

Knowledge-based Project Management Apps To Improve Quality of Non-Engineered Residential Buildings in Indonesia

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Abstract:

Indonesia is located in an area that has a high potential for earthquake. Most of the fatalities occurred due to the collapse of non-engineered residential buildings, which are still widely available in Indonesia. Non-engineered building are a simple buildings which in the process of construction are not use the correct technical rules and patterns. The Indonesian government has made regulation for simple earthquake-resistant residential buildings. However, its implementation is not easy, because the construction process usually done by the community itself and has become a habit for a long time without regard to the provisions that have been made. Several initiatives have been carried out involving cross-parties and various fields to improve skills, knowledge and awareness of this issue. How to manage supervision, increase skills and maintain shared awareness can occur continuously and growing is still the problem. Project management ensure the quality of work as planned. The application of appropriate knowledge management can increase people's skills, knowledge and awareness. With IT technology, process will be continuously and accessed from all locations of Indonesia. The development of knowledge-based project management applications is expected to be a solution to improve the quality of non-engineered residential buildings in Indonesia.

Keywords: Project Management, Knowledge Management, Web Application, Non-Engineered Building.

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I. INTRODUCTION

Non-engineered residential buildings are structures that are designed, built and monitored in an unsystematic manner, usually built by traditional builders or by building owners using a traditional approach. The number of non-engineered residential buildings in Indonesia is very large. Non-engineered residential buildings in the city of Yogyakarta right before the 2006 earthquake, approximately 93.5% were non-engineered houses. The percentage of non-engineered houses made of heavy materials, namely half-brick brick buildings, is 84.8% [1].

Earthquake regulations and building techniques can not be applied in the implementation of construction of non-engineered residential buildings, mainly due to the lack of building technical

knowledge and inappropriate construction techniques applied by the construction fieldworker. Implementing seismic rules in non-engineering construction is the key to ensuring earthquake safety. In reality, the implementation is not simple, because it is related to all interdisciplinary and cross-sectoral relations at various levels of understanding, commitment and skills. Some recommended solutions include the same attention to non-engineered buildings as in the engineering construction of the authorities as well as more effective government inspections and controls on construction implementation to ensure that building rules are obeyed [2].

Project management is the application of knowledge, skills, tools, and techniques to project activities to meet project requirements. Project

management is completed through the appropriate application and integration of the project management processes identified for the project. Project management enables organizations to carry out projects effectively and efficiently [3].

Knowledge Management (KM) as a process of managing various knowledge assets that exist in a organization in the form of tacit or explicit so that it can be used for users and companies to enable the creation, communication and application of knowledge in order to achieve organization goals [4].

Project success analysis, presented through the definition of critical success factors, key performance indicators and the performance measurement process has a very positive influence on the acquisition and transfer of knowledge in the project environment [5].

This study intends to contribute to the construction process of non-engineered residential projects in Indonesia by improving the quality performance through the development of knowledge management project management tools applications. The use of web-based applications is expected to be widely used by the people of Indonesia in managing the construction of non-engineered residential building so that the quality of the building improves. The KM function will assist in the process of storing, developing, sharing and applying knowledge so that project management in non-engineered residential buildings in Indonesia will improve continuously.

II. LITERATURE REVIEW

A. Non-Engineered Buildings

Referring to the performance of buildings against earthquakes, buildings are classified into two, engineered and non-engineered. The engineered buildings are systematically designed, built, and supervised using a technical approach and carried out by competent professionals [1]. Conversely, buildings that are not engineered are structures that are designed, built, and not supervised systematically. Non-engineered buildings are usually built by traditional builders and / or building owners using the same traditional approach.

There are two types of non-engineered buildings. First, non-engineered buildings that are made by adapting to the local context and made with local

materials. Usually using construction techniques passed down from generation to generation. The development of traditional settlements is carried out in harmony with its cultural and social environment and hence fosters social resilience to natural disasters. The second is non-engineered buildings that are made with or in part using imported materials, often not using traditional techniques. This construction is often copied because it is considered modern but does not consider local conditions. Due to lack of technical knowledge, suitable materials, accurate monitoring and concrete building regulations, this construction becomes vulnerable to natural hazards [6].

