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Development of an Application for Document Management in Construction Companies Using Prototyping Method

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Abstract

This research aims to develop a document management application solution in the context of a construction company. Using a prototyping-based software development approach, this research describes the steps from requirements analysis, prototype design, and testing to final evaluation. Testing involved performance, security, and usability tests that proved the quality and effectiveness of the application. The initial post-launch evaluation results showed positive responses from test users regarding ease of use and functionality. Based on the data, 80% of the users found the user interface easy to understand, while 75% indicated a positive level of acceptance towards the app. The main contribution of this research lies in developing an application capable of optimizing document management and operational efficiency in the construction industry. Prospectively, this research provides insights into the potential use of AI and data analytics technologies in future research.

Keywords*: Document Management, PrototypingMethods, Development, Application.*

1. INTRODUCTION

Effective document management in construction projects is necessary for many reasons related to project success, operational efficiency, and regulatory compliance. Construction projects involve many information and documents, including plans, designs, contracts, permits, schedules, ''etc. Without good document management, the risk of losing or incorrectly accessing critical information increases, resulting in possible project delays, confusion in execution, and even unexpected costs[1]–[3]. Documents in construction projects often have to be delivered to stakeholders such as project owners, contractors, subcontractors, inspectors, and regulators. Managing documents properly helps ensure that all parties have access to consistent and accurate information, minimizes potential conflicts or misunderstandings, and promotes efficient collaboration[4]. In addition, legal and regulatory demands in the construction industry often require accurate and detailed documentation, and proper document management can ensure regulatory compliance and minimize legal risks. Thus, good document management in construction projects is critical to achieving efficiency, transparency, and accuracy in project management[5].

Utilizing information technology developments in document management positively impacts efficiency, accessibility, and transparency. Information technology enables digital storage, search, and sharing of documents, eliminating physical limitations and shortening access time. With a digital document management system, companies can easily organize documents, facilitate collaboration between teams in different locations, and reduce the risk of information loss or document duplication. Moreover, information technology

enables the implementation of security and authorization features, ensuring that authorized parties can only access documents. By utilizing information technology in document management, companies can increase productivity, reduce costs, and stimulate innovation in sustainable management strategies[6]–[9].

One of the construction companies in Indonesia needed an adequate document management system in place, causing many problems that severely impacted the company's operations and success. Vital documents such as project plans, permits, contracts, and reports are often scattered across multiple platforms or even in physical form, making it difficult to access important information quickly. This can slow down the decision-making process, cause project delays, and lead to unwanted additional costs. Furthermore, the lack of organized document management can result in inaccuracies and loss of information, which can lead to errors in project execution and even conflicts with related parties. Therefore, implementing an effective document management system is crucial in mitigating such risks and improving productivity and transparency in construction company operations[10].

Several previous studies have underscored the importance of effective document management in the construction industry and the benefits derived from implementing information technology. Some studies highlight that implementing information technology-based document management systems has helped reduce the risk of information loss and improve efficiency in construction project management. Other studies have shown that using mobile applications in managing construction project documents positively impacts team collaboration, information access, and more accurate decision-making[11], [12]. On the other hand, several studies highlighted the negative impacts of a lack of good document management, including increased risk of errors, project delays, and conflicts with related parties[13]. In these studies, the lack of application of information technology in document management is one of the leading causes of this problem. Therefore, this research will deepen the understanding of how implementing mobile-based applications can provide real solutions for construction companies to overcome document management challenges and improve overall project performance[11], [12], [14].

In this research, application development uses the Prototyping method. Previous research has shown significant benefits in developing applications using prototyping methods. In some studies, prototyping has been used to develop project management applications in the construction industry. The development team gathered feedback from users earlier in the development process by building an initial prototype that includes critical features. As a result, the application achieved a higher level of user satisfaction and reduced the risk of costly changes at a later stage.

