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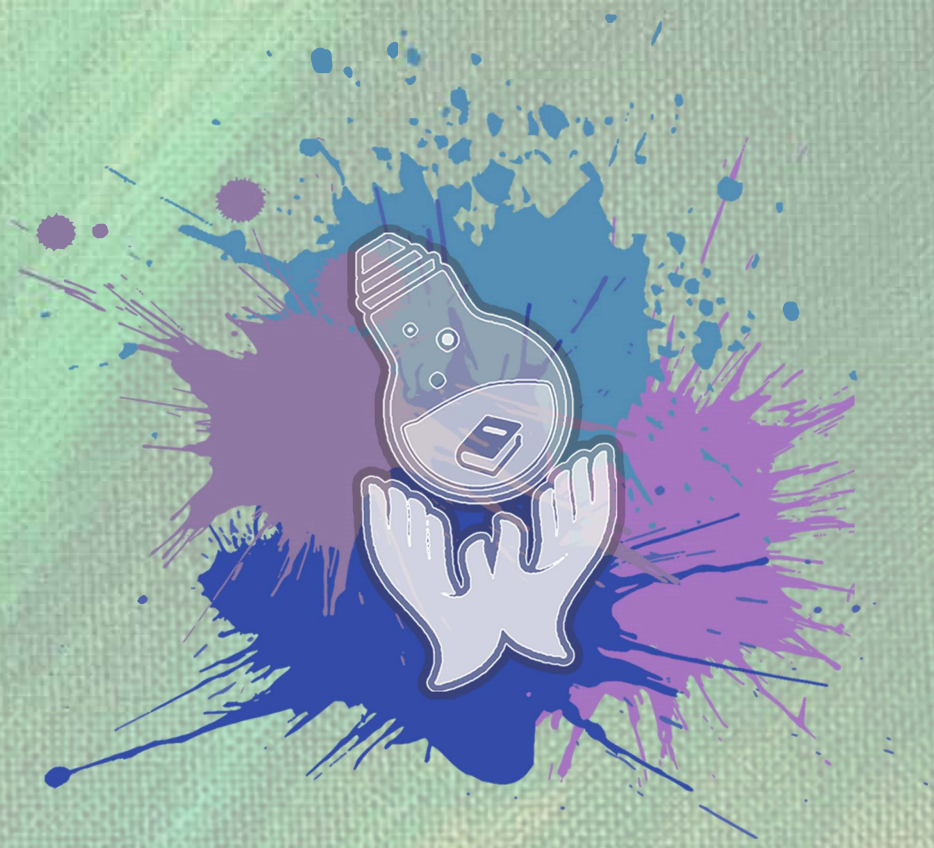

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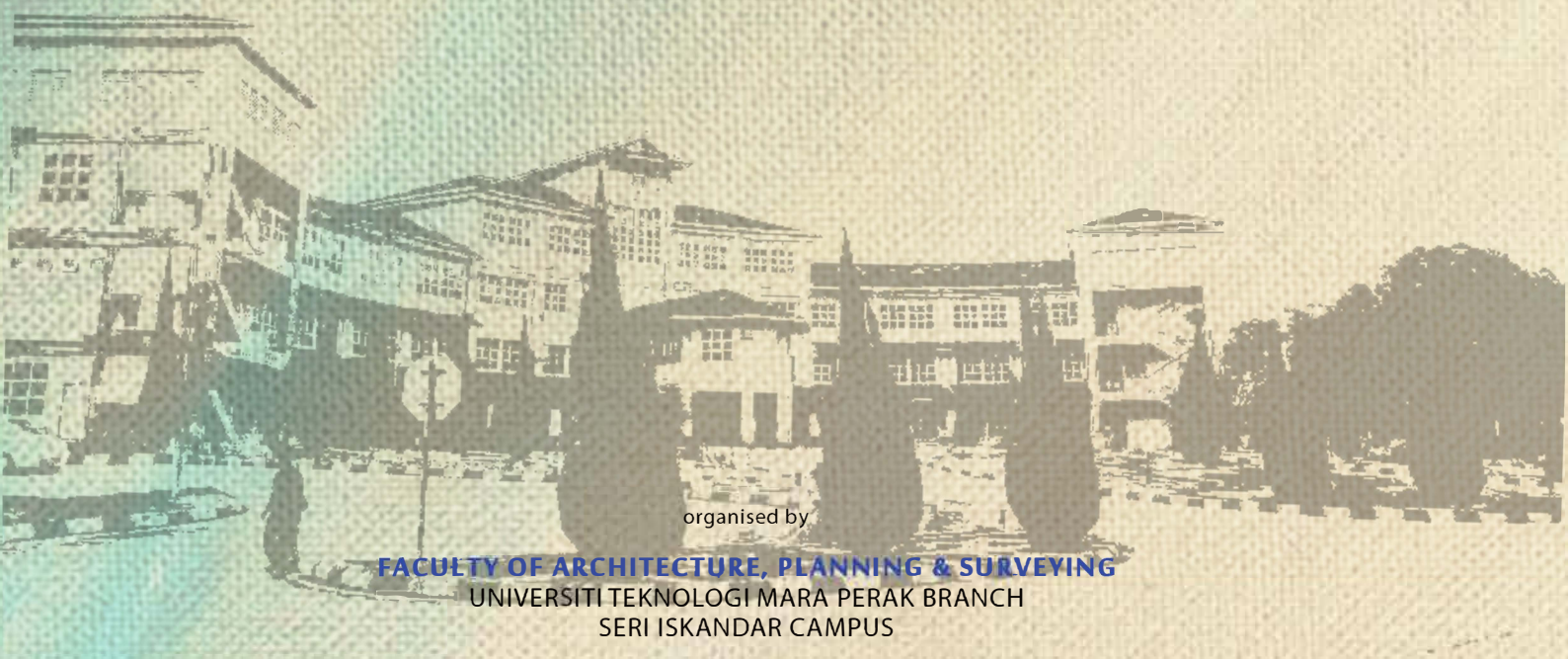

