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Digitalization of OHS Management Process in Road Construction Projects with User-Centered Design Approach

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ABSTRACT IN ENGLISH

In Indonesia, workplace innovation in the context of Occupational Health and Safety (OHS) has great potential to shape the future of a safer and healthier workplace. One of the innovations in the workplace is the digitalization of the OHS management process. The proposed digitalization of the OHS management process is used as a system that documents and reports in an integrated and real-time manner related to the OHS management process in road construction. The need for a system that does not make workers overload information is very necessary and the system design must also be adjusted to user needs. The purpose of this study is to design the digitalization of the OHS management process in road construction projects with a User-Centered Design approach. Observation, interviews, and focus group discussions are used as data collection methods. The UCD is a design approach that focuses on user needs as the center of design. The stages are identification of user context, specification of user needs, solution design, and evaluation. The results obtained are that the designed digitalization has helped companies in controlling the risk of work accidents and helping companies in implementing a better OHS management system. In addition, the result of this research is a system design that documents and reports in an integrated and real-time way related to OHS management with a user approach, so that the issue of over-information can be minimized.

1. INTRODUCTION

Workplace innovation is one of the potential interventions to be implemented in improving Occupational Health and Safety (OHS). The development of digital technology is the background to research related to workplace innovation. This is based on the increase of Indonesia's digital society index by 5.38 in 2023. This is very important to prevent hazards and change from traditional approaches [1]. Research on workplace innovation in the context of OHS in Indonesia has great potential to shape the future of safer and healthier workplaces [2], [3].

Workplace innovation is not only technological innovation but also considers non-technological innovation that focuses on organizational design, management task design, and job design. One of the workplace innovations is digitalization in the OHS management process [4]. Digitalization of OHS management processes can make a significant contribution to increasing efficiency and effectiveness in preventing hazards [5], [6]. OHS management is the process of managing risks related to work activities and ensuring a safe work environment for individuals and organizations.

One of the industrial sectors that has high-risk occupations is the construction project. Based on a literature study, construction is an industry that has implemented many digital innovations for OHS [7]. One of the construction industry sectors that is the focus of this research development is road construction. Road construction is one of the constructions that is currently being developed in Indonesia to improve quality infrastructure to support economic growth. Road construction requires special attention to occupational health and safety. Preliminary research has been conducted to identify hazards in one of the road construction projects and how risk mitigation is designed [8]. Based on the results of observations and interviews, the organization only acts after an accident occurs and there has been no proactive action to prevent accidents. Thus, the digitalization of OHS management is one of the mitigations proposed in the preliminary study to prevent and reduce work accidents occurring on the road project. It is in line with the previous study that implemented digitalization in the risk register process to increase risk management effectiveness [9].

The proposed digitalization of the OHS management process is used as a system that documents and reports in an integrated and real-time way related to the OHS management process. The importance of an integrated and real-time system is created because the risks are increasingly complex and dynamic. In addition, this innovation is to increase efficiency and effectiveness in preventing the risk of hazards and creating a safe and healthy workplace. However, several issues have emerged which involve workers and organizations [5]. One of the important issues that needs to be considered is how digitalization does not provide a mental burden for workers, especially those directly related to the OHS management process. The need for a system that does not make workers overload information is very necessary and the system design must also be adjusted to user needs. Thus, the User-Centered Design approach is used in this study.
User-centered design (UCD) is a multidisciplinary design approach based on active user involvement to enhance the designer's understanding of user requirements and tasks [10]. Several previous studies have used this approach to design systems that are close to users and provide a better experience. This method is used in designing mobile applications in the field of public transportation and the government sector [11]. This method is also used in designing marketing systems [12], [13]. In the context of the construction sector, this UCD method is used in designing the digitalization of monitoring project activities. UCD approach is used in designing a dashboard for budget and resource management and loan system management construction equipment [14], [15]. Based on that, the study on the implementation of the UCD approach for conducting digitalization in the context of OHS management is still limited.

