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Comparative Analysis of As Built Drawings with Implementation Results at the Kadiri University Construction Field

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ABSTRACT

Comparative analysis of as-built drawings with construction company standards shows that the as-built drawings made meet most of the expected characteristics and parameters. This illustrates that 3D modeling technology, especially using Autodesk software, can provide accurate and reliable results. This as-built drawing can be used as a good reference for analyzing differences between initial plans and implementation in the field. Although there are some limitations in the information that can be displayed, this as-built drawing can provide a general idea of the structure and dimensions of the building. Thus, it can help in identifying potential errors or discrepancies between drawings and actual implementation. This research contributes to increasing efficiency, quality and safety in the building construction process. By using 3D modeling technology and analyzing as-built drawings, researchers can identify potential differences and provide recommendations for improvements or design changes to minimize risks and ensure good quality of the final result. This research also provides insight into the development of standards or guidelines for making as-built drawings in the construction industry. Based on the analysis of the level of conformity of the project results in the field with the as-built drawings for building construction, the quality of the as-built drawings has good geometric accuracy as indicated by an RMSE of 1.9 cm and a standard deviation of 1.4 cm, which means it falls into the appropriate mm-cm fraction. with image validation criteria. As built drawings also meet all drawing validation criteria. Apart from that, the as-built drawing meets all the parameters in the characteristic criteria for the as-built drawing model.

Keywords: *As Built Drawing; Comparison of Construction Standards; 3D Modeling Technology; Plan Analysis; Efficiency.*

INTRODUCTION

Design Estimate Engineering (DED) is the main guideline in planning the development process. In making planning designs, sometimes changes or deviations from the initial design occur during the implementation process. By analyzing as-built drawings, we can ensure that the building is being built in accordance with the approved plans. It is necessary to analyze as-built drawings for building construction, it is important to have a strong understanding of the construction techniques used. Various knowledge of construction methods, building materials, structures, as well as mechanical and electrical installations. Building construction drawings involve the ability to understand technical drawings, such as plans, views, sections and construction details.[1]

Changes in work contract drawings and implementation times on construction projects often occur, this is due to a mismatch between plans and those in the field. Previous studies have shown that the main cause of project failure is the lack of competency in soft skills of project management professionals. Thus, it is necessary to examine the influence of soft skills on the critical success of these factors, this increases the probability of project success. Most of the existing studies related to project manager soft skills were conducted in developed country contexts. The construction industry is expected to maintain a nominal growth rate of 11.43% in 2014-2018 due to the government's focus on industrial and residential construction in Vietnam.[2]

As-built drawings of building construction can be analyzed by comparing applicable standards and specifications. This allows researchers to identify whether images meet established requirements, such as building codes, safety requirements, and other regulations. Drawing analysis can also involve evaluating the suitability of drawings to established plans. This involves comparing technical drawings with architectural, structural, mechanical, and electrical plans, and identifying differences or inconsistencies between the two.

The aim of this research is to improve efficiency, quality and safety in the building construction process. By analyzing drawings related to construction projects, researchers can identify potential errors or discrepancies between drawings and actual implementation. This allows necessary remedial steps to be taken to minimize risks and ensure good quality of the final result. This research can also facilitate design innovation in building construction. By analyzing related images, researchers can identify areas where design improvements can be made to improve functionality, aesthetics, or energy efficiency in buildings.[3]

Identify errors or discrepancies in construction drawings, such as dimensional errors, design errors, and lack of detailed drawings. Evaluate the conformity of the drawings with the plans and specifications that have been determined for the Kadiri University Building construction project. Recommendations for improvements or design changes to improve construction efficiency, quality, or safety in the building project. Contribution to design innovation, including identification of areas where the design can be improved or new technologies can be applied in development.[4]

The aim of this research is to identify differences or discrepancies between the initial plan and implementation in the field. This research will also look for potential increases in efficiency during the development process. This research will produce recommendations based on the image analysis carried out. These recommendations may include design changes, corrective measures, or the use of new technology to improve quality, efficiency, and safety in the construction process.[4]