The number of non-engineered buildings of the second type is very large. The number of non-engineered buildings in the city of Yogyakarta right before the 2006 earthquake, there were 93.5% of houses in the city of Yogyakarta were non-engineered structures. The percentage of non-engineered residential buildings made of heavy materials, namely one half-brick building, is 84.8% [1].

1) Project Management of Non-Engineered Buildings Quality

The implementation of the construction of non-engineered buildings compared to the construction of engineered buildings is that the majority of the implementers of the construction of non-engineered buildings are in the same community or in adjacent communities. Construction materials, such as bricks and wood produced by local manufacturers, usually lack quality control. Workers also live in the same area. Most project foremen also come from the same community that forms the construction team by employing people in their environment (often with limited experience in construction work). Another aspect of this situation is the economic aspect so that owners who build houses are usually low income and unable to hire contractors or engineers [6].

2) Earthquake Hazards in Non-Engineered Buildings

Non-engineered buildings will be most affected during an earthquake. Most of the victims died during the earthquake due to the collapse of these buildings. Most low-rise residential buildings are

buildings with non-engineered construction. The increasing number of non-engineered buildings without earthquake resistance in earthquake prone areas causes the risk and vulnerability to earthquakes to increase [6].

3) Latest Condition

In New Zealand, to save existing and future building works from the impact of a possible earthquake disaster, the need for a holistic approach in creating public awareness, education and training, and research and development[7]. Nepal also promotes the construction of buildings that are safer from earthquakes carried out by training masons, and relies more on homeowner's awareness of earthquake safety rather than merely controlling them through the building permit process [8]. In Indonesia, the initiatives to solve earthquake-related building codes are not easier applied for non-engineered buildings; elements of practice where problems occur and where changes can increase the use of building codes in their application to non-engineered buildings; actions for change to improve regulations for the design and construction of non-engineered buildings; and practical and effective methods for disseminating research to industry, academic, and community stakeholders [9].

B. Quality Requirements in Non-Engineered Buildings in Indonesia

Non-engineered residential are regulated in Minister of Public Works and Public Housing Regulation No. 5 of 2016 concerning Permits to Establish Buildings (Izin Mendirikan Bangunan) in the classification as simple one floor buildings with provisions that meet the basic requirements of earthquake resistance and use a prototype design of a simple one-storey building [10].

The basic requirements for earthquake resistance are practical guidelines in the construction of simple buildings. Fulfillment of basic requirements for earthquake resistance is aimed at realizing residential buildings that are safer against the impact of damage caused by earthquake disasters. The basic requirements for earthquake resistance include:

1. Good quality building materials;
2. The existence and dimensions of the appropriate structure;

3. All main structural elements are well connected;
4. Good quality workmanship.

Table1 Non-engineered building quality items

Category	Item
Building Material	Concrete, Water, Gravel, Cement, Mortar / Plastering Mixture, Foundation Stones, Bricks, Bricks Immersion, Wood
Main Structure	Foundations, Binding / Sloof Bars, Columns, Circular / Ring Beams, Batching, Roofing Structures, Wooden Horses, Bonding Easel, Steel Plate Dimension and Bolts for Binding Wood Easels, Wind Ties, Walls, Plaster
Relationship between Structure Elements	Relationship between Binding Blocks / Sloof, Relationship between Binding Blocks / Sloof and Columns, Relationship between Columns and Walls, Relationship between Columns and Circular Beams, Relationships between Circular / Ring Beams with Wooden Horses, Transportation Material
Casting concrete	Column and Beam Casting

C. Project Quality Management

Project management is the application of knowledge, skills, tools, and techniques for project activities to meet project requirements. Project management is completed through the appropriate application and integration of the project management processes identified for the project. Project management enables organizations to carry out projects effectively and efficiently [3].

