POLITEKNIK UNGKU OMAR

THE EFFECTIVENESS OF THE AUTOMATED SOLAR-POWERED ROAD BARRIER SPECIALIZED FOR CONSTRUCTION SITE

MUHAMMAD YUSRI BIN MOHD SALIM LIM

(01BCT20F3020)

CIVIL ENGINEERING DEPARTMENT

SESSION 2 2022/2023

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A project report/thesis submitted in partial fulfilment of the requirements for the award of Bachelor of Civil Engineering Technology with Honours

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STATEMENT OF AUTHENTICITY AND PROPRIETARY RIGHTS

THE EFFECTIVENESS OF THE SOLAR-POWERED ROAD BARRIER SPECIALIZED FOR CONSTRUCTION SITE

1. **I, MUHAMMAD YUSRI BIN MOHD SALIM LIM (NO KP: 980418-02-5907) am a student of Bachelor of Civil Engineering Technology, in Politeknik Ungku Omar, at the address Jalan Raja Musa Mahadi, 31400 Ipoh, Perak.**

2. I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged.

3. I hereby agree to let go the intellectual property ownership of this project to Ungku Omar Polytechnic in partial of the requirement for the award of the **Bachelor of Civil Engineering Technology with Honours.**

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As the project supervisor, dated:)

APPRECIATION

In the name of Allah SWT, most gracious, most merciful, peace and blessing be upon Prophet Muhammad SAW. Firstly, I would like to offer my deepest gratitude towards Allah SWT because of His Grace and His Guidance which I can successfully complete this report “The Effectiveness of the Automated Solar-Powered Road Barrier Specialized for Construction Sites.

Thank you to my family and friends for their continuing support and encouragement which make me who I am today. Their belief in me, their sacrifices, and guidance motivates me to strive for excellence and to overcome challenges with determination and resilience. I am truly feel blessed to have such a loving and supporting family and I am forever will be grateful for their unwavering faith in me.

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Thank you.

ABSTRACT

Road accidents in construction sites not only result in human injuries and fatalities but also lead to project delays, increased costs, and legal implications. The Automated Solar Powered Road Barrier is an accessory equipped with night-time lighting that has been innovated as an improvement to the existing temporary road barrier. This innovation uses solar energy that will be charged into storage batteries and also capable of Flip Flop functionality that can affect the sensitivity of a person. The objective of this study is to improve the visibility of existing road barriers, especially at night. The effectiveness of this innovation is tested by conducting the lighting stage experiment. It is found that the Automated Solar Powered Road Barrier has the potential to increase road safety factors while reducing traffic accidents. A set of questionnaires has been distributed to 50 respondents from various backgrounds for collecting information. The prototype has been tested and reviewed by the respondent consists of construction manager, project manager, site engineer and site supervisor. The effectiveness of the prototype was testedusing Scientific Lux Meter. The test result showed that the prototype has a significant differencecompared to the existing road barrier. This prototype was proven to be more effective and suitable to be use on site construction road.

ABSTRAK

Kemalangan jalan raya di tapak pembinaan bukan sahaja mengakibatkan kecederaan dan kematian manusia tetapi juga membawa kepada kelewatan projek, peningkatan kos dan implikasi undang-undang. Penghalang Jalan Berkuasa Suria Automatik ialah aksesori yang dilengkapi dengan pencahayaan waktu malam yang telah diinovasikan sebagai penambahbaikan kepada penghadang jalan sementara sedia ada. Inovasi ini menggunakan tenaga solar yang akandicas ke dalam bateri simpanan dan juga berkeupayaan dengan fungsi Flip Flop yang boleh menjejaskan sensitiviti seseorang. Objektif kajian ini adalah untuk meningkatkan jarak penglihatan penghadang jalan sedia ada terutamanya pada waktu malam. Keberkesanan inovasi ini diuji dengan menjalankan eksperimen peringkat pencahayaan. Didapati Automated Solar Powered Road Barrier berpotensi meningkatkan faktor keselamatan jalan raya sekaligus mengurangkan kemalangan jalan raya. Satu set soal selidik telah diedarkan kepada 50 orang responden daripada pelbagai latar belakang untuk mengumpul maklumat. Prototaip telah diuji dan disemak oleh responden terdiri daripada pengurus pembinaan, pengurus projek, jurutera tapak dan penyelia tapak. Keberkesanan prototaip telah diuji menggunakan Scientific Lux Meter. Keputusan ujian menunjukkan prototaip mempunyai perbezaan yang ketara berbanding penghadang jalan sedia ada. Prototaip ini terbukti lebih berkesan dan sesuai digunakan di tapak pembinaan jalan.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

The last two and three decades have seen the use of road furniture in Malaysia increasing. This street furniture is an object that helps and facilitates traffic in a certain area so that it runs more smoothly. Among the road furniture that can be seen in Malaysia are overpasses, streetlights, temporary road barriers and others. This type of road furnitureshould be in used situations to prevent pedestrians, cars, lorry or machineries from accessing dangerous and closed areas.

