many old mosques have been renovated. Despite local laws and regulations regarding cultural heritage, strong evidence shows that the renovated buildings have been preserved. However, if the building's significance data is related to historical values, an assessment study by the Cultural Heritage Expert Team (TACB) can be carried out more quickly. This approach allows qualitative data and historical building values to be collected in an integrated manner in a 3D building model. Consequently, , the public can easily access the building model when visiting the religious tourist attraction of the Al-Hilal Katangka Gowa Mosque complex. It is necessary to

apply the latest technology in preservation efforts so that it can enhance the process and save more buildings.

1.2 Heritage Building Information Modelling (HBIM)

Parametric Modeling was developed to design, construct and reconstruct existing buildings. Using BIM modelling, the data obtained is not only a virtual model but also provides analytical data related to structure, energy, economics, and project management. (Dore et al., 2015). HBIM research is extensive, using various device systems and remote sensing from various BIM platforms. The data collection method in HBIM uses laser scanning or photogrammetric surveys which can be converted into building models. Historic structures in the environment are assisted by the creation of intelligent computer models to analyze conservation efforts and find solutions for historical structures. HBIM is a multidisciplinary system developed by European universities in which architectural element data is represented by descriptive geometric language.

A systematic method for producing Historic Building Information Models (HBIM) for architectural restoration projects is supported by a structure of contemporary and historical case studies (Moyano et al., 2022). Digital structuring of the environment fulfils conservation objectives so that every process can simplify knowledge and intervention processes. This systematic approach is possible by considering access to historical data, maintenance and conservation aspects. This methodology has laid the foundation for an effective procedure.

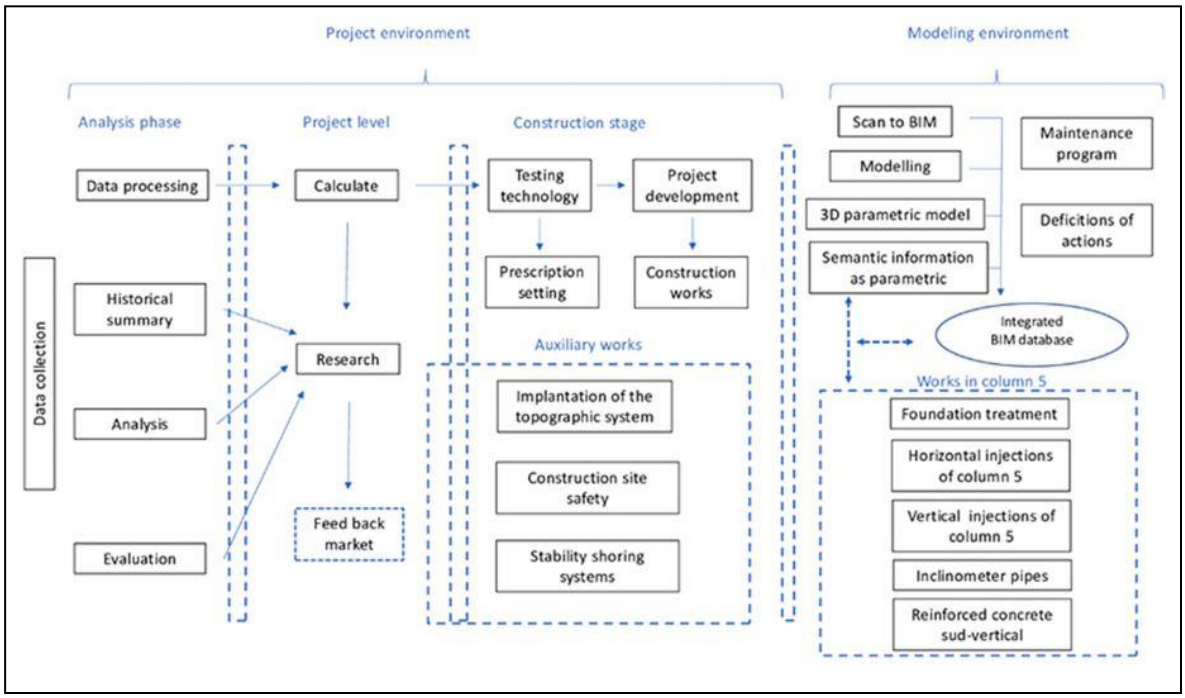


Figure 1 BIM database integration scheme in Modeling Environment (Moyano et al., 2022).