MATERIALS AND METHODS

This research aims to analyze the comparison between the As Built Drawing and the results of implementation in the field for the construction of the Kadiri University Building. The research stage begins with a literature study to understand the concept of construction management and similar methodologies, followed by identification of research variables such as suitability of dimensions and materials between drawings and field results. Data will be obtained through collecting As Built Drawings and field surveys, which will then be analyzed in detail through comparisons, field measurements, and if possible, 3D modeling. This stage will provide an in-depth understanding of the correspondence between initial design and actual implementation,

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with the hope of identifying factors that influence these differences. It is hoped that the results of this research will provide valuable insights to improve the quality of construction project implementation in the future.

Research sites

The research site or location is at the Kadiri University Building Construction Project, which is at Kadiri University Jl. Selomangleng No.1 Kediri, East Java. The research time was during the ongoing building construction project.

Observed Variables

The following are some variables that can be observed/measured:

a. Physical Dimensions
   Compare the physical dimensions recorded in the As Built Drawing with the results of measurements in the field, such as the height, width and length of the room, structure or other elements. Identifying differences between the dimensions planned in the As Built Drawing and the actual dimensions resulting from implementation in the field.
b. MEP (Mechanical, Electrical, and Plumbing) System
   Checking MEP system installations, such as air conditioning, lighting, sanitation and security systems planned in the As Built Drawing. Observe whether the MEP system installed in the field is in accordance with what was planned in the As Built Drawing, including layout, type of equipment and capacity.
c. Construction Details
   Analyze construction details recorded in the As Built Drawing, such as structural details, connections, and planned construction methods. Identify differences between construction details recorded in the As Built Drawing and implementation results in the field, including deviations from the initial design or errors in implementation.
d. Change or Revision Note
   Check records of changes or revisions that occur during project implementation that are not documented in the As Built Drawing. Assess the impact of these changes or revisions on the differences between the As Built Drawing and the results of implementation in the field.

These variables can be measured and compared to analyze the differences between the As Built Drawing and the results of implementation in the field. This will provide insight into the level of conformity between the initial design and its implementation, as well as the factors causing differences that may occur in the building construction process

Model Used

Using a direct comparison method between the As Built Drawing and the results of implementation in the field. Analysis is carried out by comparing dimensions, room configurations, material specifications, MEP systems, construction details, and records of changes between the As Built Drawing and the results of implementation in the field. This model can help identify the level of conformity between the As Built Drawing and the results of implementation in the field.

Research design

The following is a research design that can be used in the research topic of comparative analysis of As Built Drawing (ABD) with the results of implementation in the field in building construction:

a. Research purposes

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Assess the level of conformity between the As Built Drawing and the results of implementation in the field on building construction projects. Identifying differences between the As Built Drawing and the results of implementation in the field. Analyze the factors causing these differences. Provide recommendations to minimize future errors or non-conformities.

b. Research methods
The research method that can be used is the case study method. Taking several building construction projects as research samples. Analyze As Built Drawings and implementation results in the field on each selected project.

c. Data collection
Collect As Built Drawings from developers or project owners. Conduct surveys and field observations to obtain implementation results in the field. Collect dimensional data, room configurations, material specifications, MEP systems, construction details, and change records.

d. Data analysis
Comparing As Built Drawing data with data from implementation results in the field. Analyze the differences between the As Built Drawing and the results of implementation in the field quantitatively and qualitatively. Identify factors that cause differences, such as construction errors, design revisions, or changes in customer requests.

e. Data processing
Analyze collected data, such as difference tests, correlation coefficients, or questionnaire analysis in the field. Interpretation and Conclusion. Interpret the results of data analysis to illustrate the differences between the As Built Drawing and the results of implementation in the field. Make conclusions about the level of conformity between the As Built Drawing and the results of implementation in the field. Provide recommendations to improve the quality of the building construction process in the future.

It is important to follow research ethics, obtain necessary permissions, and maintain the confidentiality of sensitive or confidential data.