Furthermore, several studies have examined prototyping methods in developing document management applications in the construction sector. By combining prototype iterations and user feedback, the development team identified better needs and customized the application's interface and functionality. As a result, efficient use of the application increased, and

productivity in managing project documents improved significantly[15]–[18]. The results of this previous study show that prototyping methods can play a crucial role in developing document management applications in the construction industry. By involving users early and understanding their needs through prototyping, it can result in applications that are more fit for purpose and increase the success of implementation[19], [20]. The main objective of this research is to develop an innovative application for document management in the construction industry using the prototyping method. This research aims to design and develop an initial prototype of an application that enables stakeholders in construction projects to manage, share, and access project documents more efficiently. In addition, this research aims to identify better user needs through prototype iterations and feedback, with the ultimate goal of producing an application that fits the needs and positively impacts the efficiency and transparency of document management in the construction industry.

This research contributes to developing an innovative document management application using the prototyping method to overcome construction industry challenges. This contribution is realized in the form of a technological solution that can improve document management efficiency, facilitate cross-team collaboration, and reduce the risk of errors. With the proper application of the prototyping method within the scope of the construction industry, this research also provides practical guidance for the development of similar applications in other sectors. It contributes to operational efficiency and the latest technological developments in construction project management.

2. RESEARCH METHODOLOGY

This research will follow a structured series of stages to develop a document management application using the prototyping method, as shown in Figure 1.

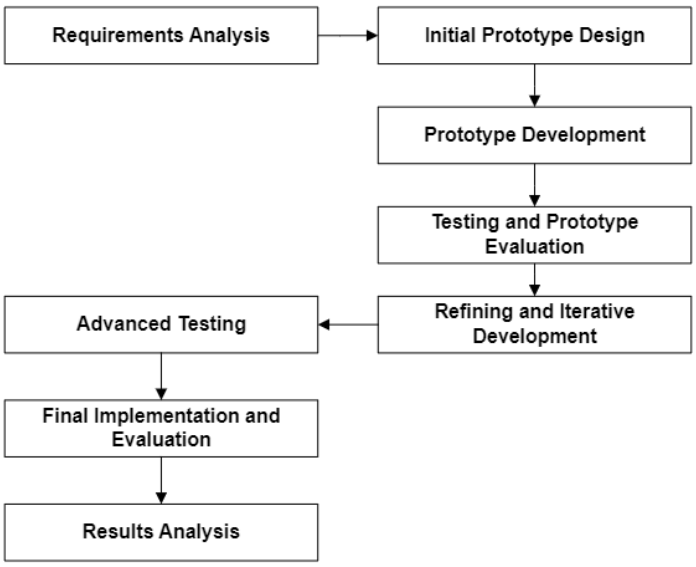

Figure 1. Research Stages

2.1. Requirements Analysis

At the Needs Analysis stage, to understand the needs and expectations of stakeholders in the construction industry. This stage is for identifying stakeholders such as contractors, project managers, and document controllers, then gathering insights on the specific needs and challenges they face. Through interviews, surveys, and workshops, detailed requirements for the document management application were obtained by understanding the desired features, functionalities, workflows, and integration points. Using user personas helped design user-centric features, and prioritizing needs based on criticality helped focus on critical functionalities. Furthermore, these needs were validated and carefully documented through technical evaluation and constant interaction with stakeholders. This needs analysis process provided a solid foundation for the later stages of application development, ensuring that the resulting solution matched the expectations and actual needs of the construction industry.

2.2. Initial Prototype Design

In the Initial Prototype Design stage, they were carefully designing the initial framework of the application. First, an intuitive and efficient user interface (UI) was designed, considering the layout of elements, navigation, and user-friendly interaction. Next, the application workflow was defined in detail, covering the user's steps from start to finish in document management. Key features required to meet stakeholder needs were identified and planned. In addition, the design also considers integration that may be required with other systems or tools in the construction environment. Visual components and interactive elements, such as buttons, menus, and forms, are also designed to create an optimal user experience. At the end of this stage, an initial prototype summarizing the interface design, workflow, and critical features was produced. This stage provides a solid foundation for developing subsequent functional prototypes during application development.