The entire approach is divided into two main parts of parallel environments: 1) the project environment, which includes research on the condition of the asset's heritage architecture and previous interventions during the analysis phase, project level, and construction phase. 2) The modelling environment, which is used to obtain and define information in the project within the latest HBIM model created from 3D reality data capture.

Every detail is tailored to follow the geometric shape of the historical building. Specifically, this research uses adaptive meshing techniques in ArchiCAD graphics for parametric modelling. An alternative method for parametric modelling is Autodesk Revit. In Autodesk Dynamo, algorithms developed in the Visual Programming Language are used to fit parametric objects from the mesh. After obtaining the parametric model, reconstruction quality evaluation can be performed with Cloud Compare C2M (from cloud to model). Next, an HBIM implementation unit that includes all data restoration and enriching model semantics must be created. With this structure, restoration procedures are defined in the context of BIM.

RESEARCH METHOD

This study used a qualitative approach as well as a qualitative-rationalistic paradigm. The research object was a mosque as the unit of analysis. Photographs were used to record variations in the shapes and elements of mosque buildings. Secondary data from previously produced research was analyzed using the content analysis method. The diversity of secondary data includes books specifically about the Katangka mosque (Duli et al., 2013), a journal describes the meaning and symbols of the elements of the Old Mosque (Sutrisno et al., 2019), a dissertation discussing units of analysis regarding symbolic interactionism (Sutrisno et al., 2020), and a study of three cases of old iconic mosques in South Sulawesi (Sutrisno, 2023).

Table 1 Secondary data in the content analysis process from previous research on iconic mosques in South Sulawesi, especially the Al-Hilal Katangka Mosque in Gowa

Source Content Analysis	Year	Title	Source Content Analysis
Book	2013	Monumen Islam di Sulawesi Selatan	Published by the Makassar Cultural Heritage Conservation Center, Unhas Identity Collaboration
Journal	2019	Posi Bola of Jami Mosque as Spatial Transformation Symbol	Published by SINTA Journal and indexed by Scopus
	2023	Tracing Persian Influences: Exploring The Meaning of Mosques and Mausoleums in South Sulawesi as Iconic Islamic	Published by SINTA Journal and indexed by Scopus

Source Content Analysis	Year	Title	Source Content Analysis
		Architecture	
Dissertation	2020	Posi Concept: The Meaning of Space in the Old City of Palopo	Defended in the exam to obtain a Doctoral degree at UGM

Next, the qualitative data was digitized using Building Information Modeling (BIM) tools in the Historic category, specifically using ArchiCAD. Meanwhile, Virtual Reality Objects collaborated with the scientific discipline of informatics engineering to ensure that building models could provide virtual information and present the information digitally and up to date with current developments.

ArchiCAD assists in reconstructing building plans and views. The digitization stage is carried out when the 3D model is complete; then, the content analysis data is input into the HBIM platform according to the building elements that have meaning. This article also analyzes the applied HBIM model, modelling software, and applications used for virtual reality. This article also presents part of a research series carried out in one case, the Al-Hilal Mosque building in Katangka, Gowa.

HISTORIC SCOPE

Mosques are closely related to their historical context and environment (Sutrisno et al., 2019). The history of the XIVth King of Gowa, Sultan Alauddin, founded the Al-Hilal Mosque in 1603 AD is significant. Datuk Ri Bandang converted Sultan Alauddin to Islam, and his real name was *I Mangu'rangi Daeng Manrabia. The Kadi (daengta kaliya)*, as the companion and advisor to the King of Gowa, was responsible for maintaining the continuity of Islam in Gowa. In the 18th century, the return of the Katangka and the destruction of the Somba Opu kingdom impacted the Katangka Mosque building, as explained in the book Islamic Monuments in South Sulawesi.

The Katangka Mosque, is one of the landmarks of the Gowa district that is well known to people outside Gowa. Despite its simple appearance, it holds a complex meaning. The mosque is likely one of the oldest buildings for Islamic worship functions. Most people consider the mosque a prominent landmark at the city border and the Syech Yusuf road connects Makassar to Gowa.