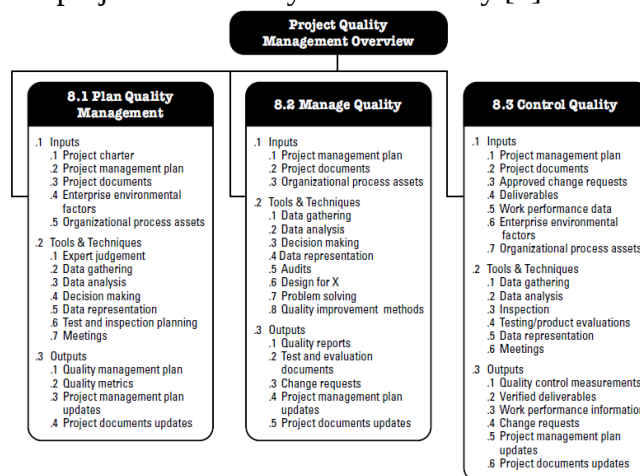


Fig. 1 Project quality management overview

Project Quality Management includes a process for

combining organizational quality policies related to planning, managing, and controlling project and product quality requirements to meet stakeholder objectives. Project Quality Management also supports ongoing process improvement activities such as those carried out on behalf of the conducting organization.

D. Knowledge Management

Knowledge management (KM) covers everything related to knowledge. In a narrow sense, KM is sometimes also defined as an information technology system that provides organizational knowledge. KM is actually both and more. One of the consensus fields in the field is that KM is a very multidisciplinary field[11].

Projects could promote the inter-project communication and improve transfer intention, which further influences knowledge transfer effectiveness positively within Project-based Organizations. The urgency of projects has a negative impact on inter-project communication and transfer intention. The temporality of projects also negatively affects inter-project communication. They consequently hinder the knowledge transfer behaviors between projects. Additionally, the application of IT improves the frequency of communication and makes up for the negative impact of geographical distance between projects on knowledge transfer [12].

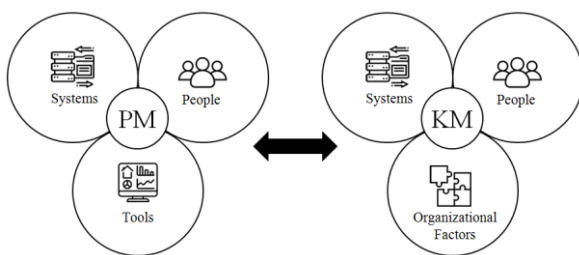


Fig. 2 KM and PM Component

If accumulation of knowledge is not recorded and shared among other projects, that knowledge will be lost and no longer available to assist future projects, which leads to an increase in future project costs and lower quality of project results. [13].

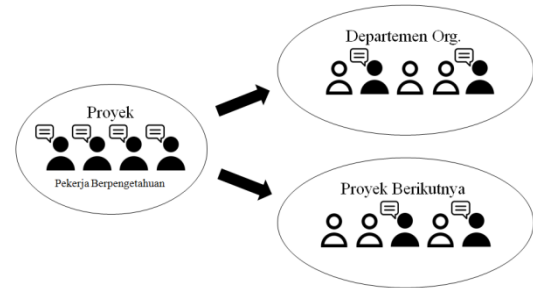


Fig. 3 Knowledge worker dan knowledge sharing

Usually, knowledge from past projects accumulates in the mind or document and in each individual. People with knowledge of previously carried out projects are assigned to similar projects where their knowledge can be shared to benefit the implementation of the project and broaden the overall organizational knowledge base as can be seen from Fig. 3.

E. Project Management Apps

The top management of the project believes that the application of project management provides benefits in increasing overall productivity. Meanwhile, middle managers are more concerned in automating operational efforts such as in the inspection and reporting process to help increase their productivity [14] [15]. Another advantage is the ease of use and ease of communication with some other mobile device users[15].