2.3. Prototype Development

At this stage, meaningful activities are created to create an initial working version of the document management application. The user interface design was elaborated with user experience needs and principles in mind and transformed into a visual prototype that provided a rough idea of the appearance and interaction flow. Critical features identified in the needs analysis were translated into tangible implementations, including a real-time collaboration system, document approval workflow, and role-based access. Integration with supporting technologies such as project management systems and other applications is arranged so that the application connects with existing infrastructure. Security, authorization, and notification features were also developed to safeguard data and notify users of document changes. The development of offline synchronization features enabled access and editing of documents outside the network. Developers and end-users tested the initial prototype to identify improvements and ensure the

application met the expected needs. This stage provided the basis for the initial evaluation and further application development.

2.4. Testing and Prototype Evaluation

In the Prototype Testing and Evaluation stage, comprehensive tests and evaluations of the developed application prototype are conducted. The main objective of this stage is to ensure that the prototype conforms to the functional and design requirements set earlier while identifying and addressing any issues or deficiencies that may arise. Activities in this stage include functional testing, user testing, performance testing, security testing, UI/UX evaluation, user satisfaction measurement, problem identification, prototype updates based on feedback, and business feasibility evaluation. This stage is critical to ensure that the prototype developed is of good quality before proceeding to the next stage of development.

2.5. Referining and Iterative Development

This stage involves a series of steps to improve and develop the application prototype based on the evaluation results and feedback received. First, the evaluation results are analyzed to identify areas that require improvement. After that, bug fixes are performed to ensure functional and technical issues are fixed. Functionality improvements were made based on user feedback, while UI/UX adjustments were made to improve the user interface. Performance aspects of the prototype were also optimized to ensure adequate response and loading speed. Security was strengthened by addressing potential vulnerabilities based on security tests. After improvements, retesting was conducted to validate changes and resolve issues. Iterative use is performed, with the prototype re-evaluated by users to gather additional feedback. This process can be repeated several times until the prototype reaches the desired level of quality. All changes are recorded in documentation, while regression testing and business feasibility evaluations are performed to ensure the changes do not break pre-existing functionality and still meet business objectives. With this approach, the prototype can be continuously improved and developed continuously.

2.6. Advance Testing

This stage ensures the quality and readiness of the prototype before it goes into production. Activities include performance testing to measure response and loading times, security testing to identify potential vulnerabilities, stress testing to test the limits of the system's capabilities, and usage and compatibility testing to ensure the user interface is appropriate and the application can run on various environments. Regression testing ensures fixes do not break pre-existing functionality, while user acceptance testing involves end users in testing the application according to their use cases. This stage also includes data migration testing, locality testing for different languages and cultures, and accessibility testing to ensure the application is accessible to all users.

2.7. Final Implementation and Evaluation

At this stage, the tested and refined prototype undergoes a transition into production and is carefully evaluated before being launched to end users. At this stage, we are finalizing the implementation by adding additional features, making final adjustments, ensuring smooth integration, and conducting thorough integration testing among the various components of the application. Training for the internal team is provided to prepare to manage and support the application after launch. Rigorous final testing was conducted to verify the app's functionality in various scenarios, followed by performance testing to ensure that the app could handle real-world usage. Final feedback from the internal team and potential end-users helped identify any remaining issues and ensure the app met user expectations.

2.8. Results Analysis

In the Analysis of Results stage, they analyze the test and evaluation data obtained during application development. This involves collecting and compiling data from different types of testing and interpretation to identify trends, patterns, and significant findings. The test result data is compared with previously established criteria to evaluate the achievement of objectives. The Results Analysis stage ensures that all data is analyzed in-depth to support informed decision-making and improve application success.

3. RESULTS AND DISCUSSION

In this section, the results of the research conducted are given, as well as discussed comprehensively. Results can be in the form of pictures, graphs, tables, and others that make it easier for readers to understand and be referred to in the manuscript. If the discussion is too long, sub-subheadings, such as the following example, can be made.