Figure 2: The form and architectural style of the Al-Hilal Katangka Gowa Mosque today.

The Al-Hilal Mosque has historical relevance in South Africa, Yemen, and other contexts. The Persian influence is evident in the Islamic architecture of South Sulawesi, especially the shape of the tombs in the Al-Hilal Mosque complex, Katangka, Gowa (Sutrisno, 2023). Each building element has contextual meaning. The shape of the roof reflects the character of the Indonesian architecture and the decoration on the window grilles shows local wisdom about *sulapa appa* or *walasuji.*

3D MODELING SOFTWARE

Autodesk 3d Max is used in VR modelling, working with Apple Macintosh and Windows operating systems (Saeed Alqahtani et al., 2017). These applications are widely used in films, video games, TV, and architecture. Apart from that, GL Studio software is another option for creating graphics. In previous HBIM research , ArchiCAD was used as a 3D modelling tool. Building Information Modeling (BIM), the newest technology in the AEC industry, allows professionals to create 3D building models with more data than traditional 2D CAD files (Weygant, 2011).

BIM IN THE PRESERVATION OF HERITAGE BUILDINGS

Historic Building Information Modeling (HBIM) has been developed at the Dublin Institute of Technology and is an evolving multi-disciplinary system. The process consists of surveying the structure using remote sensing and then making a parametric and information-rich mapping of the object into a geometric framework based on remote survey data (Dore et al., 2015).

However, this research process did not include the remote sensing stage because the mosque has qualitative data to digitise.

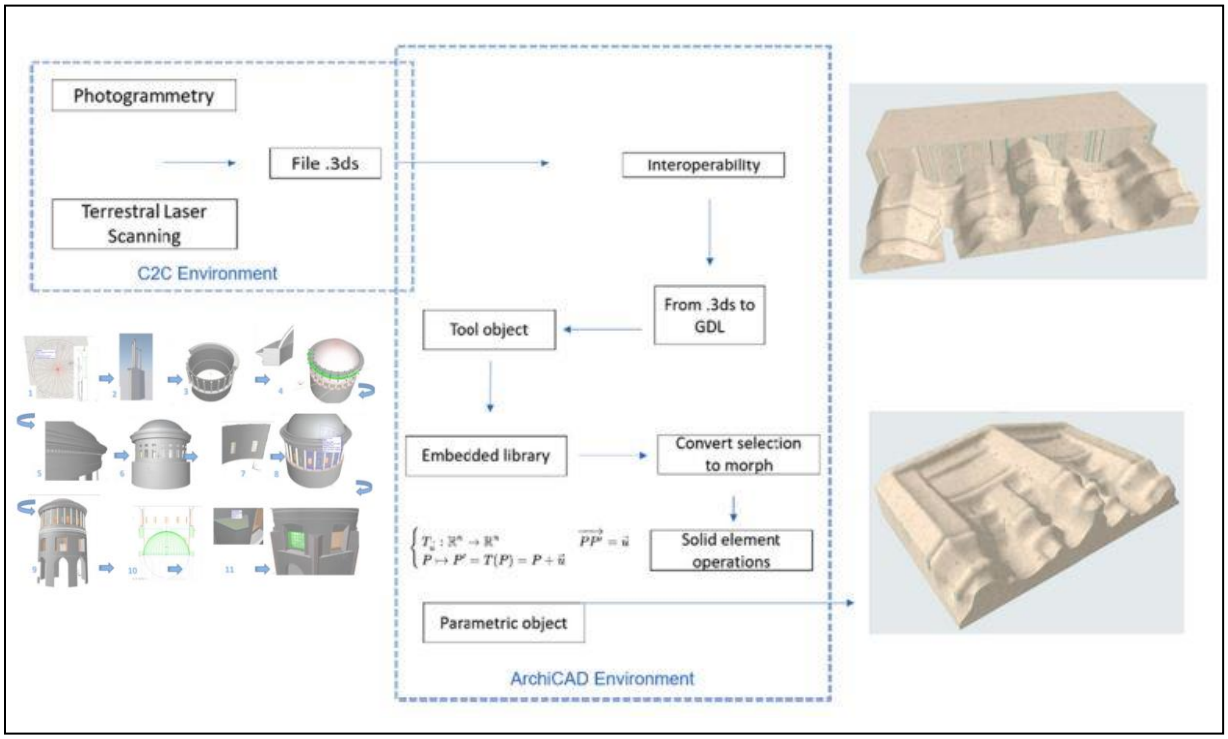


Figure 3 Parametric Model Generated from an AM in ArchiCAD.