1) Project Management Apps in Construction

Azhar et. al. (2017) have a research about mobile applications that can be used in the construction project life cycle. A total of 205 facility design, construction and management applications were recorded. The majority of mobile applications found are applications that will be used during the construction phase of the project. The study also aims to find the ten best applications for construction managers. The ten applications are Tradie's App, Procore, Onsite Punchlist, Plan Grid, OnSite Files, Aconex Mobile, OnSite Photo, PunhIt, Poreman's Mate dan Drawvis [16].

In Liu et. al. (2017) studies, based on popular applications and their main features show that PlanGrid, with project collaboration features and cloud-based management systems being the most popular, then followed by JobFlex which is an estimate and tender software, Procore used for

project management, and SmartBidNet for bidding management[17].

2) Comparison of Project Management Application Features

For the time of this research, the applications that can still be found on Google Playstore were 5 applications; Contractor Workzone which was formerly Tradies Apps after being acquired by Trimble, Procore, PlanGrid by Autodesk, Fieldwire and BuilderTrend. Table 2 illustrates the comparison of the main features of the five applications.

Table2 PM apps features comparison

Key Feature	Contractor Workzone	Procore	Plan Grid	Fieldwire	BuilderTrend
Communication Management	Yes	Yes	Yes	Yes	Yes
Task Management	Yes	Yes	Yes	Yes	Yes
Quality Inspection	Yes	Yes	Yes	Yes	Yes
Drawing Management	Yes	Yes	Yes	Yes	Yes
Admin & Finance	Yes	Yes	No	No	Yes

From the five mobile applications for project management, five functions are categorized as communication tools, task management, quality inspection, drawing management and financial management. Relatively all applications have all their functions, except for the financial management function.

3) Main Functions in Project Management Application

Mobile devices and applications change the way individuals collect, process and share information. Silvius and Silvius (2015) have a research about these development that also applies in project management. Explorative study of the functionality of 50 project management applications. Applications are analyzed on variables: type of function, project management processes supported, methodologies / standards supported, topics discussed, web site support, languages supported, project roles supported, number of team members supported and number of projects supported. The current project management application function is mainly focused

on two application fields[18]:

1. Support the planning process and project organizing
2. Support in communication and team collaboration.

4) Obstacles in PM Application Implementation

The obstacles in applying the project management application to upper management are that there is no time to study, it is not easy to change, licensing fees are too expensive and data security issues. Different from the middle operators, the obstacles faced are the attitude of not wanting to change, the price of mobile devices that are too expensive, expensive licensing fees and attention to data security issues. Some input was also conveyed about the application requiring training and often there was not enough time to do it. Resistance may occur to changes among workers and that not all workers use all aspects of mobile devices [14].

Other studies find the top two problems identified are [16]:

1. Lack of training
2. Trouble viewing documents on a mobile device.

III. METHODOLOGY

In this research, a literature study was conducted to build a KM-based PM application. Takes a two approach in this study: 1) Collect, store, filter and review relevant academic journals for Meta Analysis; 2) develop proposed KM model and PM Application basic concept.

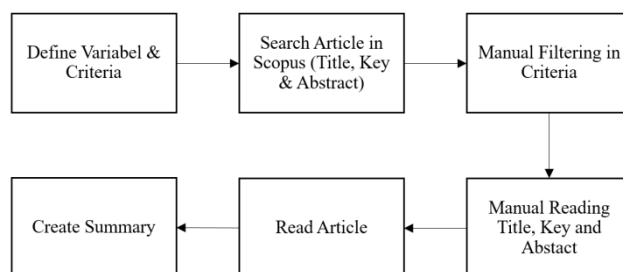


Fig.4 Meta-analysis process

The first step is to identify the academic journals and databases that may contain any relevant material for this review. Meta-analysis will be conducted on the application of KM in the PM apps. The steps

taken in the literature review is as shown in Fig. 4.

The second step, based on the relevant literature will be selected the appropriate KM Model and develop the proposed a conceptual PM apps as a solution to improve the quality of non-engineered residential buildings in Indonesia.