This study aims to design the digitalization of the OHS management process in road construction projects with the UCD approach. The output produced is a prototype of an OHS management system that is in accordance with user needs to provide comfort for users. This system is expected to be an innovation that can increase the effectiveness and efficiency of the OHS management system in preventing workplace hazards in road construction projects. This field is one of the opportunities in the application of digitalization as explained above. In the literature study presented, digital innovations developed in OHS such as smart wearable technology, AR/VR, wireless sensor devices, building information modeling, and so on [7]. In Indonesia, digitalization in construction projects is still designed in project activity reporting. Thus, this research has the potential to be a novelty in designing a system that documents and reports in an integrated and real-time way related to OHS management with a user approach.

2. METHOD

The approach used in this study is User Centered Design (UCD). The principle of this approach involves the user or stakeholder in the design process of the system. The design results are tested and iterated based on user feedback. The principle is defined well in the previous research where users are considered from the identification of user needs until the evaluation of the design [14]. This method has an important role in solving the problem because the method provides an approach that does not make workers overload information and the system design must also be adjusted to user needs. This method correlates with providing efficient working tools and working conditions to achieve success in OHS [16].

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Based on the Interaction Design Foundation (2016), the stages of UCD are identification of user context, specification of user needs, solution design, and evaluation.

2.1 Identification of user context

The identification of user context stage is the stage to identify who the users of the OHS management system are and what their characteristics are. Interview methods are used in this stage. Based on the OHS management process that was identified first, the stakeholders are the OHS Team, the head project, and the worker.

2.2 Specification of user needs

The specification of users needs the stage of identifying user specifications in achieving their goals. A focus group discussion is conducted between researchers and stakeholders where this stage focuses on the design of the system designed, based on the characteristics of each user. The technical response is identified as a specification that will be developed into a solution design.

2.3 Solution design

The solution design stage is the stage of designing a system design or prototype according to user specifications. A data flow diagram will be presented. The solution design can be in the form of a low-fidelity prototype or a high-fidelity prototype.

2.4 Evaluation

The last stage is the evaluation stage of the design that has been designed. This stage obtains feedback on where design improvements may be made according to the stages that require improvement. This method will be carried out in several iterations in building the system interface until a design solution is obtained that truly meets user needs.

3. RESULT AND DISCUSSION

Figure 1 shows the OHS management process in road construction projects based on observations and interviews. In the OHS management process, the parties involved are project workers, the OHS team, and the project head. The problem owner is the OHS team. This process includes planning, implementation, evaluation, and follow-up processes. Thus, the process has adjusted Plan, Do, Check, and Action (PDCA) where PDCA has been proven to create stability and continuous process improvement [17].

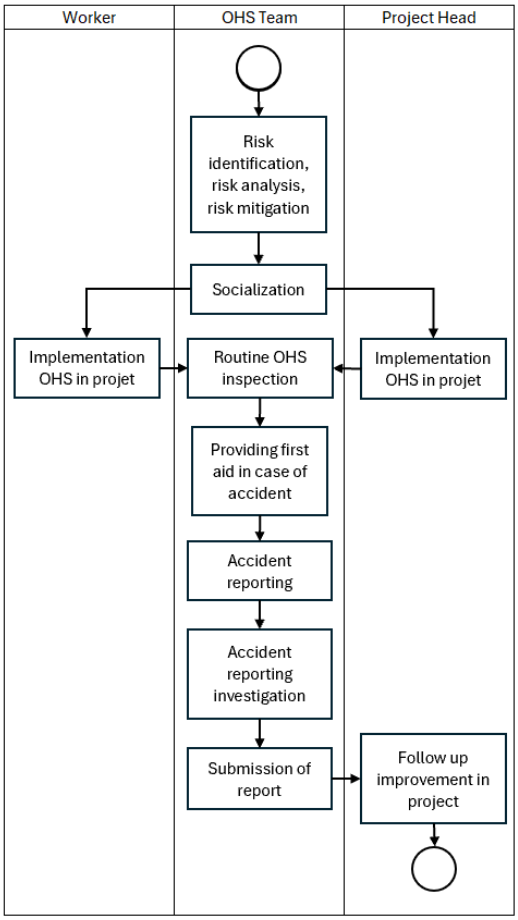


Figure 1 – OHS Management Process in Road Construction Projects

3.1. Identify User Context

Based on the OHS management process above, the users of the designed OHS management system are project workers, OHS teams, and project heads. The characteristics of each user in the process can be seen in Table 1 below.