In the history of HBIM, modelling of facades and complete building exterior geometry required specific procedures. For the first time, the C++ programming language was used with the ArchiCAD BIM software API to retrieve data relating to groups of parts selected by the user. These rules were also used to create plug-in prototypes for ArchiCAD BIM software. Software development has been very rapid. Informants and public perception indicate that ArchiCAD is a favourite software for creating 3-dimensional building models. In BIM, ArchiCAD is a pioneering platform that provides complete building information. Long before the rules for using BIM were enforced, the ArchiCAD platform had been used by architects to make it easier to obtain building volumes, complete detailed engineering drawings, and prepare up-to date presentations such as BIMX application.

However, ArchiCAD's BIM tool is limited to modelling non-vertical circular walls undergoing deformation. With new rules, more accurate and efficient HBIM survey data can be generated to aid structural analysis and conservation of existing buildings. HBIM data can be exported for further analysis in other software because Open BIM is a model-based design approach that relies on the Industrial Foundation Class or IFC model exchange format. The modelling process requires collaboration between scientific disciplines, thus, the architectural model needs to be converted into an IFC file. The following is an example of the HBIM model (see Figure. 3), used as a precedent in digitizing and analyzing research data. This reference shows that ArchiCAD's role in the Heritage Building Information Modeling research process.

PANORAMIC DESIGN

One of the main advantages of using Kolor Panotour Pro 2.5 is its easy-to-use interface and easy-to-understand design. With little programming knowledge or technical skills, users can easily create panoramic designs. Kolor Panotour Pro 2.5 offers many templates that allow users to get started quickly. Another advantage of this software is its compatibility with various devices and platforms. VR software like Google Cardboard, Oculus Rift, and HTC Vive enable panoramic visualization in both desktop and mobile browsers.

Figure 4 Kolor Panotour Pro 2.5 is applied to view objects virtually.

The initial appearance of an application or program gives the user a first impression and a brief introduction to the application. This view includes elements such as the app's logo, title, description, and navigation to other pages within the app. The initial display design attracts virtual visitors to continue their search. The application home interface includes an additional feature: a button that can be used to start a tour of the relevant service centre. Users who want to visit the virtual data centre can enjoy an interactive and educational experience with this feature. Users can view and learn more about it through this virtual tour feature without visiting the physical location. The results can be clicked and rotated because the image is 3-dimensional. Hence, it can be rotated horizontally or vertically, as if the user were in the natural environment.

Panorama VR is developing rapidly and has become the latest visual technology because it can provide a new experience for its users by displaying different viewpoints when viewing panoramic photos. VR Panorama provides users with an interactive experience . HBIM integration with VR applications aims to add performance information to the meaning of buildings through software. Thus, the application not only provides information such as location

images, archaeological artefacts, and location plans but also displays the significance of the building as an essential value of cultural heritage buildings that must be preserved.

SEMANTIC INFORMATION

In the mosque elements, a variety of meanings are found. In line with the objectives of using BIM in buildings, any information about the building can be input into a 3-dimensional model. Each diverse meaning highlights the importance of parts of the building in conservation efforts. Each object plays a role in the educational process which reflects s the era of mosque construction in the classical period. In classical times, hypersemiotics mentioned the concept of form following meaning (Piliang, 2012).

Table 2 List of Semantic Information

Object	Meaning
Wall Thickness	Technological advances of his time
Mosque Pillar	Philosophy sums something in Islam
Roof Shape	Archipelagic Architectural Form

In the pre-modern era, meaning became important for buildings. Every building shape, motif, number of pillars, carving patterns and other decorations tended to have its specific meanings. The meanings were related to the context of the surrounding environment. For example, the Sulapa appa shape in the window trellis motif represents fire, water, earth and air. The four elements are a symbol of balance in human life. The sulappa appa motif is a significant element in the traditions of South Sulawesi, both at weddings and at traditional death ceremonies.

