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# Development of Mobile Application Prototype for Building Inspection Work
## (Pembangunan Prototaip Aplikasi Mudah Alih untuk Kerja Pemeriksaan Bangunan)

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ABSTRACT

*Building surveyors traditionally relied on descriptive longhand surveys to record an information by hand during on-site building inspections. However, the traditional approach such as checklist that usually practiced were unstructured and unstandardized among organization. In certain cases, it might have a missing document and issue on time-consuming for analysis. Therefore, this mobile application prototype purposely built to track the building defects where it can be used on site during building inspection. This is to record the information according to 11 evaluation criteria namely defect classification, type of building, type of location, type of element, sub-element, causes of defects, defects categories, defect groups, type of defects, building condition level and priority level of repairs. Besides that, the pictures or images can also be kept as supporting evidence. This mobile application prototype included three development phases which are design and utilization, system installation and maintenance and implementation. This mobile application has been projected to be used with mobile devices such as tablets or smartphones. It can also be accessed either through Play Store (for Android User) or the App Store (for Apple's iOS user). This mobile application also provides a convenient and alternative method in recording the real time findings instead of using manual checklist. Finally, it has the potential to be developed and commercialized with the addition of more user-friendly features.*

*Keywords: Mobile application; prototype; inspection work; building surveyors*

ABSTRAK

*Juruukur bangunan secara tradisinya bergantung kepada keterangan bertulis yang panjang untuk merekodkan maklumat semasa pemeriksaan bangunan di tapak. Namun begitu, pendekatan tradisional seperti senarai semak yang biasa diamalkan adalah tidak tersusun dan tidak seragam antara organisasi. Dalam kes tertentu, ia mungkin mempunyai dokumen yang hilang dan isu yang memakan masa untuk di analisa. Oleh itu, aplikasi mudah alih ini dihasilkan bertujuan untuk merekod kecacatan bangunan di mana ia boleh digunakan semasa pemeriksaan bangunan dijalankan. Aplikasi ini direka bentuk untuk merekodkan maklumat mengikut 11 kriteria penilaian iaitu klasifikasi kecacatan, jenis bangunan, jenis lokasi, jenis elemen, sub-elemen, punca kecacatan, kategori kecacatan, kumpulan kecacatan, jenis kecacatan, tahap keadaan bangunan dan keutamaan tahap pembaikan. Selain itu, gambar kecacatan boleh disimpan sebagai bukti sokongan. Prototaip aplikasi mudah alih ini merangkumi tiga fasa pembangunan iaitu reka bentuk, pemasangan sistem dan penyelenggaraan dan perlaksanaan. Aplikasi ini telah direka bentuk untuk disesuaikan pada peranti mudah alih seperti tablet atau telefon. Ia juga boleh diakses sama ada melalui "Play Store" (untuk pengguna "Android") atau "App Store" (untuk pengguna "iOS Apple"). Aplikasi ini menyediakan kaedah yang berguna sebagai alternatif dalam merekodkan penemuan pada masa pemeriksaan dijalankan dan bukannya menggunakan senarai semak manual seperti kebiasaan. Aplikasi ini berpotensi untuk dikembangkan dan dikomersialkan dengan penambahan ciri yang lebih mesra pengguna.*

*Kata kunci: Aplikasi mudah alih; prototaip; kerja pemeriksaan; juruukur bangunan*

## INTRODUCTION

The availability of mobile applications is on the increase such that it produces a visible change in the way humans feel and practice computing. Formerly, in other to access the internet, check and read mails, one had to use the computer but today this has changed. It is because computing is now carried everywhere in mobile devices. Additionally, mobile devices have become an integral part of so many individuals due to these apps, such that it could be said that it supports towards sustaining systematized life.