Data collection technique

In the research topic of comparative analysis of As Built Drawing (ABD) with the results of implementation in the field in building construction, the following are several data collection techniques that can be used:

a. Collection of As Built Drawings (ABD)
Collect As Built Drawings from developers, project owners, or other related parties. Request a copy of the As Built Drawing which is a representation of the initial design of the building construction project.

b. Field Observations
Conduct surveys and direct observations at the project site. Observe the results of implementation in the field, including dimensions, room configuration, MEP system, and construction details in accordance with the As Built Drawing.

c. Interview
Conduct interviews with related parties, such as developers, main contractors, design consultants, or project supervisors. Ask about the implementation process, changes that occur, and factors that influence the differences between the As Built Drawing and the results of implementation in the field.

d. Photographic Documentation
Take photos of implementation progress in the field, including structural details, room configuration, MEP systems, and construction details. Record the differences between the

As Built Drawing and the results of implementation in the field using photography before and after implementation.

e. Document Analysis

Analyze project-related documents, such as design revisions, change requests, change notes, or meeting notes. Examine these documents to understand the changes that occurred during the implementation process and compare them with the As Built Drawing.

Using a combination of the techniques above will provide a comprehensive approach to collecting the data needed for comparative analysis between the As Built Drawing and the results of implementation in the field during building construction. It is important to ensure the validity and reliability of the data collected and adhere to research ethics in data collection.

Data analysis

In the research topic of comparative analysis of As Built Drawing (ABD) with the results of implementation in the field in building construction, the following are several data analyzes that can be used:

a. Dimensional Comparative Analysis

Measuring the physical dimensions recorded in the ABD and the results of implementation in the field. Compare measurement results to identify differences in height, width, room length, or other building elements. Calculate the difference between the dimensions planned in the ABD and the actual dimensions resulting from implementation in the field.

b. Analysis of Differences in MEP Systems (Mechanical, Electrical, and Plumbing)

Compare the MEP system installation planned in the ABD with the results of implementation in the field. Identify differences in layout, equipment type, capacity, or systems installed. Analyze the suitability of the MEP system between ABD and implementation results in the field.

c. Analysis of Construction Details

Analyze construction details recorded in the ABD and compare them with implementation results in the field. Identify differences in structural details, connections, or construction methods used. Assess deviations from the initial design or implementation errors that occur.

d. Analysis of Change or Revision Notes

Analyze records of changes or revisions that occur during project implementation that are not documented in the ABD. Identify the impact of changes or revisions on differences between the ABD and implementation results in the field.

RESULTS AND DISCUSSION

Based on the results of interviews from construction companies that are directly related to the work of making as-built drawings, there are several important points that are discussed as characteristics of making as-built drawings. These characteristics include the characteristics of the as-built drawing model, information on the drawing, and drawing validation parameters. Based on these characteristics, the results of interviews with companies show that each company has its own criteria for each characteristic. Even though each company interviewed has different criteria for making as-built drawings, there are several similarities between one company and another.

Based on the results of interviews, all national construction companies do not yet have standard characteristics or standards in making as-built drawings, each company has its own characteristics in making them. However, one of the construction companies that was interviewed has specific criteria for making as-built drawings in terms of model characteristics, drawing information and drawing validation in addition to following the Work Terms of Reference (TOR) or agreement between the contractor and the work owner.

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From the results of these interviews, criteria and standards were formulated for making as-built drawings which can be seen in the table below.

Table 1. Interview results for making as-built drawings based on company standards

Information		Description	
A	Model Characteristics As Built Drawing	1	According to field conditions
		2	Facades are formed
		3	Details of the object depicted
		4	Can be read easily
		5	Measurement results = depiction results
B	Information in Figure	6	Object
		7	Dimensions
		8	Slope
		9	Types of Materials
		10	Material Specifications
		11	Structure
		12	Description and object details as needed
C	Validation Parameters Figure	13	According to field conditions
		14	Test dimensions
		15	Thickness test
		16	High accuracy mm-cm
		17	Maximum dimensional error tolerance of 1 – 2 cm
		18	According to quality
		19	Facade suitability
		20	Test results should not be significant and affect the geometry / other project elements

Source: Researcher Process, 2024

From the table above, the results of interviews for making as-built drawings based on company standards can be described.