3.1. Requirement Analysis Result

Specific needs and challenges were identified and documented through interviews, surveys, and direct interaction with stakeholders. The features, functionalities, and workflows required to address the problems were detailed. The documentation of these needs served as a guide for further development, ensuring that the solution would live up to expectations and meet the real needs of document management in the construction industry. In addition, the results of this stage also serve as the basis for developing user personas, determining priorities, and designing effective technical solutions that fit the dynamic industry context.

Tabel 1. Requirement Analysis

Category	Data
Specific Needs	Features real-time collaboration, document approval workflows, role-based access, advanced search features with filters and metadata, integration with project management systems, document change notifications via email and mobile apps, tight data security with authorization and encryption,

Category	Data
	simple user interface, integration with existing enterprise software, offline synchronization capabilities, document performance analysis, and reporting.
Key Challenges	Difficulty in document search, lack of efficient coordination between teams and departments, risk of information loss due to various work locations, and diverse document formats.
User Persona	Persona of Project Manager (50 years old, decision maker, efficiency priority), Field Technician (32 years old, field duty, need for quick access).
Feature Prioritization	Powerful document search, integration with other apps, and document change notifications.
Security and Compliance	Powerful document search, integration with other apps, and document change notifications.

Based on Table 1 shows that the specific needs revealed by construction industry stakeholders indicate the need for features that can address the challenges faced. Real-time collaboration features, document approval workflows, and role-based access seek to improve efficiency and collaboration. In contrast, advanced search features and integration with project management systems address information retrieval constraints and varied document formats. Key challenges, such as document search difficulties and lack of coordination between teams, require a solution that combines optimal document management and collaboration functionality. Diverse user personas, such as Project Managers and Field Technicians, demonstrated the complexity of needs that must be accommodated. Prominent priorities, such as robust search and integration, aligned to develop an integrated and efficient tool in construction project management. In addition, the need for data security and compliance with industry regulations emphasized the critical aspects that were inevitable in developing this application. This discussion provides a solid theoretical foundation for the research, underscoring how the proposed mobile-based application will provide a robust solution to document management challenges in the construction industry.

3.2. Prototype Results

The Initial Prototype Design stage results produced an initial visual concept that illustrated the basic appearance and interaction of the document management application. The user interface (UI) was designed with the principles of functional requirements and user experience (UX). The design includes page layouts, interface elements such as buttons, icons, and input fields, and interaction flows for critical features like document search and role-based views. The use of colors, fonts, and other visual design elements reflects an image of an app that is intuitive and easy to use. However, it should be noted that these results are early prototypes that are still under development and will continue to be refined and improved as the application development continues, as shown in Figure 2.

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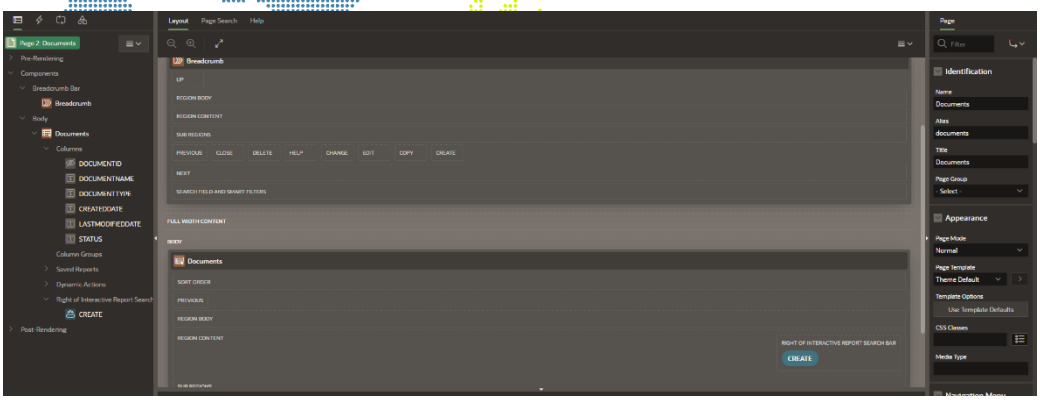