The road furniture to be discussed is a plastic road barrier. These temporary road barriers have many shapes such as boxes, cones, cylinders and others. The use and importance of these temporary road barriers is to change driving lanes while repair work is being carried out. In addition, it can become a barrier if the road is damaged and has notbeen repaired. These plastic road barriers are the crowd control device of choice because they are UV resistant, easy to move, and come in a modular design. These barriers are easyto deploy, and they have a twisting feed at the bottom of each device to

The temporary roadblocks used are box-shaped and red or white. The materials used are based on plastic, rubber (Elastomer), PVC and PE. One of the reasons these materials are chosen for use is based on their suitability for the environment. These temporary road barriers also have weights to ensure durability when blown by the wind or when facing vehicles. The weights used are moist sand, water and concrete.

The plastic road barrier is also widely used in construction site areas. Construction sites are a dangerous area, and this danger increases whenever a construction project takes place near an active roadway with traffic nearby and also in the site itself wherethere are many roads closure for various works such as excavation of soil or any concreting works. As construction projects increase and more activities such as machineries and lorries are on play, the use of plastic road barrier is more critical than ever before to maximize the safety of construction workers, machine operators and drivers.

Therefore, the use of temporary road barriers is very important in construction areas to avoid various unforeseen possibilities. This temporary roadblock should be upgraded in various aspects. One of them is the aspect of visibility.

1.1 PROBLEM STATEMENT

Road markings have become an important and inseparable part of road infrastructureand one of the common safety elements around the world (Li et al., 2017). Temporary road barriers are one of the elements in the category of road furniture that work to help guide roadusers and prevent users from passing through areas that are undergoing maintenance. However, these temporary roadblocks are sometimes one of the main contributors to accidents.

However, this particular sector of the economy and specific uses for safety barriers solely pertain to accident prevention in terms of facility operations. More injuries and fatalities occur at construction sites than during operations, including those that are underground. Despite this, the building industry has paid less attention to the monitoring of danger energy and safety barrier analyses. With complicated technical and organizational settings, a changing environment, and people, there are many research problems in this field that need advanced approaches and strategies to further develop preventive measures (Karim et al., 2017).

The existing temporary roadblocks have a moderate level of visibility, especially at night. The visibility is decreasing especially in cloudy, rainy or at night. This situation can get worse if the driver is tired, sleepy or lacks focus. Accidents can happen when the driver notices the existence of a temporary roadblock when the distance is too close. The fact that the drivers change the position of the vehicle to be closer to the edge of the road when the road is marked with center and/or edge lines was also recorded in a 2004 study (Davidse, 2004).

On two-way roads, where it has been demonstrated that the vehicles are systematically linearly moving away from the center line, changes in the lateral position of the vehicle have been seen in particular. It begins when the distance between the vehicles isbetween 2.5 and 4 seconds apart, and it gets bigger as they get closer. This is due to an increase in the driver's sense of safety while driving on a road containing road markings, since they provide information on the road trajectory, thus allowing early identification of road areas that may constitute a hazard for road safety, such as curves & intersections.

Generally, as part of the traffic control plan, road markings delineate the traffic surface by using lines, text, and symbols to provide visual guidance information for road users (Babić, 2016). Therefore, this innovation is carried out to increase the level of visibility of road users against temporary road barriers, especially at night. These temporaryroadblocks will be upgraded by placing solar-powered LED lights so that they can be seen from a greater distance.

1.2 OBJECTIVE OF STUDY

Based on the introduction and problem statement that has been clarify above, the areseveral objectives of this project that are crucial in making this project become beneficial and successful.
The objectives of this study are:

1. To identify the visibility of the road barrier using Lux meter.
2. To develop a system that is automated road barrier using in a project.
3. To evaluate the effectiveness of the automated road barrier in project.

1.3 SCOPE OF STUDY

The scope of this study focuses on road of construction sites that are full of turn and cornersthat are dangerous due to low visibility of any drivers not only for drivers of concrete trucks but also for any machine operator such as backhoe and also excavator that are working on night shift. This project scope was implemented at 19B Warehouse which is a proposed development of two story warehouse in phases consist of Parcel A1 and Parcel A2 on part of the Lot 109363, Persiaran Bukit Raja Kayangan/KU5, Kawasan Perindustrian Bandar Bukit Raja 2, Mukim Kapar, Daerah Klang, Selangor Darul Ehsan.

The road barrier acting as street furniture was defined by examining what constitutes obliquitous street furniture and how it came to be introduced, by identifying its expected roles, by examining basic patterns of human street behavior. Surveys were conducted in this study in order to allow an analysis of how it will become impactful to road users.