As Built Building Drawing

The as-built drawing or what is usually called the final recorded drawing of construction work in this research was made based on the results of the 2D model of the Kadiri University Building. One of the criteria for as-built drawing results is the information in the image which includes objects, dimensions, material types, material specifications, building structures, descriptions and object details. The as-built drawings created in this research can only provide objects, dimensions, building structures, as well as descriptions and details of objects. Based on this review, the as-built drawing in this research prioritizes the overall structure of the Kadiri University Building which includes the exterior, pillars and foundation. The results of the as-built drawing that was created and displays pieces of the building structure can be seen below.

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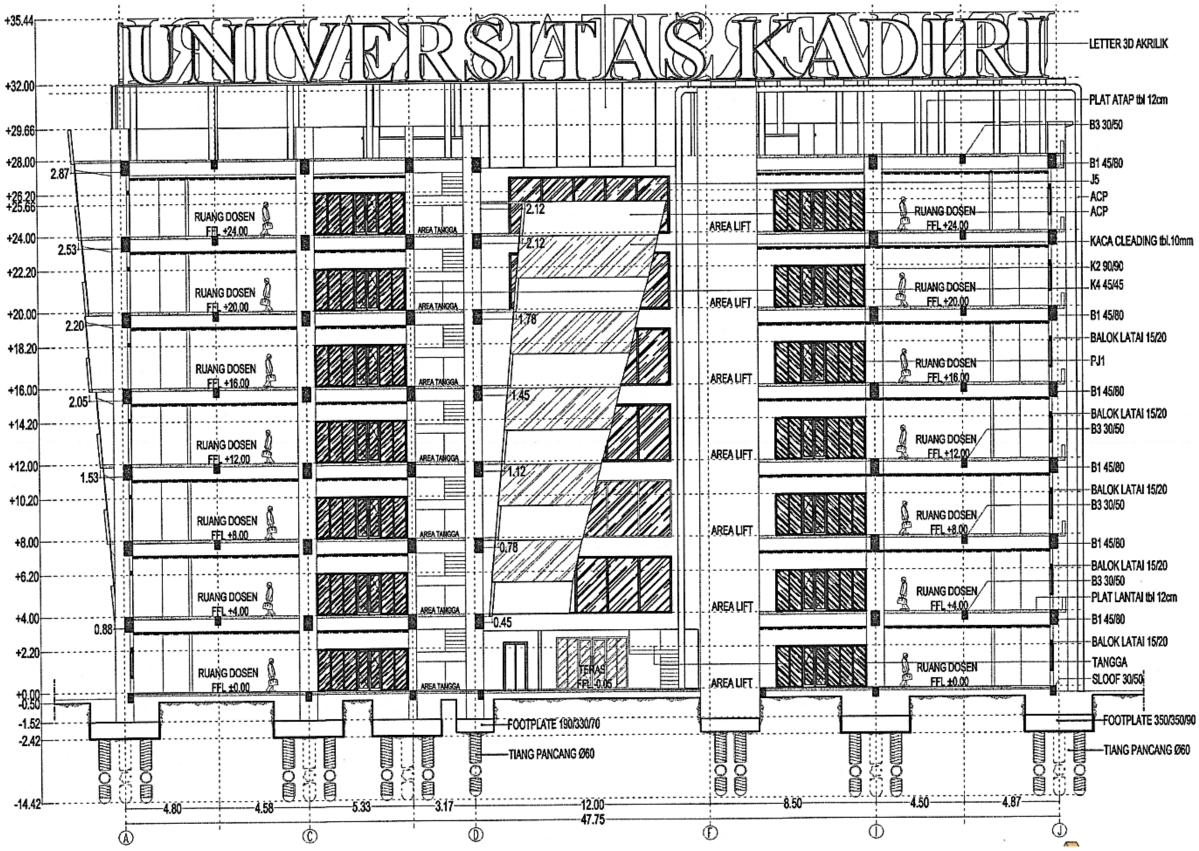

Figure 1. Sectional image of the building during planning

From the picture above, you can describe the cut-out drawing of the building during planning at Kadiri University. Furthermore, the results of the as-built drawing of the building section can be seen below.