Table 1 – User Characteristics

Users	Characteristics
Worker	Receive socialization related to OHS Access OHS-related information Obtain and use PPE Follow instructions regarding OHS Get help and protection related to OHS Get a safe and healthy working environment
OHS Team	Conduct risk identification, assess risk, and determine mitigation Conduct socialization regarding OHS information, including risks, their mitigation, and OHS instructions Conduct routine OHS inspections Assist in accident Conduct reporting and investigations related to accidents Create and submit reports
Project Head	Receive socialization related to OHS Access OHS-related information Obtain and use PPE Follow instructions regarding OHS Supervise the implementation of OHS Help determine mitigation Follow up on improvements within the project

3.2. Identify User Requirements Specifications

This stage aims to determine the specifications of user needs which will later be accommodated in the solution design. At this stage, this study integrates with the concept of product development by Ulrich et al. related to need statements and technical response [18]. Need statements or user needs are focused statements that describe the needs of the targeted user. The technical response is a technical response that will be developed into a design and adjusted to the needs that have been identified.

Table 2 - User Requirements Specifications

Users	Need Statement	Technical Response
Worker	Workers can access OHS-related information	Availability of OHS-related information in the system
OHS Team	The OHS team can identify risks, assess risks, and determine mitigation	Availability of risk control forms Availability of accident interview format Availability of root cause analysis format
	The OHS team can carry out routine OHS inspections	Availability of checklist sheet for use of PPE Availability of project area inspection checklist sheet
	The OHS team can report incidents	Availability of work accident reporting forms
	The OHS team can submit reports	Availability of OHS report submission form
Project Head	The project head can access OHS-related information	Availability of OHS-related information in the system
	The project head helps determine the mitigation	Availability of access to risk control forms
	The project head can follow up on improvement	Availability of access to OHS reports

3.3. Design Solution

The next stage is the design of a solution that has been adjusted to the technical response. A data flow diagram presents a visual representation of the flow of data in a system. Figure 2 shows the data flow diagram. In designing the solution design, this study uses Linktree media which is a platform that allows you to create a single link but contains a list or links to several other sources. This media is very suitable for design needs where each user has their own needs but is expected to be easily accessed in one process link. Several studies have used this platform as a practical and effective media in learning [17],[18].

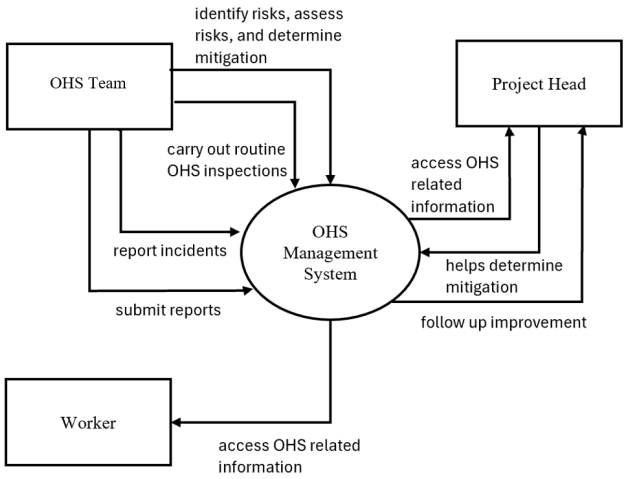


Figure 2 - Data Flow Diagram

Figure 3 below is the home page for the digitalization system of OHS management. The system contains links for each user's needs such as the availability of OHS information, the availability of risk control formats, the availability of OHS inspection forms/checklists, and the availability of reporting systems.