As a mean of to improve its reliability and workability, the survey was be conducted as person-to-person interviews combined with few set of questions in a questionnaire, thereby reducing any statistical errors, and observational surveys will also introduced to add reliabilityto the results of the survey analysis.

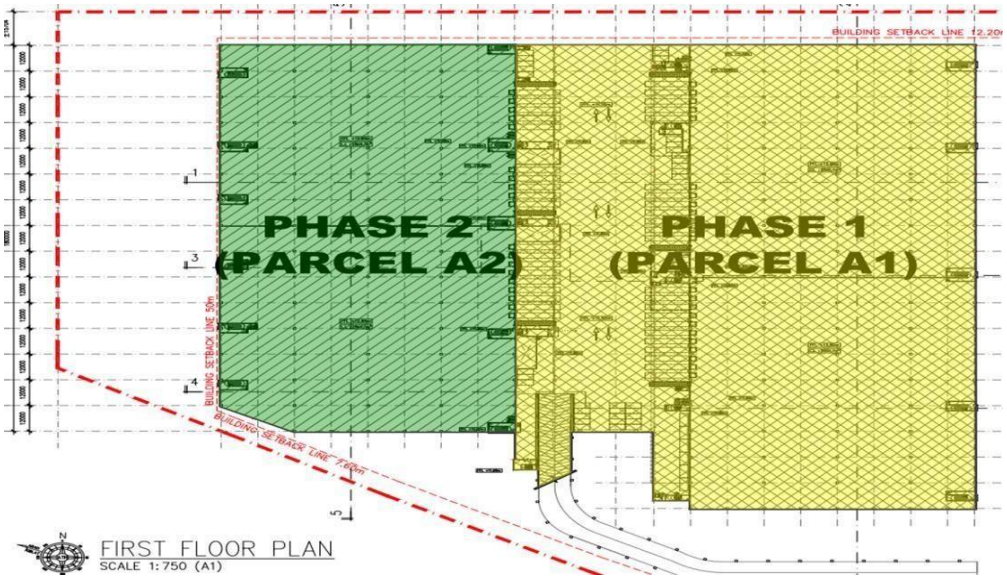

Figure 1.1: Site Overall Plan

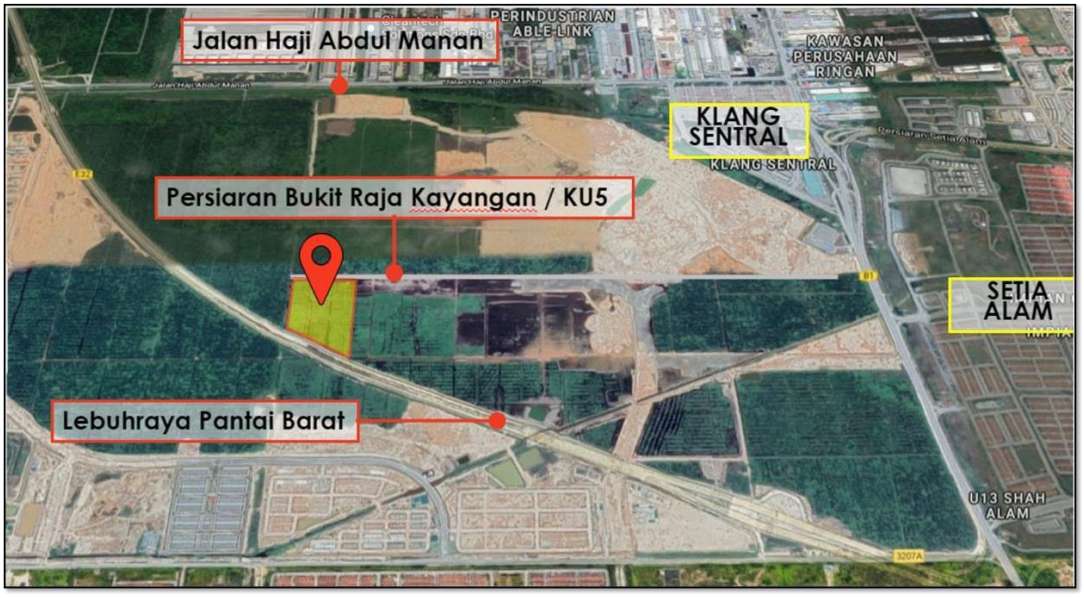

Figure 1.2: Site Location

1.4 SIGNIFICANT OF THE STUDY

The importance of this study is to improve the visibility of temporary road barriers so that the innovative road barriers can be seen easily at night. These temporaryroad barriers are designed to be used in road repair areas as well as in construction areas related to roads. It is also one of the measures to increase the sensitivity of driversespecially at night. With the innovation of temporary road barriers, the level of visibility at night can be increased to reduce the probability of accidents caused by temporary road barriers, especially in the construction sites area. With this innovation and improvement, it will help drivers and also machine operators to be working with ease and full swing at night without any constraints due to lack of visibility to maneuver their machine at nighttime.