Many researchers have explored research in mobile technologies over the last decade, which has resulted in various developments of mobile applications. According to Kulkuska-Hulme et al. (2009), mobile applications may be effective in reaching places that other systems cannot; they are best delivered as part of a combination of actions; they offer a collection of pieces to be tailored to a business need rather than a only result; and they are not merely a device for task delivery but can be used for learning through creativity, collaboration, and communication.

Today, mobile devices being practical, accessible, and flexible for humans. Thus, it made mobile devices the most ubiquitous devices among users (Malavolta et al. 2015). There are many studies about cross-platform mobile development approaches. According to Wasserman (2010), many approaches used for assessment of traditional software are modified for mobile application development and testing. Harpe (2012) mentioned that mobile application development is a context-dependent activity which is affected by the context when the application was set up. Therefore, the studies that are related to mobile application development are crucial. This is because it needs to be involved in future work or development that meets the similar setting. For example, there is a report about a work that integrating participatory design approach in active development (Kautz 2014).

A study done by Usman et al. (2014) stated that the initiation of Agile Software Development (ASD) approach helps the entire software development community. This development has an iterative and incremental approach which includes self-organizing teams and cross-functioning teams who work together to construct software (Kaur, 2016). There are not many studies that have reported about estimation of effort in agile development as is a new scope of study (Aslam et al. 2017). More future research on mobile technology and their applications are required as more tertiary students use mobile devices to support their learning. Moreover, the acceptance of mobile technology among students in higher education is growing rapidly (Karim & Mustapha 2023).

## PROBLEM STATEMENT

According to Che-Ani et al. (2011), building surveyors traditionally relied on descriptive longhand surveys to record information by hand during on-site building inspections. Mike (2002) further added that there are a variety of methods of recording information on site based on surveyor's preferences such as taking notes by long hand, using portable tape-recorder, sketches on drawing, form of checklist, word process by secretary and speech recognition software. However, the traditional approach such as checklist that usually practiced were unstructured and unstandardized among organization. In certain cases, it might have a missing document and issue on time-consuming for analysis. Tommy & Choi (2004) added visual inspection of a building usually depends on the surveyor's subjective opinions and inaccurate assessment of the condition of the inspected building. Moreover, visual inspection can be slow, expensive, and unsafe. With regards to these problems, the RICS (2009) suggest that there is a need for a quick, reliable and practical approach to conduct a building inspection. Therefore, the mechanism of handheld gadget is to be highlighted in this research.

Today, with rising fierce competition for the jobs that are available, it is important that organizations stand out from the crowd and be able to prove the positive impact that they can provide to the industry. Thus, the organization should ensure themselves to give impact on their performance and they need to constantly look at how they can develop and improve. Therefore, recognizing the need to offer mobile access to mobile applications for business and professional development is a crucial motivating factor behind this research. The existing situation evidently demonstrates this need, wherein the use of mobile devices among professionals and digitaliza-tion in construction is currently exponential and will con-tinue to do so in the future (Mohammed Izrai 2023).

## BUILDING INSPECTION WORK

Joao (2008) explains that building inspection work is a complex technical task, requiring knowledge, time and equipment. It needs to be assessed and checked based on the diagnosis of the level of deterioration in the building elements. Wordsworth (2001) added, inspection is a process to assess the quality of a product or service to achieve something that has been set standards. Mike (2002) explained that among the things that need to be recorded during a building inspection are the design and construction, the state of the structure, the sources of faults and the best treatments technique. The condition examination of this building will involve the structure, fabric, finishing and basic parts.

In the Malaysian context, the Comprehensive Asset Management Manual (MPAM) outlines the inspection requirements to ensure periodic assessments are carried out throughout the asset's life cycle (Government of Malaysia 2009). An introduction to the rating system and matrix calculation is important to provide an accurate explanation of defects in addition to saving time (Alani et al. 2001; Che-Ani et al. 2008). The Condition Survey Protocol matrix (CSP 1) may be used to evaluate if a building's overall grade is good, average, or deteriorated (Adi Irfan et al. 2011). The introduction to CSP1 aims to optimize data collection time, record defects found, determine the rating (rating) of the overall condition of the building and analyze statistical data.