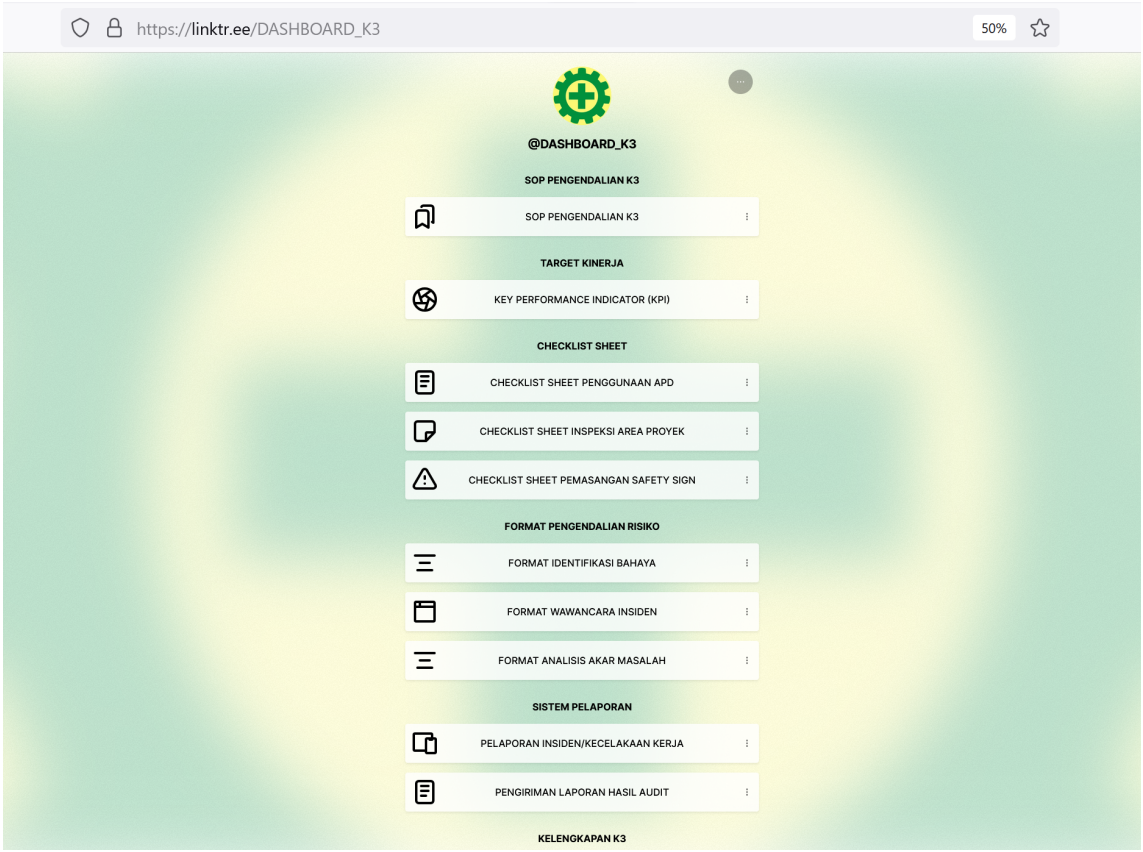


Figure 3 – Home Page of the OHS Management System

Based on the technical response in the form of the availability of OHS information, this system provides information related to OHS control SOPs, key performance indicators (KPIs), OHS procedures, and Job Safety Analysis forms which can be accessed by all users. Figure 4 shows the part of the Standard Operating Procedure (SOP) of the OHS Management Process in Road Construction that is informed in the system.

STANDAR OPERASIONAL PROSEDUR
PENGENDALIAN K3 (KESEHATAN DAN KESELAMATAN KERJA)
PROYEK KONSTRUKSI JALAN

ALUR PROSES PENGENDALIAN K3 PROYEK KONSTRUKSI JALAN

Tahapan	No	Aktivitas	Pelaksana			Kelengkapan	Output	Keterangan
			Pekerja	Tim K3/Safety Officer	Kepala Proyek			
PLAN	1	Mulai						
	2	Melakukan identifikasi risiko				- Data historis kecelakaan kerja - Format pengisian identifikasi bahaya	Dokumen identifikasi bahaya	
DO	3	Sosialisasi mengenai analisis risiko				Dokumen Hasil Identifikasi Bahaya	Pengetahuan mengenai potensi bahaya di tempat kerja	
	4	Inspeksi rutin K3				Checklist sheet penggunaan APD, Inspeksi area proyek, dan pemasangan safety sign	Dokumen hasil pemeriksaan K3	
	5	Pertolongan pertama jika terjadi kecelakaan kerja				- Laporan Kejadian - PJK	Penanganan kecelakaan kerja	
	6	Pelaporan kecelakaan kerja ke dashboard				Form dan sistem pelaporan	Laporan dan dokumentasi kecelakaan kerja	
CHECK	7	Observasi dan investigasi kecelakaan kerja				Lembar atau format untuk wawancara dan dokumentasi kecelakaan kerja	Laporan investigasi dan penilaian risiko	
	8	Analisis akar penyebab kecelakaan kerja				Lembar atau format untuk wawancara dan dokumentasi kecelakaan kerja	Penilaian risiko dan rekomendasi tindakan perbaikan	
ACTION					A			