The emphasis in this research is on the implementation of appropriate theories to solve existing problems. The problem in this research is the poor management of the quality of non-engineered residential buildings, it is hoped that the implementation of the appropriate KM model in the PM application that will be made can be the solution.

IV. RESULT AND DISCUSSION

A. Meta Analysis: Integrated KM in PM Applications

1) The article filtering process

The article to search for is articles about the application of KM in PM applications in the field of construction, to obtain the following field:

1. Project Management
2. Knowledge Management
3. Information Technology in Construction

Keyword searches on Scopus are performed on titles, keywords and abstracts of academic articles that fit the criteria. The search is in the format Scopus search uses: *TITLE-ABS-KEY((knowledge-based OR "knowledgemanagement") AND construction AND "project management" AND (mobile OR apps OR application OR system OR "information system" OR web OR website OR online OR cloud OR computer))*.

Initially wanted to find the latest articles for these topics, however, not a lot of articles in this topics. Then the limit of the search year was removed, so found 547 articles.

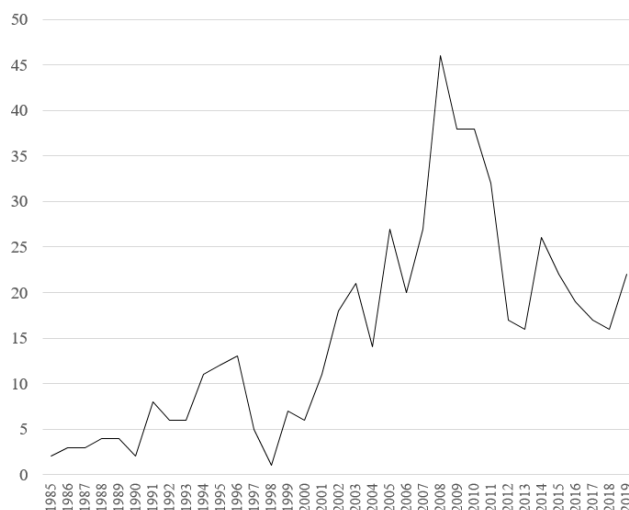


Fig.5 Number of articles per year

In Fig. 5, the number of articles per year shows topics that began to be discussed from 1985 and increased to a peak in 2008 of more than 40 articles per year. After that the number of articles on this topic is around 20 articles per year. Based on the document type of article of a total of 500 articles consisting of 237 articles, 302 conference papers and 7 from book chapters.

From all articles obtained, manual filtering is performed on titles and keywords to ensure that the selected article is about software or project management apps. This process is useful to ensure that the article selected is really about the project management apps. Obtained a number of 56 paper that meet these criteria. Articles that were eliminated included 164 KM systems, 32 Decision Support Systems, 23 Expert Systems, Information Systems 17 and other not relevant criteria 255 paper.

Parallel to the process, conducted a literature study on the KM model found one obstacle in the implementation of KM on the project is the additional time and attention when using the KM System. So included in further criteria, the process of knowledge creation and its application is not an additional process in the PM process.

The next screening process is based on more detailed criteria and is done by reading the Title, Keywords and Abstract from the previous article. In this screening process, 25 scientific articles were finally obtained that fit the advanced criteria. This article is then read entirely and rigorous to ensure that the contents of the article meet the criteria, and there are only 9 paper that meet the criteria.

2) Meta Analysis Summary

From 9 selected articles, they still cannot match what was desired. The article about the most suitable KM-based PM application belongs to Lundkvist et. al. (2010), but in the process of making a model, no KM model has been offered yet.

Tu and Feng's (2011) article is actually interesting, showing great benefits in the application of KM in integrated construction management. It is said that it has been implemented in the Metro West and Baoli Cultural Square Projects in China. But the process is not be explained.

Research from the most recent year, from Oti et. al. (2018) concerning integration of lesson learned systems with BIM. Process of integrating KM into BIM as a PM process provides benefits so that the lessons learned process in using BIM becomes efficient.