Koru and Tian (2004) emphasized the relevance of a defect management strategy in project management, which may assist project teams in using data to understand the nature of defects and enhance quality. Defect control is critical for construction and operational quality in general. Dong et al. (2019) suggested that this procedure comprises building inspection, problem diagnosis, defect recording, data entry into a computerised system, and public communication of correction steps.

Therefore, the study aims to integrate between the traditional approach and technology as part of defect management strategy specifically focused on building inspection.

## DESIGN AND DEVELOPMENT OF MOBILE APPLICATION

Designing and developing mobile applications is something that is challenging. For this task, we need to have knowledge of software programming, graphic design, instructional design, and content localization (Karim et al. 2017). Mobile learning devices can help students' motivation, organisational skills, foster a sense of responsibility, support both independent and collaborative learning, act as reference tools, track students' progress, and provide assessment (Savill-Smith, 2004). As a result, some educational institutions began to develop specific mobile applications for students' learning. Therefore, some educational institutes, universities or schools started to develop specific mobile applications for their students according to their curriculum and particular need. Hsu et al. (2014) indicated that their research has effects that can affect improved design and development phases such as teaching and learning strategies, affordances, theory, settings of learning, assessment, learners, mobile technologies and interface design, context awareness and augmented reality, infrastructure and administration and country and digital division. Wafaa et al. (2017) suggested the mobile application development process. The phases in the mobile application development process are as follows: (1) investigation of the App idea, (2) the user interface design, (3) the App development using the tools and programming languages of the target platform, (4) the App testing on diverse devices and (5) publishing the App on the target platform store.

This mobile application purposely built to track the building defects where it can be used on site during building inspection. The objective of the building examination is to evaluate the building's state (Che-Ani et al. 2011). This mobile application uses Android operating system. This mobile application purposely built to track the architectural defects where it can be used on site during building inspection to record the information according to 11 evaluation criteria namely defect classification, type of building, type of location, type of element, sub-element, causes of defects, defects categories, defect groups, type of defects, building condition level and priority level of repairs. Furthermore, the picture can be save as supporting document. Kariogiorgi and Symeou (2005) proposed that different views be used throughout the design and development process of a mobile application for devices such as tablet or smartphone. The application provides useful and alternative method of recording the real time findings instead of using manual checklist.

## OBJECTIVES

The objective of the study is to design and develop a virtual and flexible mobile application for building defects tracker for encouraging users to use mobile applications.

For next phase, the research attempt to install and maintain the application on Google Play (Android) and App Store (for Apple's iOS user) system after validating the implementation of mobile application with instructional designer and Information Technology (IT) experts.

# METHODOLOGY

Many mobile application developers have recently been created to assist users in creating their ideal personalised mobile application. It is because the administrators and users of this system may lack ICT capabilities, the system employed should be easy and effective to administer and use. As a result, this project chooses *Andromo App Maker for Android*, which is one of the mobile application builders that does not need coding. The study presents a novel evaluation approach based on the applicability of mobile applications to assess the state of the structure for each reported problem. Thus, this research is divided into three stages in Table 1:

TABLE 1. Methodology

| No | Development Phase | Description |
|---|---|---|
| 1 | Design and Utilisation | There are five main section:<br>**Section A:** About Us – Product Description<br>**Section B:** Evaluation – 11 Criteria of assessment<br>**Section C:** Result<br>**Section D:** Pocket Tools – Photo Gallery, Calculator, Location Maps, Notes<br>**Section E:** Contact Us<br>The design is considered the most significant aspect of the application since it uses a tiny screen and contains a lot of information. |
| 2 | System Installation and Maintenance | The designated mobile app will apparently be accessible on Google Play for Android users and the App Store for iOS users. The end users can then download it whenever it's convenient using their own devices. Users get unlimited access to this application. The developer commits to update this application on a regular basis through the developer's store account. Hence, users always use the most recent versions of the application thanks to this method. |
| 3 | Implementation | Installing the Android operating system for the actual mobile application is the research's final output. Below is a summary of the mobile application's design and development:<br>a) developing a framework for research<br>b) doing task analyses at each stage and navigating using the framework<br>c) discussing with instructional designers and IT specialists<br>d) revision and modification of instructions putting into practise, creating a prototype, and validating it with knowledgeable instructional designers |