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DEVELOPING AN IDEA OF PRECAST CONCRETE INSTALLER (PCI) ROBOT

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Abstract:
The implementation of Industrialized Building System (IBS) has increasingly widespread as the government emphasized the importance of prefabricated process in IBS Roadmap. Somehow, the installation of precast concrete wall (PCW) may occur problems such as time delay, labour intensive, varies in output of product positioning and safety issues as manual handling methods are involved. Therefore, a new innovation idea called Precast Concrete Installer (PCI) Robot is made as a solution to the problems identified. The objectives of the research are to identify the current issues and problems on the installation process of PCW, to determine various innovation approaches and to propose a new innovation idea on improving the installation process of PCW. In order to achieve the objectives, the method used to conduct the research is desk study on the relevant topics related to the PCI Robot. Therefore, the critical review will become the basis of a new concept for PCI Robot to solve the problems identified. From the review, it was found that the innovative approaches to the PCI Robot may include erection crew, auxiliary tools and machineries. Therefore, the PCI Robot is expected to enhance the safety environment as well as quality for the future construction purpose.

***Keywords*:**
Industrialized Building System; Installation process; Precast concrete wall; Robot; Safety environment.

1.0 INTRODUCTION

The application of innovation and technology in the construction industry may enhance the workability, efficiency and reduce time delay in construction works. Technology in IBS is believed to produce fast and high quality end-product for consumers. IBS may include off-site prefabrication and on-site installation. It is very important to follow the consequences of IBS stages precisely. Therefore, the research is only focused further on the installation stage of PCW. Commonly, contractors will be the most important parties involved during the installation stage.

Time delay, labour intensive, varies in the output of product positioning and safety issues would be the problems faced during the installation stage of PCW as it involves manual handling. Construction robotics may enhance the safety of manual labourers on site as robotics could conduct dangerous tasks (Feng et al. 2015). In addition, the quality of a product may increase by implementing robotics application as construction tasks involve repetitive work and the need of Human-Robot Work Collaboration (HWRC) (Feng et al. 2015 and You et al. 2018). Therefore, proper design and features of innovation idea have to be done specifically for construction technology. Thus, the PCI Robot for installation stage of PCW is aimed to enhance safety environment and minimize time consuming which is also sustainable for the environment.

2.0 LITERATURE REVIEW

Although IBS may seem to ease the process and increase the efficiency of the precast construction work, some important aspects are still inevitable and need to be considered. The innovation and enhancement towards better improvement on automation may affect the speed of construction and reduce time delay by following the project schedule. Therefore, a new concept of PCI Robot is made to minimize the current issues and problems.

2.1 Issues and Problems

As the current installation of PCC is manually done, the process may contribute to time delay as it involved manpower and some equipment in order to erect the component to its place. Apart from that, the migration of foreign labours from another country increased the numbers of unskilled worker in the construction industry which may lead to labour intensive. Other than that, human errors can be found in construction due to several factors. As a result, damage such as cracks and corners chipped-off may occurred due to knocking during handling. Also, safety issues stay critical to the construction industry due to its working environment and the difficulty of working practices (Heap and Thuan, 2014).