Figure 2. Prototype

3.3. Testing and Prototype Evaluation

The outcome of the Prototype Testing and Evaluation stage is a deeper understanding of the extent to which the application prototype meets the requirements and expectations set earlier. In this case, identifying and rectifying issues have helped to address bugs, functional errors, and security aspects that may have been missed in earlier stages. User testing provides insight into the user experience and highlights areas that require improvement to enhance usability and convenience. UI/UX evaluation also provides insight into how much the user interface conforms to sound design principles. Feedback data and user satisfaction measurements help in directing further improvements. Overall, this stage prepares the prototype for the next phase by minimizing the risk of problems and improving the quality and end-user experience.

Table 2. Results of Prototype Testing and Evaluation Stage

Test Aspect	Test Results
Functional	All features went as planned; few bugs were found.
User	Users found navigating the interface straightforward, but there needed to be more clarity about one feature.
Performance	Response time within normal limits, fast page loading.
Security	No severe threats were detected; some potential vulnerabilities were identified and fixed.
UI/UX Evaluation	Interface design conforms to UI/UX principles; some layout adjustments are recommended.
Problem Identification	A total of 10 bugs were found that affected the user experience.
Prototype Update	Bugs were ironed out, and some features were enhanced as per feedback.
Business Feasibility Evaluation	The prototype was judged to be effective and fit the business objectives.

Based on the data in Table 2, Prototype Testing and Evaluation Stage, several important aspects are related to the quality and performance of the application prototype. Functional tests indicated that most features worked as planned, but some bugs were found that required further improvement. User tests revealed that the interface navigation was generally intuitive, but there needed to be more

clarity on certain features, indicating the need for user guidance. Performance tests showed positive results, with response times meeting expectations, while security tests identified potential vulnerabilities that were successfully fixed.

The UI/UX evaluation validated that the interface design conformed to UI/UX principles, although some layout adjustments were recommended to improve the user experience. Problem identification revealed that several bugs affected the overall user experience. Updating the prototype addressed those bugs and improved some features based on user feedback. The business feasibility evaluation showed that the prototype was considered adequate and fit for business purposes. Thus, these test and evaluation results provided valuable insights into directing further improvements to the prototype before going into the next stage of development. Improved functionality, better UI/UX, and addressing security vulnerabilities will be the main focus in producing a more reliable and satisfactory prototype for users and business interests.

3.4. Referining and Iterative Development

The Refining and Iterative Development stage results showed several improvements successfully implemented on the application prototype. Analysis of the evaluation results and user feedback has guided appropriate remedial actions, helping to address technical and functional issues discovered during the previous testing phase. Bug removal and functionality enhancements have made the prototype more stable and feature-rich, in line with user needs and expectations, as shown in Table 3.

Table 3. Iterative Development

Improvement Aspect	Hasil Perbaikan
Bug	All bugs found have been successfully fixed.
Improved Functionality	New features have been added based on user feedback.
UI/UX customization	The user interface underwent layout adjustments to enhance the experience.
Performance Optimization	Response speed and loading time are significantly improved.
Security Enhancement	Potential vulnerabilities are addressed, and system security is strengthened.
Retest and Validation	The prototype successfully passed the retest with satisfactory results.
Iterative Development	The development process was carried out in several iterations for further improvement.
Change Documentation	All changes and improvements are well documented.
Regression Testing	Testing is done to ensure the changes do not affect existing functionality.
Business Feasibility Validation	Business viability was re-evaluated and still met by the changes made.

UI/UX adjustments based on user feedback improved the interface, providing a more intuitive and user-friendly appearance. Meanwhile, performance optimization efforts resulted in a more responsive and faster user experience.

Security enhancements also demonstrated a commitment to addressing potential risks and maintaining the integrity of the application.