The thickness of the walls of mosque buildings is a symbol of technological progress during the Islamic classical period. In an analytical study of three classic iconic mosque buildings in South Sulawesi, all three have thick walls (Sutrisno, 2023). This feature distinguishes mosques that existed in the Classical, Modern and Postmodern eras. The walls of the mosque are 1.2 meters thick, indicating that the mosque was essential, luxurious and large. It is estimated that at that time, most buildings were constructed from bamboo or wood, so the brick walls made the Katangka Mosque an icon of its time.

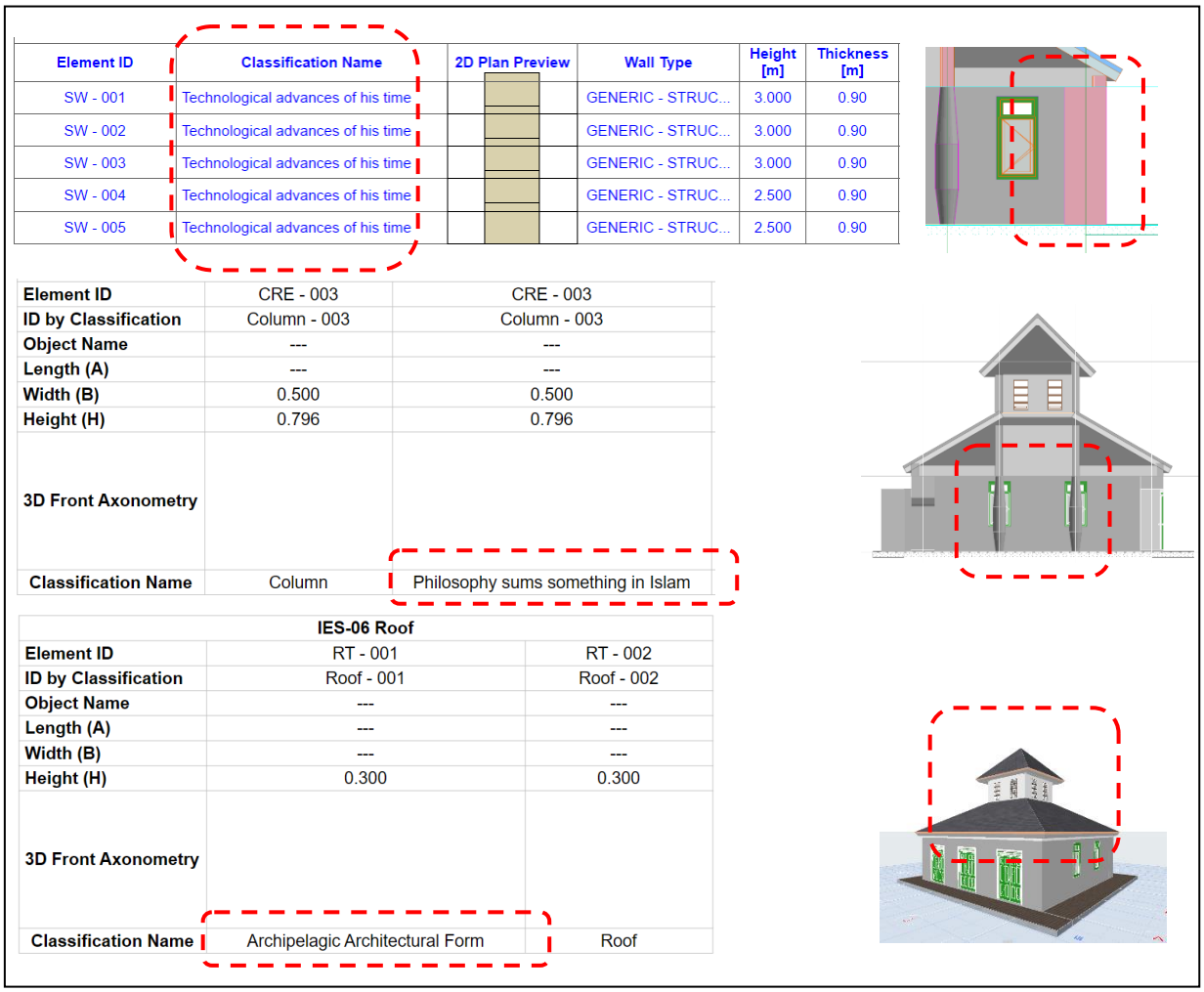
The architectural meaning of the mosque is documented in the information table provided by the BIM platform. ArchiCAD provides columns of information for BIM Modeler to write. Each study result from analysis content from various sources is recorded into the ArchiCAD application menu. This information will be stored in the HBIM database. In BIM Maturity, levels have been classified into BIM disciplines, starting from 3D to 8D. The scope relevant to this research is 7D, which involves the operation and maintenance of building facilities integrated with 7D CAD simulation to optimize asset management from the design process to demolition.