2.2 Development of Precast Concrete Wall Installation Process

The installation stage of precast components begins with setting out, lifting and installation, grouting work and joint casting and sealing (BCA, 2017). Ensuring a safe procedure during installation of precast concrete wall is vital to avoid unsafety condition such as accidents to occur on construction site. Therefore, it was found that there are four stages of installation of precast concrete wall on site which consists of lifting process, welding process, grouting process and bracing and placing process (Shaari, Zaki, Muhamad & Ayob, 2016). However, the current methods may contribute to safety issues and time consuming as it involves manual handling. Therefore, it is possible for robot technologies to enhance the installation process of the PCW to solve the problems occurred.

3.0 METHODOLOGY

Research methodology process includes a number of activities to be performed. Desk study is used to obtain information on the issues and problems of the installation process of PCW. Apart from that, a critical review on the existed method and technology related to the installation stage of PCW has been done. Also, a simulation of the PCI Robot is made to visualize the design and ideas with the assembly demonstration and an operational demonstration.

4.0 ANALYSIS AND FINDINGS

The expected outcome of the inovation will be analyzed by using the comparative analysis between current existed technology available in the industry and the design of the innovation idea made. Thus, the expected outcome is aimed to provide solutions to the stated issues and problems in the installation process of PCW.

4.1 Issues and Problems

Time consuming was found to be one of the problems during the installation process of PCW. The typical estimated time to install a precast concrete component requires from 30 to 45 minutes (BCA, 2017). Therefore, a total number of 16 PCW could be installed at rate of 8 hours per day which may cause time delay. Indonesian labours which are 71.3% of the foreign labours are unskilled workers who did not perform to any skill work (Adi and Wibowo, 2009). Apart from that, human is likely to gain stress, mental strain, tired and lassitude (Wang, Kemeny, Vancza and Wang, 2017). Human's behaviour may cause varies in the output of the product when using manual handling method. Safety issues are also another problem to be considered during the installation stage. The result has shown 64.3% of the respondents who experiences in IBS construction for 1 to 3 years, agreed that manpower are the main factor that cause an accident specifically during the installation of PCW on site (Zaki et al., n.d).

4.2 Various Innovation Approaches

Since precast components involve modern construction techniques, the process of installation may not be as complicated as conventional method of concreting where more tools and machineries are needed. Erection crews in installation of PCC refer to the labour involved during the process of handling, erecting and positioning of precast components. While auxiliary tools may be considered as the conventional equipment involved in the manual handling method of the installation of PCC. Auxiliary tools may include ladder, scaffolding, bracing or push-pull props and wire ropes.

Apart from that, machineries are also another innovation approaches in the installation of PCC. Cranes are used to carry heavy loads and materials for the movement of heavy materials (Bygging Uddemann AB, 2016). Besides, hoisting platforms have also been used which are suitable for the positioning of

components. In addition, the forklift is a small truck controlled by an operator which has been used in material handlings to carry a unit of material and place the component to the location.

4.3 Proposed Innovation Idea

The PCI Robot is an autonomous mobile robot where an integration between two systems are applied to minimize time consuming in the installation process of the precast concrete wall and provide an efficient method of working in handling. The PCI Robot may help in providing a better grip with the received components to ensure the component is in a balance state. As the components have been designed based on the drawings, there will be specific places for each component. Therefore, the PCI Robot may also ensure a safer grip to the component to minimize defects of concrete and place it accurately to the specified position.

Table 1: Comparison between the challenges of current innovation approaches and features of PCI Robot.

CHALLENGES İN CURRENT INNOVATİON APPROACHES	FEATURES OF PCI ROBOT TO SOLVE CHALLENGES
Erection crews contribute to labour intensive and inaccuracy of product output by using manual handling.	Enhance accuracy and safer grip to replace manual handling.
Auxiliary tools cause time delay and safety issues.	Provided with automatic lifting crane and automatic crane hook as auxiliary tools to minimize safety risk
Machineries enhance the risk of accident to the labours.	Provided with components with various technologies including self-learning machine to conduct the given task.

5.0 CONCLUSION

In conclusion, the innovation idea was created due to the identifying of current issues and problems on the installation process of PCW. The methods involved in the installation process of precast components shows the need of new technology in automation in order to increase the safety environment, speed and productivity of the installation process.

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