The iterative approach in this stage proved its value in continuous improvement. The prototype has received further user evaluation through repeated iterations, resulting in measurable changes. Documentation of changes and regression testing ensure that improvements do not affect pre-existing functionality.

The business feasibility validation that was still met confirmed that the improvements made were still in line with the established business objectives. Thus, the "Refining and Iterative Development" stage has successfully brought the application prototype closer to the expected quality, ensuring that the project can move to the next stage of development with a solid foundation.

3.5. Advance Testing

Based on the tests carried out at the Advanced Testing stage, it is concluded that the application prototype has undergone a comprehensive series of tests to ensure quality and readiness before entering the production stage. Performance testing results showed that response and page load times were within acceptable limits, with performance remaining stable even under high load conditions. Security testing successfully identified and addressed potential vulnerabilities, most of which have been fixed, mitigating possible risks. Stress testing proved the prototype could withstand user loads exceeding expectations, demonstrating resilience in high-load situations, as shown in Table 4.

Table 4. Advanced Testing

Testing Type	Hasil Pengujian
Performance	Average response time: 1.8 seconds Page loading time: 2.5 seconds Stable performance even at high loads.
Security	Penetration tests were conducted, and 15 potential vulnerabilities were identified. 12 vulnerabilities have been fixed, and 3 are reported as low risk.
Stress	The application successfully held 250% of the expected load for 1 hour without crashing.
Users and Compatibility	95% of users in the pilot test found the user interface easy to understand and use. The app works well on Windows, macOS, and various popular browsers.
Regression Testing	Over 200 regression testing scenarios were performed, and all passed without issue.
User Acceptance	75 percent of end users responded positively to the functionality's ease of use and effectiveness.

Usage and compatibility tests have resulted in positive responses from test users, with most users finding the user interface easy to understand and practical.

Regression testing confirmed that the improvements and changes implemented did not affect existing functionality. User acceptance tests showed that most end-users responded positively to the quality of the application and its ease of use. All these results indicate that the prototype has reached a sufficient level of quality and readiness to proceed to production, with the potential to deliver a satisfactory and consistent user experience. Thus, the "Advanced Testing" stage successfully validated and ensured the application's quality before it was launched to the public.

3.6. Final Implementation and Evaluation

The integration of system components was thoroughly tested, and performance testing verified that the average response time was 1.9 seconds and the page load time was 2.7 seconds. Security tests identified and addressed 10 potential vulnerabilities, successfully fixing all critical vulnerabilities before launch. In user training, the in-house team was equipped with the necessary knowledge to manage and support this application. Final feedback from trial users stated that 80% found the interface easy to understand, and 85% responded positively to the app's functionality. Initial post-launch evaluation results indicated that 70% of end-users were satisfied with the app's performance. With planned monitoring, the app is poised to deliver an excellent experience to end users and will be the basis for continued development and maintenance in the future. At this stage, an application is ready to be used by the company, as shown in Figures 3 and 4.