Table3 List of selected articles

No.	Reserach Title	Researcher	Year	Location
1	Integrated Management of Construction Project Based on Knowledge Base	Xiaojing Tu, Weimin Feng	2011	China
2	Construction productivity fuzzy knowledge base management system	Emad Elwakil, Tarek Zayed	2018	USA
3	Knowledge model for integrated construction project management	Ginevičius T., Kaklauskas A., Kazokaitis P.	2011	Lithuania
4	Computer-assisted construction methods knowledge management and selection	Udaipurwala A., Russell A.D.	2002	Canada
5	Knowledge-based standard progress measurement for integrated cost and schedule performance control	Jung Y., Kang S.	2007	South Korea
6	Ontology-based model of mobile knowledge service for the inspection of construction project	Kaiji L., Qihui L., Xinglu Z.	2009	China
7	Integration of Lessons Learned Knowledge in Building Information Modeling	Oti A.H., Tah J.H.M., Abanda F.H.	2018	UK
8	Digitalization of inspection data: A means for enhancing learning and continuous improvements?	Lundkvist R., Meiling J., Vennström A.	2010	Sweden
9	Systematizing construction project evaluations	Kumaraswamy M.M., Thorpe A.	1996	Srilanka, UK

PM and KM separately are part of a broad field of science. The application of KM in PM has been very much researched. However, if it is more specific about the application of KM in the PM application system in a seamless live capture is still have a gap. This research is hoped will be a scientific contribution to this gap.

B. Implementation KM Model in PM Apps

The KM model will be developed in the PM application is based on the Polyaninova model [13],

about the dissemination of knowledge between projects by knowledgeable project workers.

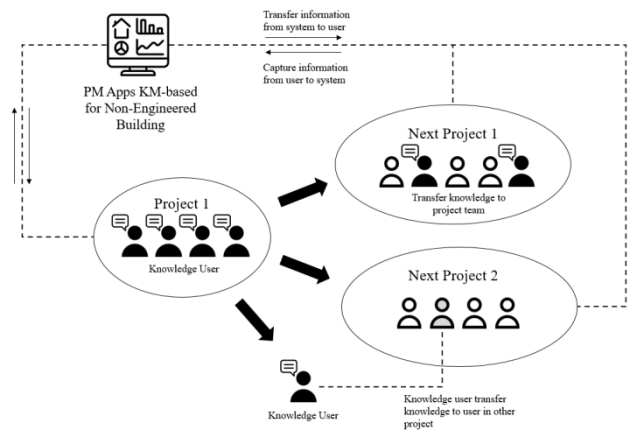


Fig. 6Knowledge sharing between project

In Fig.6 shows that the knowledge worker on the project 1 will get his first experience. The knowledge and skills in this first experience will be shared by all team members in each role. In the next project there are two possibilities, first the team member will enter the next project team, or the team member no longer has the project, for example the owner of the building.

Knowledge transfer by team members who subsequently have a project with this system can occur to other team members. Knowledge transfer can also occur if personnel alumni who have worked using this system can be contacted by team members from other projects to make a consultation or just for a small sharing.

Based on this mechanism a KM model was developed in the proposed PM apps. Principles of the system can capture knowledge from project activities in a live capture, transfer of knowledge can occur, carried out by the system to the project team, project team to the project team.

The knowledge creation process is a live capture of project management activities so that PM apps users are not disturbed by the knowledge management process. Project management focuses on achieving project performance, the process of capturing information is carried out automatically by the system.

The knowledge transfer process is also carried out in stages according to the needs of each project team. The process of learning and receiving knowledge is

parallel with the project management process.

C. Proposed Web Application

1) Apps user

The PM application will be designed to serve building owners in supervising the construction of their own home. There are 2 parties who will use this application, the owner and field worker.