In Figure 1, there are five phases involved in developing this mobile application as mentioned: (1) planning, (2) design, (3) development, (4) testing and integration and (5) deployment and maintenance. This mobile application chose and used *Appy Pie App Maker for Android*, which is one of the free mobile app builders that does not need coding.

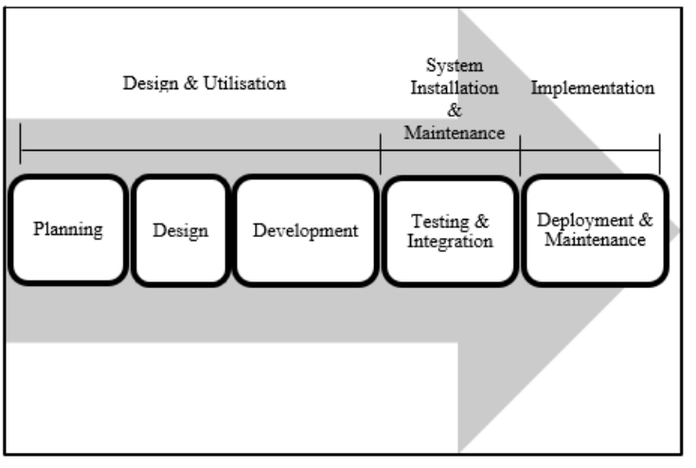


FIGURE 1. Mobile application development phases

A literature search on the present problems associated with defects tracking served as the foundation for the planning phase of the process. The next step was a brainstorming session with a practitioner to confirm the problem and seek input. Three case studies have been involved in order to test the application and readiness to trace bulk information at one time.

# DESIGN AND UTILISATION INTERFACE

## SECTION A: FRONT PAGE & MENU


FIGURE 2. Front page & Menu

In Figure 2, it shows the access needed to log in the application for security purposes since it will record confidential information on building character.

## SECTION B: ASSESSMENT CRITERIA

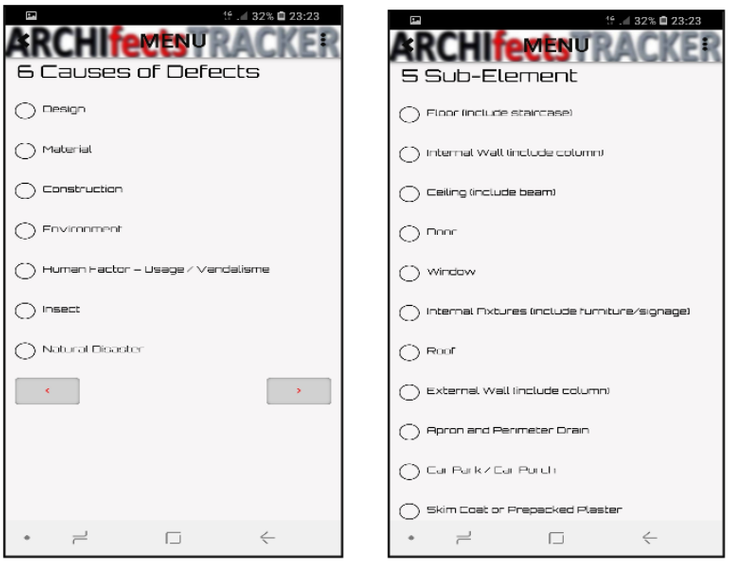


FIGURE 3. Criteria of Assessment (Sample)

This begins with the preparation of a checklist so that the analysis performed can assess the actual condition of the research building. The checklist is established based on several guidelines used at the national level (Refer Table 2). There are 11 assessment criteria that have been identified.