Figure 4 – Standard Operating Procedure (SOP) of OHS Management Process as the Availability of OHS Information in the System

Furthermore, for the availability of risk management formats, this system provides risk control forms, accident interview formats, and problem analysis formats. Figure 5 below is a risk control form containing hazard identification, risk assessment, and mitigation recommendations. Hazard identification, risk assessment, and determining control (HIRADC) are used as an approach in creating this risk management form and could be accessed by the OHS team and project head [6]. Risk management is one of the processes in OHS management [19],[20].

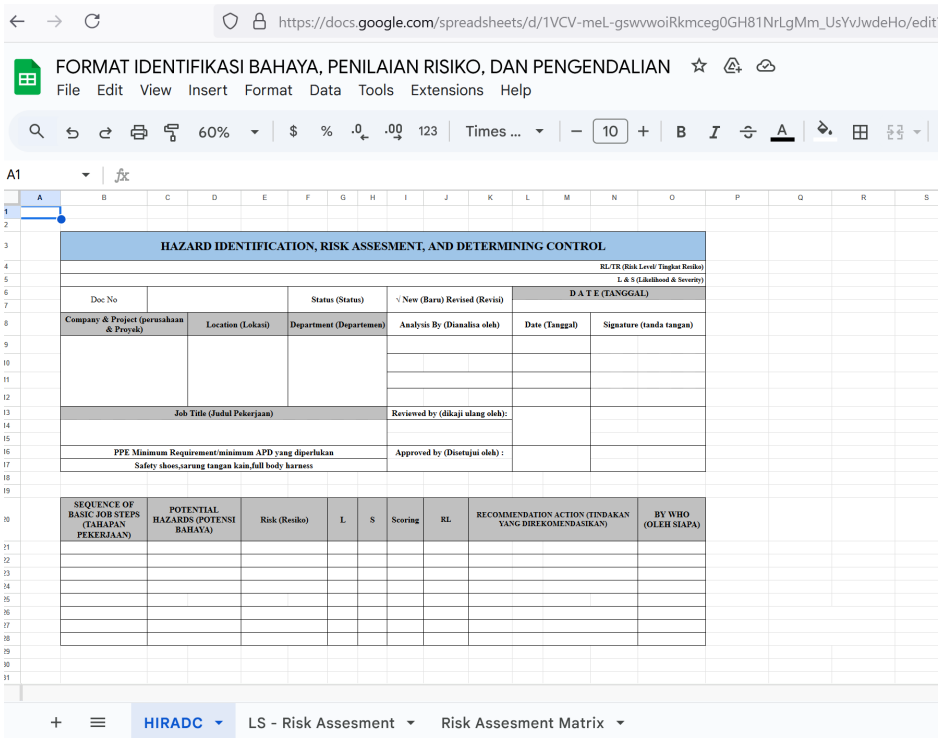
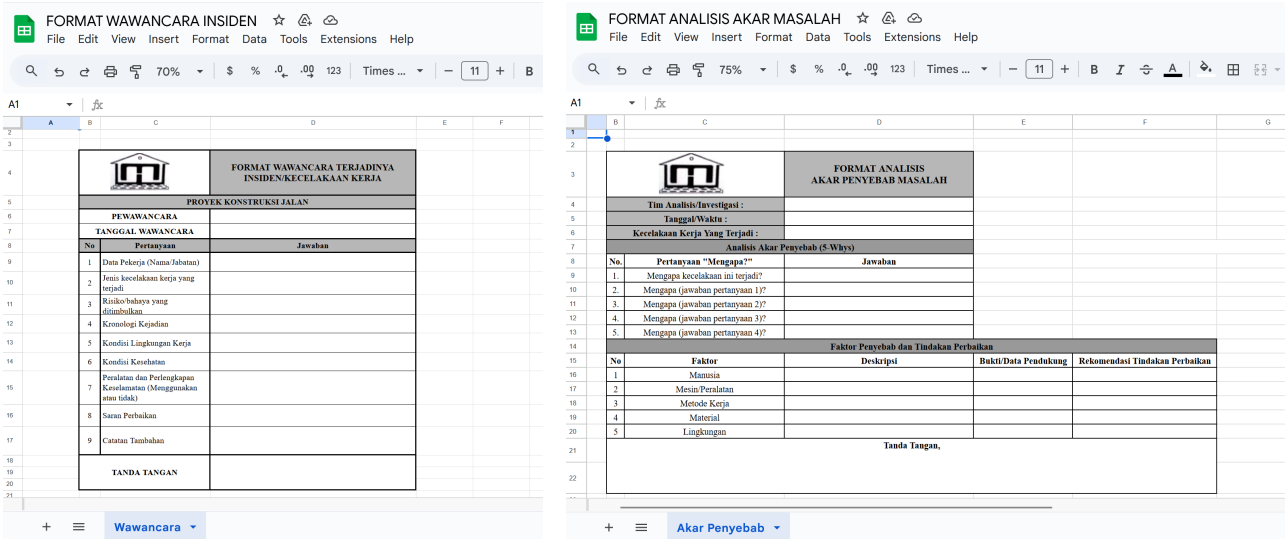