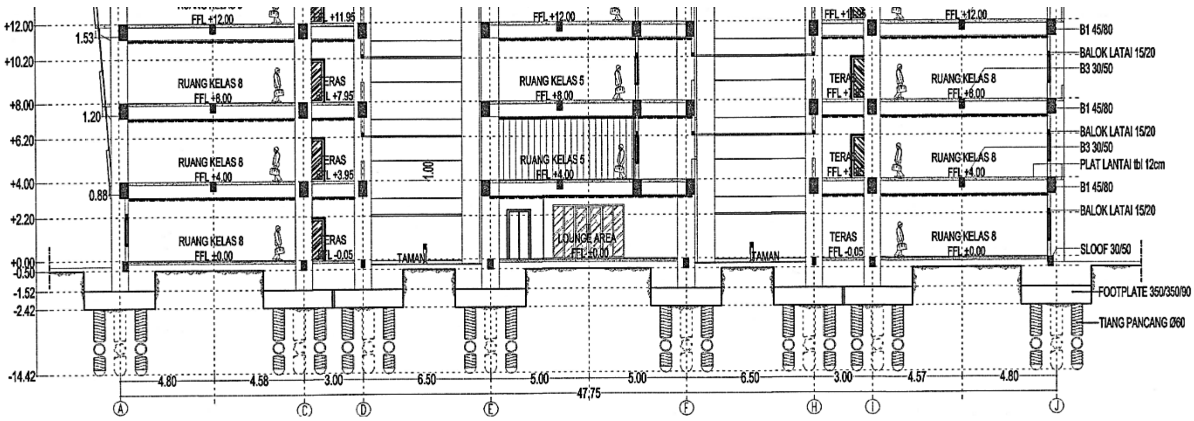

Figure 2. Results of as-built drawings of building pieces

Overall, all parts of the building have similar structures on each side, all sides have several similar structures such as glass, pillars, walls, foundations and roofs. Apart from depicting pieces of the Kadiri University Building which represent each side of the building, the as-built drawings in this research also depict the ground floor plan of the building. The results of the as-built drawing showing the ground floor building plan can be seen below.

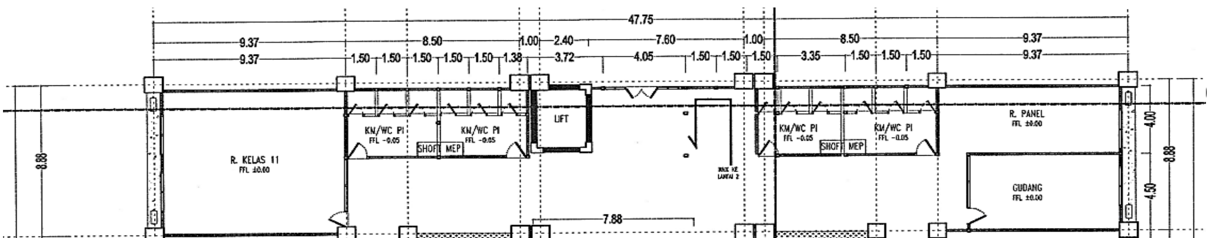

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Figure 3. Results of the as-built drawing of the ground floor plan.

The plan above is the Kadiri University Building seen above on the ground floor. The building plan displays information in the form of the appearance of the ground floor, top view, which contains information: space access, space orientation, space openness, and space dimensions. Space access describes access to and from buildings and rooms depicted by doors. The level of openness can be explained through the picture of the availability of voids in the middle of the ground floor. Space dimensions contain information about the size of the building object depicted. A comparison of the appearance of the facade was carried out using the as-built drawing that was made as in the picture below.