The result from building inspection will be transferred to a checklist according to 11 evaluation criteria namely defect classification, type of building, type of location, type of element, sub-element, causes of defects, defects categories, defect groups, type of defects, building condition level and priority level of repairs. Figure 3 shows a sample of checklist provided by the mobile application.

## SECTION C: RESULT

| No | Defect Classification | | Type of Building | | | | | | | | | Type of Location | | | Type of Element | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1a | 1b | 2a | 2b | 2c | 2d | 2e | 2f | 2g | 2h | 2i | 3a | 3b | 3c | 4a | 4b | 4c | 5a | 5b |
| 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 3 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 4 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 5 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 7 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 8 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 9 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 10 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 11 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 12 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 13 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 |
| 14 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 15 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 16 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 17 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 18 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 19 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 20 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 21 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 22 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |

FIGURE 4. Result from defect analysis

Once the building inspector has completed the assessment checklist, the data is saved and displayed in MS Excel sheet to provide quick results and reliable analysis (Figure 4). As a result, we were able to determine the most common entry for each criterion. For analysis enhancement, data can be transferred into SPSS software.

## SECTION D: POCKET TOOLS


FIGURE 5. Extra features under pocket tools

TABLE 2. Assessment criteria

| No. | Menu | Code | Item | References |
|---|---|---|---|---|
| 1 | Defect Classification | 1a | Major defect | Guideline of Inspection Criteria for Building Acceptance (PWD 2009) |
| | | 1b | Minor defect | |
| 2 | Type of building | 2a | Administration / Office Building | Common building in higher learning institution (as benchmarking) |
| | | 2b | Academic building / Faculty / Lecture Hall | |
| | | 2c | Hostel | |
| | | 2d | Islamic Centre (Mosque / *Surau*) | |
| | | 2e | Sport & Recreational Facility / Student Centre | |
| | | 2f | Cafeteria | |
| | | 2g | Health Centre | |
| | | 2h | Library | |
| | | 2i | Others building | |
| 3 | Type of Location | 3a | Principal Location | Construction Industry Standard CIS 7:2014 – Quality Assessment System for Building Construction Work (CIDB 2014) |
| | | 3b | Service Location | |
| | | 3c | Circulation Location | |
| 4 | Element | 4a | Internal Finishes | Construction Industry Standard CIS 7:2014 – Quality Assessment System for Building Construction Work (CIDB 2014) |
| | | 4b | External Finishes | |
| | | 4c | Material and Functional Tests | |
| 5 | Sub-Element | 5a | Floor (include staircase) | Construction Industry Standard CIS 7:2014 – Quality Assessment System for Building Construction Work (CIDB 2014) |
| | | 5b | Internal Wall (include column) | |
| | | 5c | Ceiling (include beam) | |
| | | 5d | Door | |
| | | 5e | Window | |
| | | 5f | Internal Fixtures (include furniture/ signage) | |
| | | 5g | Roof | |
| | | 5h | External Wall (include column) | |
| | | 5i | Apron and Perimeter Drain | |
| | | 5j | Car Park / Car Porch | |
| | | 5k | Skim Coat or Prepacked Plaster | |
| | | 5l | Wet Area Water – Tightness Test / Ponding Test | |
| 6 | Causes of Defects | 6a | Design | Guideline for Building Condition Assessment and Inspection (PWD 2008) |
| | | 6b | Material | |
| | | 6c | Construction | |
| | | 6d | Environment | |
| | | 6e | Human Factor – Usage / Vandalism | |
| | | 6f | Insect | |
| | | 6g | Natural Disaster | |