Figure 5 – Risk Management Form

Next, Figure 6 is the accident interview format and problem analysis format. Both are used to help identify the root cause of the accidents by the OHS team. The accident interview format contains 5W+1H questions.

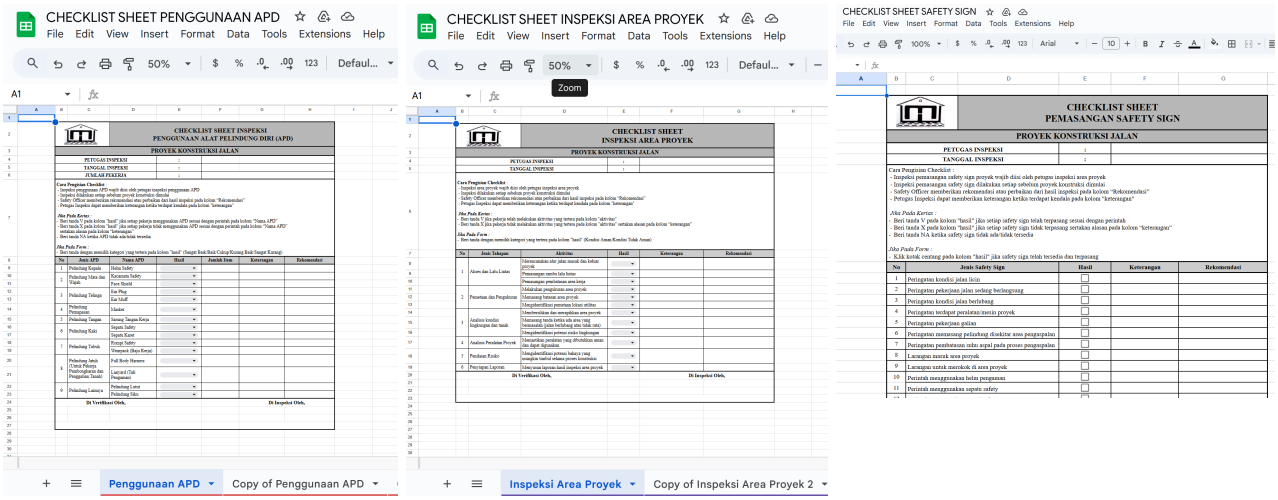


(a) **(b)**

Figure 6 – (a) Incident Interview and (b) Root Cause Analysis Format

Figure 7 shows the routine OHS inspection checklist form by the OHS team in the form of a checklist for the use of PPE, a project area inspection, and an inspection of safety sign installation. The PPE inspection checklist aims to ensure that workers use PPE following the provisions and to assist the OHS team so that this PPE is carried out consistently during the project. The project area inspection checklist aims to monitor and ensure that the workplace is safe, orderly, and in

accordance with standards so that the project can be implemented. Meanwhile, the safety sign inspection checklist aims to ensure the installation of safety signs in the project that help inform and warn about the potential hazards in the project area. The previous research states that the OHS inspection process is one of the indicators that affect job satisfaction [23]. This also answers the needs of previous research which requires standardization of the work environment according to the company's needs [24].