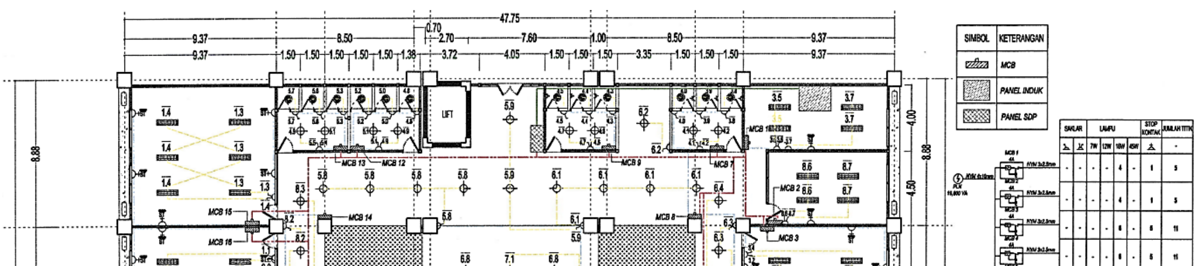

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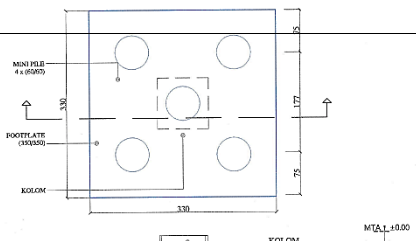
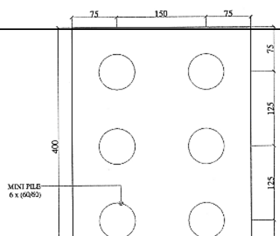
Figure 4. Comparison of as-built drawings with field visuals.

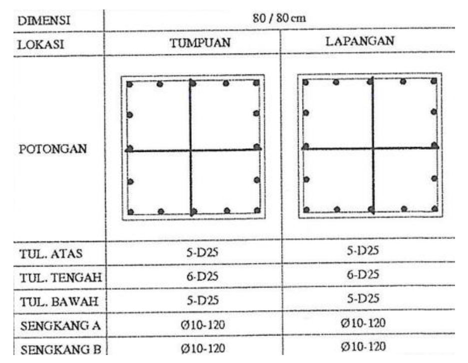
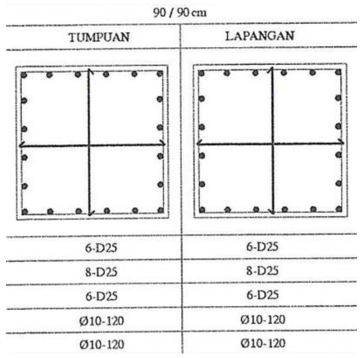
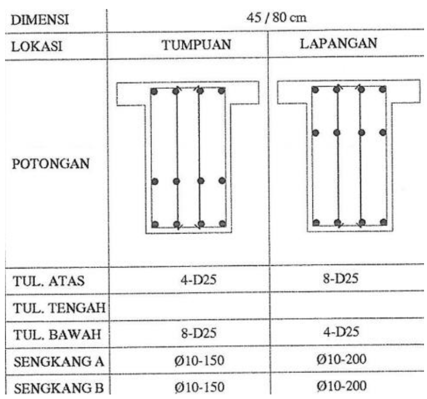
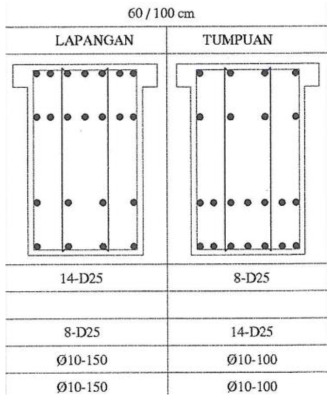
In the picture above you can see the results of the as-built drawing of the original appearance in the field on each side of the building. As a relevant comparison, specific parameters are needed to be able to assess the results of the as-built drawings created. Next, it will be discussed in detail through the results of the as-built drawing of the original appearance on the earth's surface based on the detailed parameters of the object. Research objects that have complex and intricate shapes can be depicted in good as-built drawings based on 3D models. This is proven by the similarity in the number of objects, the similarity in detailed shapes, and the depiction of the length of the object dimensions down to fractions of mm as presented in the picture.