*continue ...*

*... cont.*

| | | | | |
|---|---|---|---|---|
| 7 | Defect Categories | 7a | Safety | Guideline of Inspection Criteria for Building Acceptance (PWD 2009) |
| | | 7b | Functionality | |
| | | 7c | Maintainability | |
| 8 | Condition Level | 8a | Very Good | Guideline for Building Condition Assessment and Inspection (PWD 2008) |
| | | 8b | Good | |
| | | 8c | Moderate | |
| | | 8d | Critical | |
| | | 8e | Very Critical | |
| 9 | Priority Level | 9a | Normal | Guideline for Building Condition Assessment and Inspection (PWD 2008) |
| | | 9b | Routine | |
| | | 9c | Repairing / Rectification | |
| | | 9d | Recovery / Restoration | |
| | | 9e | Replacement | |
| 10 | Defect Groups | 10a | Finishing | Construction Industry Standard CIS 7:2014 – Quality Assessment System for Building Construction Work (CIDB 2014) |
| | | 10b | Alignment & Evenness | |
| | | 10c | Crack & Damages | |
| | | 10d | Hollowness / Delamination | |
| | | 10e | Jointing | |
| | | 10f | Roughness | |
| | | 10g | Joints & Gap (Door / Window / Internal Fixtures) | |
| | | 10h | Material & Damages (Door / Window / Internal Fixtures) | |
| | | 10i | Functionality (Door / Window / Internal Fixtures) | |
| | | 10j | Accessories Defects (Door / Window / Internal Fixtures) | |
| 11 | Type of Defects | 11a | Crack | Guideline for Building Condition Assessment and Inspection (PWD 2008) |
| | | 11b | Dampness | |
| | | 11c | Fracture | |
| | | 11d | Peeling off | |
| | | 11e | Condensation | |
| | | 11f | Detach | |
| | | 11g | Withdrawn / Pulled out | |
| | | 11h | Break off | |
| | | 11i | Not Follow Specification | |
| | | 11j | Missing | |
| | | 11k | Fungus | |
| | | 11l | Mould Growth / Moss | |
| | | 11m | Plant Growth | |
| | | 11n | Insect / Termite Attacks | |
| | | 11o | Bent | |
| | | 11p | Sagging | |
| | | 11q | Misalignment | |

*continue ...*

*... cont.*

| | | | |
|---|---|---|---|
| | | 11r | Hit / Crashed |
| | | 11s | Swing |
| | | 11t | Leaking |
| | | 11u | Water Absorb / Penetrate |
| | | 11v | Faded |
| | | 11w | Tear |
| | | 11x | Settlement |
| | | 11y | Broken |
| | | 11z | Clogged |
| | | 11aa | Corrosion / Rusty |
| | | 11ab | Crusty |
| | | 11ac | Incline |
| | | 11ad | Hole |
| | | 11ae | Collapse |
| | | 11af | Rotten |
| | | 11ag | Deteriorate |
| | | 11ah | Tilted |
| | | 11ai | Dirty |
| | | 11aj | Blister |
| | | 11ak | Break up to Split Apart |
| | | 11al | Messy |
| 12 | Upload Photo | 12a | Insert Photo |

## CONCLUSION

This prototype offers a wide range of functionality to better serve the community. There may also be an emphasis on filling in gaps in the aspect of recording and reporting defect data so that they are more systematic. The distinctive characteristics of this product are as follows: (1) it combines three nationally recognized guidelines; (2) it includes 11 assessment criteria for the thorough information gathered; and (3) it is supported by extra features like a photo gallery, calculator, location maps, and site notes.

The prototype benefited society by enabling users to conduct inspections, creating a comfortable learning environment, being mobile-friendly, and gaining user feedback and awareness. As a result of the research, a virtual and adaptable mobile application for tracking building defects was successfully developed. Future research can be expanded to adapt the inspection method to diverse building types with extra attributes.

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