(a) **(b)** **(c)**

Figure 7 – Routine OHS Inspection Checklist Form for (a) APD (b) Project Area (c) Safety Sign Installation

Figure 8 shows the availability of an accident reporting system by the OHS team. This form helps in documenting accidents which will later be used in risk management. The form defines when the accidents happen, and the type of accident.

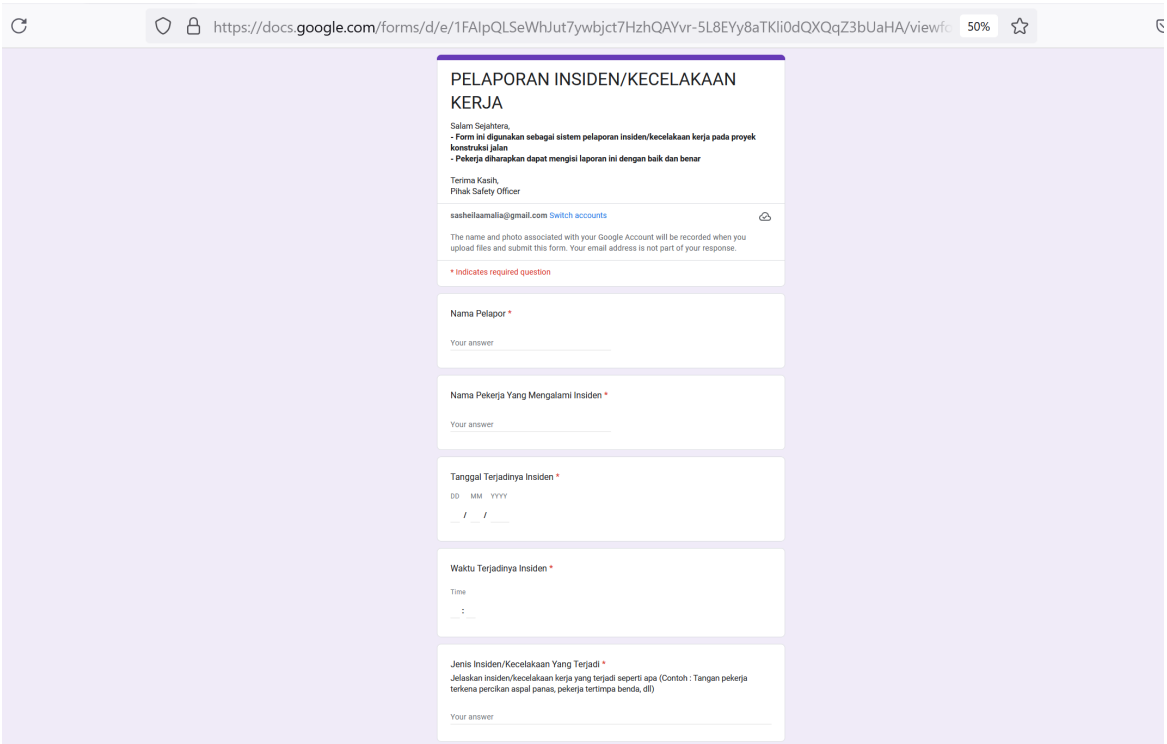


Figure 8 – Incident Reporting System

3.4. Evaluation

The next stage is the design evaluation. This evaluation process aims to ensure that the design results are in accordance with the needs of the company's stakeholders and can help reduce existing problems in the company. This process is carried out through practice and interviews with stakeholders. The results obtained that the designed digitalization has

helped the company in controlling the risk of work accidents and helping the company in implementing a better OHS management system. This is in accordance with previous research where the integration of digital technology into the OHS domain can significantly reduce accidents in the workplace [25].

From the stages above, the UCD approach can provide a solution design from digitalization that is in accordance with the needs of users and companies. Therefore, the issue of over-information can be minimized.

4. CONCLUSION

This study aims to design the digitalization of the OHS management process in road construction projects with the UCD approach. Based on the results above, digitalization is able to control the risk of work accidents and help companies implement the OHS management system. Thus, this research has the novelty of designing a system that documents and reports in an integrated and real-time manner related to OHS management in construction projects with a user approach. UCD approach can provide a solution design from digitalization that minimizes over-information. The limitation of this research is that interface design testing has not been carried out and the iteration has been conducted by user feedback. Further research is expected to be able to conduct evaluations using user experience testing to maximize design results.

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