Figure 5 Illustration of the View Model, Section and Perspective of the Al-Hilal Katangka Mosque, Gowa

Once the project's construction phase is complete, building managers can use BIM for operations and maintenance procedures (Kymmell, 2008). During the post-construction phase, the HBIM may need adjustments to represent the as-built condition of the project. This is particularly important for visible and accessible locations such as underground utilities and pile foundations, where future research might be required to locate specific underground passages. In most cases, if you want pictures of the finished project,updating the BIM to reflect the project's current state should be considered.

The roof shape of the Katangka Mosque does not represent the local architectural characteristics of either Makassar or Bugis but is more dominant in Javanese architecture. The shape of the house's roof represents social class and strata because it resembles the Joglo roof (see Figure 5). Katangka Mosque roofs are often found in mosques and important buildings throughout the archipelago. The meaning of the mosque roof is a representation of archipelago architecture. This similarity is emphasized by the four main pillars, which are similar to the teacher's pillars.

The pillars are cylindrical with moulding at the bottom and top of the column, representing the classical Doric style of the Greek era (See Figure 6). However, the pillar pillars are reinforced to support the building beams, an iron pipe providing additional supportin the middle of each pillar. Moreover, this is also common in Joglo buildings. The poles are surrounded by other architectural elements such as rosters, windows, doors and ventilation. The meaning that arises from the existence of ventilation elements is related to colour. The ornate rosters made of ceramic and green represents Chinese buildings. The pillar adjacent to the pulpit is made of wood and is decorated with Arabic calligraphy motifs.



Element ID	Classification Name	2D Plan Preview	Wall Type	Height [m]	Thickness [m]
SW - 001	Technological advances of his time		GENERIC - STRUC...	3.000	0.90
SW - 002	Technological advances of his time		GENERIC - STRUC...	3.000	0.90
SW - 003	Technological advances of his time		GENERIC - STRUC...	3.000	0.90
SW - 004	Technological advances of his time		GENERIC - STRUC...	2.500	0.90
SW - 005	Technological advances of his time		GENERIC - STRUC...	2.500	0.90

Element ID	CRE - 003	CRE - 003
ID by Classification	Column - 003	Column - 003
Object Name	---	---
Length (A)	---	---
Width (B)	0.500	0.500
Height (H)	0.796	0.796
3D Front Axonometry		
Classification Name	Column	Philosophy sums something in Islam

IES-06 Roof		
Element ID	RT - 001	RT - 002
ID by Classification	Roof - 001	Roof - 002
Object Name	---	---
Length (A)	---	---
Width (B)	---	---
Height (H)	0.300	0.300
3D Front Axonometry		
Classification Name	Archipelagic Architectural Form	Roof

Figure 6: Meaning of structure and building construction in HBIM ArchiCAD platform

CONCLUSION

HBIM (heritage Building Information Modeling) and VR (Virtual Reality) technology help people access historical information. Its features allow users to explore and appreciate heritage objects and buildings from all angles. Meanwhile, the application of the HBIM platform in the form of ArchiCAD means that information about the meanings of each building element is documented in 3-dimensional building objects. It is easy for humans to quickly understand the diversity of values of the Al-Hilal Katangka Gowa Mosque. The existence of information from the results of qualitative research can strengthen the values of buildings and be known by all levels of society, so that buildings have more filters when there are efforts to demolish heritage buildings. The

photogrammetric method reconstructs archaeological objects by displaying a 360-degree horizontal panorama.

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