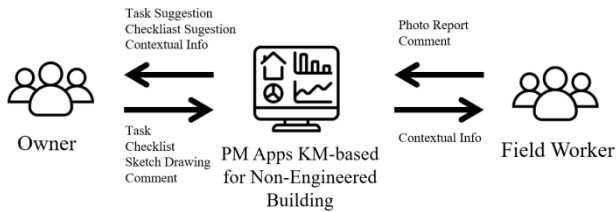


Fig.7 User KM-based PM apps

The system will automatically provide task and checklist recommendation as well as relevant information on the related issues. The system will identify the context of the ongoing discussion, then recommend a relevant content. Relevant content recommendations for each project management activity are expected to facilitate the process of applying knowledge. Knowledge will be given in stages and according to what is needed by the user. Information recommendations will be accepted equally for all work teams on a project which is expected to provide the same perspective and insight for the entire work team. This happened continuously, throughout the construction process of the project (Fig. 7).

2) Key features

In accordance with the literature review that has been done, the main function of the application is twofold, first as a tool for project management, the second as a function of communication and collaboration.

The project management process is simplified as in Table 4, in the form of project info, task management, photo reports, checklists and comments.

Table 4 Simplified project management process

	Project Management	Simplify Feature
Input	Project Charter	Project Info, Task Management, Sketch Drawing
	Project Mgt. Plan	
	Project Document	
Tools & Technique	Inspection	Photo Report
	Testing/Product Evaluation	Checklist
	Meeting	Comment
Output	Verified Deliverables	Verified Deliverables

Project info contains general information about the project such as location, duration, owner of the project. It can also include some additional information such as risk, stake holders, and more detailed scope of work.

The system also has a simple Task management feature for managing jobs and sub jobs below. Each job can be commented on and given a checklist that is relevant to the job. The checklist is a guide to the intended quality standard and ultimately it is a requirement that the job can be accepted as verified deliverables.

Photo reports complete the discussion on the project process that occurred. The project owner can view general field conditions or request details of the desired work. Discussions between project team members can be done with the comments feature.

The overall features are expected to fulfill two basic functions of the project management apps, the task management function and the collaboration communication function. The simplification process is expected to support the easier process of using the application.

3) Proposed user interface

The main difference in this developed application is the recommendation of information that is appropriate to the context and live capture to capture information so that for a long time the system can develop both data and utilized in the system development activities themselves.

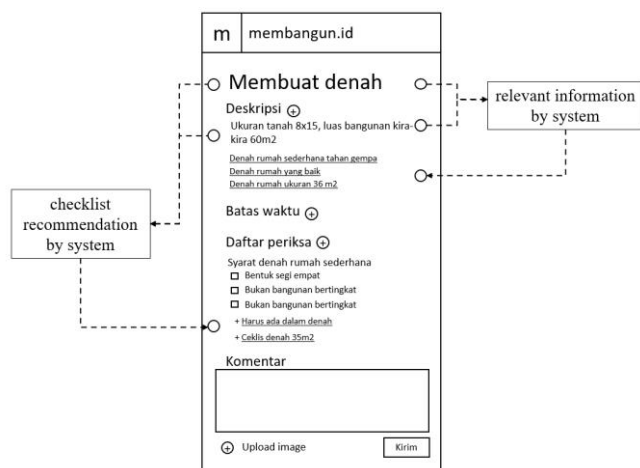


Fig. 8 Contextual knowledge in PM apps UI

The process of capturing knowledge is also carried out live capture, capturing responses from application users to enrich the data in the application system, including information that is accessed a lot, checklists that are used the most, what topics are most often discussed by users.

The content recommendation system is carried out so that the knowledge transfer process can run partially and continuously in accordance with the ongoing project management process. Fig. 8 shows that the system will identify several contexts and then recommend content based on the context. Contextual content can be related information, relevant checklists, previous users closest to the contact through the system or other information.

V. CONCLUSION

Development process of KM-based PM apps has been described in this paper. Starting from the literature review to the development of the KM model and its application in design of PM apps user interfaces. The next process will continue to the application prototype stage with the detail item of project quality management requirements will be completed in the system.

It is hoped that this research can provide benefits toward to improve the quality of non-engineered residential buildings in Indonesia so as to reduce the loss of lives in an earthquake. As a contribution of knowledge, this research contributes to the application of KM in the development of PM apps.

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