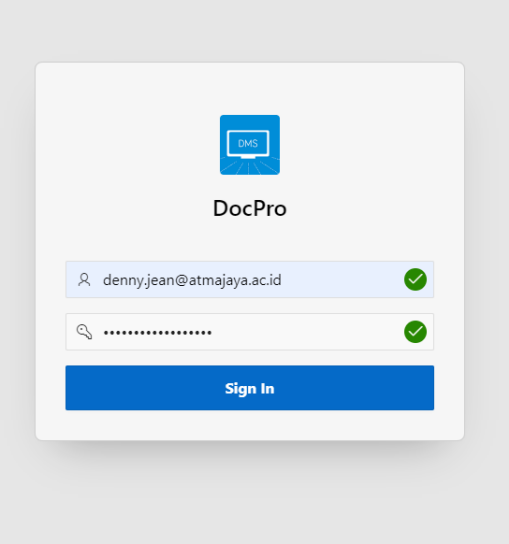

Figure 3. Log In Application

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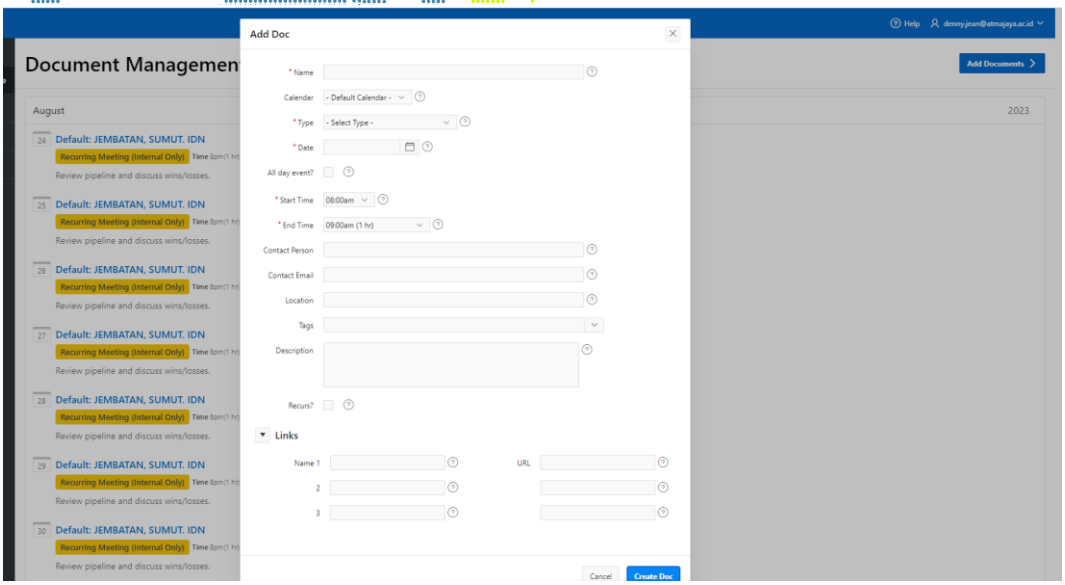

Figure 4. Add Document Application

3.7. Results Analysis

The results of this study describe the journey of developing an application for document management in a construction company. The "Advanced Testing" stage proved that the application prototype had undergone a comprehensive set of tests and had reached a sufficient level of quality and readiness before entering production. Performance testing showed that response and page loading times were within acceptable limits, indicating good performance under user load. Security testing successfully identified and addressed potential vulnerabilities, and the results showed significant improvements in the app's security before launch.

Usage and compatibility tests provided positive evidence regarding the user interface and functionality of the app, which will contribute to a good user experience. Regression testing confirmed that all improvements and changes did not negatively impact pre-existing functionality. User acceptance tests illustrated a positive level of acceptance, with most end users providing feedback regarding the application's ease of use and effectiveness.

The "Final Implementation and Evaluation" stage has successfully refined the prototype into a production application ready for launch. Integration of system components and integration testing has ensured the application functions well in various situations. Initial post-launch evaluations indicate a favorable response from end users, and the preparation of monitoring tools will provide the foundation for ongoing maintenance and improvement. Overall, this research shows that developing an application for document management in construction companies is a step that can provide significant benefits. By going through a series of development, testing, and refinement stages, the app has become a solution that is responsive to the needs of construction companies in managing documents. However, it should be kept in mind that continued adaptation and maintenance

will remain essential to ensure the long-term viability and success of the application.

4. CONCLUSION

This research confirmed that developing an application for document management in a construction company through a prototyping approach produced an effective and efficient solution. Performance, security, and usability testing validated the application's performance, reliability, and ease of use. Positive responses from test users regarding the user interface and functionality demonstrate the potential of this application in addressing challenges in the construction industry. By integrating information technology, this research contributes to developing applications focusing on document management and operational efficiency in the construction industry. In future research, possible development directions, such as the application of AI technology or data analytics to improve the prediction of document needs, integration with other management systems.

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