As Built Drawing Test Results against Construction Company Standards

In this research, as-built drawings obtained from terrestrial laser scanners were studied against the standards and characteristics of as-built drawings for several construction companies. This study was carried out to answer whether the model made into an as-built drawing can meet the standards for making as-built drawings at national construction companies. The study of as-built drawings from the modeling results can be seen in the table below:

Table 2. Study of As Built Building Drawings

No.	Parameter	Plan Drawing	As Built Drawing
1	Foundation		

2	Colums		
3	Blocks		

Source: Researcher Process, 2024

From the table above, the study of As Built Drawings of Buildings can be explained, then the Study of Interview Results of Characteristics of As Built Drawings of Buildings can be seen in the table below.

Table 3. Study of interview results on characteristics of as-built building drawings

	Information		Description	Reliability (Fulfilled/Not)

A	Model Characteristics As Built Drawing	1	According to field conditions	Fulfilled
		2	Facades are formed	Fulfilled
		3	Details of the object depicted are	Fulfilled
		4	Can be read easily	Fulfilled
		5	Measurement results = depiction results	Fulfilled
B	Information in Figure	6	Objects are	Fulfilled
		7	Dimensions	Fulfilled
		8	Slopes	Fulfilled
		9	Types of Material	Not Fulfilled
		10	Material Specifications	Not Fulfilled
		11	Structures	Fulfilled
		12	Description and object details according to requirements	Fulfilled
C	Validation Parameters Figure	13	According to field conditions	Fulfilled
		14	Test dimensions	Fulfilled
		15	Thickness test	Fulfilled
		16	High accuracy mm- cm	Fulfilled
		17	Maximum dimensional error tolerance of 1 – 2 cm	Fulfilled
		18	According to quality	Fulfilled
		19	Facade suitability	Fulfilled
		20	Test results must not be significant and affect the geometry / other project elements	Fulfilled

Source: Researcher Process, 2024

Based on Table 4, it is known that the results of making as built drawings can be used to make 2D drawings using AutoCAD or 3D software into as built models using Autodesk software which can support the creation. Based on the characteristics, the as-built drawing is made in accordance with field conditions in terms of dimensions as proven in Table 2 to an accuracy of 1.9 cm, the appearance of the facade is appropriate and the details of the object are depicted as compared in Table 3. This is due to the use of technology which is capable of forming a 3D model of the object with high detail due to good 3D point cloud density so that the appearance of the size data is close to the original object.

The information in the as-built drawing contains the appearance of the object, building structure and dimensions. This is a limitation of the acquisition process long after the Kadiri University Building was built so that there is no comparable data or basic shop drawings beforehand. Therefore, making as-built drawings cannot meet the criteria for displaying information on material types, material specifications and detailed descriptions of objects according to the design. Based on a comparison of making as-built drawings against construction company standards presented in Table 4, it was found that reliability in making as-built drawings. This is proven by the many characteristics that are fulfilled, although in this research we have not been able to fulfill one characteristic of making as-built drawings. This image can be processed in various software ranging from AutoCAD, Autodesk Revit, and Sketch Up, all of which can support the latest technology.

CONCLUSION

Based on the analysis carried out, there are several conclusions related to the research carried out. The level of conformity of the project results in the field with the as-built drawings for

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building construction at Kadiri University the quality of the as-built drawing results has good geometric accuracy as indicated by an RMSE of 1.9 cm and a standard deviation of 1.4 cm, which means it falls into the mm-cm fraction according to the drawing validation criteria. As built drawings also meet all drawing validation criteria. Apart from that, the as-built drawing meets all the parameters in the characteristic criteria for the as-built drawing model. However, the as built drawing parameters obtained are not able to meet the material specification parameters in the drawing information criteria. This is caused by not being able to display information on the top view of the building, type of material, material specifications, and detailed description of the object according to the design, due to the mapping coverage using TLS being unable to scan the roof of the building, as well as detecting the specifications and type of material.

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