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

The term of street furniture includes all objects on the road that are used for safetyand traffic control in addition to assisting drivers. Road furniture provides drivers with warnings, rules, distances and information necessary for safe road and road travel. Road furniture is divided into six types, namely road markers, guide signs, safety barriers, lightpoles, border fences, road markers (Chechar, 2006).

This literature review focuses on road barriers, which are temporary road barriers.Temporary road barriers barriers are an important element in road furniture especially when some construction is being done or road repairs are being done. A temporary road barrier is generally an object that is used to separate and flow oncoming traffic, to isolate objects on the side of the road (trees, buildings, water reservoirs and others) from possible interactions with vehicles that can cause accidents, and prevent animals enter the road (Paeglitis, 2012).

Temporary road barriers can be found in construction areas and in road improvement areas (Thiyahuddin, 2014). It is used as a warning to drivers who drive in that area of the road to be more careful in that area. If the driver cannot see the temporary roadblock, there is a possibility of a traffic accident occurring in that area because the driver's vehicle has hit the road barrier.

Temporary road barriers have undergone many developments since the introduction of various types of road furniture. The use of these barriers can actually causemore harm than good if improperly planned by engineers (Grzebieta, 2005). Therefore, temporary road barriers need to be subject to several evaluations and standard checks to ensure that these barriers do not pose a danger to passengers in the vehicle and to the environment.

2.1 Categories of Road Barriers

Road barriers are divided into two categories, namely permanent road barriersand temporary road barriers. Both are used as appropriate in a certain place on the road.

2.1.1 Permanent Road Barriers

Figure 2.1: Examples of permanent roadblocks

A permanent roadblock is a roadblock that remains in a certain place, and itcontinues to remain there and cannot be changed.

2.1.2 Temporary Road Barriers

Figure 2.2: Examples of temporary roadblocks

A temporary roadblock is a roadblock that is temporarily in a certain place. It can be changed from one place to another. Temporary roadblocks are used only when necessary. It can be found in road improvement areas, road construction, and when a road accident occurs in a certain place.

2.1.3 Types of Roads Barriers

Road barriers are divided into two groups, namely flexible and rigid barriers. These road barriers are selected according to the suitability of the road and the environment. To ensure that these road barriers are safe and effective, they have undergone simulation and crash tests before they are approved for general use.

2.1.4 Flexible Barriers

Flexible barriers are barriers that help stop vehicles, especially vehicles thatlose control. Used on the shoulder or in the middle of the road these barriers havethe potential to prevent uncontrolled vehicles from crossing into oncoming traffic,preventing head-on collisions. It can also prevent vehicles from colliding with objects on the side of the road such as poles and trees.

A common flexible barrier is a wire rope safety barrier. It has an iron pole that supports up to four wire ropes. This wire or wire rope will stretch when absorbingand dissipating the impact force when colliding with a car and redirecting the car away from the danger zone. Wire rope barriers or cable systems are becoming more widespread due to their advantages. (Hayden, 2012).

Another flexible barrier is the plastic safety barrier. It is made from polymer, the plastic barrier is very resistant and flexible, and can also return to its original state after receiving the impact of a collision. These plastic road barriers are mostly used in parking lots, industrial sites, and when any road construction or road repair work is done. These barriers are cheaper than concrete or steel barriers. (Lohse, 2007).

In particular, the flexible barrier must be able to absorb the right amount ofenergy and retain the remaining energy to allow the vehicle to be redirected. In order for this flexible barrier to provide the maximum possible level of injury reduction to the driver, the structure itself must have the right amount of flexibility. (Thiyahuddin, 2014).

Figure 2.3: Example of a flexible road barrier

2.1.5 Rigid Barriers

Figure 2.4: An example of a rigid road barrier

Rigid barriers are usually made of reinforced concrete. These barriers are often used inareas of the road where accidents rarely occur in those areas. These barriers absorb lessimpact energy from vehicles. Instead, this form of barrier is designed to move vehiclesonto the road parallel to the barrier. They are used to protect traffic from hazards veryclose behind the barrier, and generally require very little maintenance. The weakness of this barrier is that there is a barrier that is higher than the car causing the driver to notbe able to see the opposite direction (Ahmad, 2009).

2.1.6 Road Barrier Function

There are various types of flexible road barriers such as median barriers, road barriers, bridge barriers, and work zone barriers. These plastic safety road barriers are widely used in work zones such as road repair or upgrading works.

2.1.7 Road Barriers

Road barriers are used to protect traffic from road obstacles or hazards, such asslopes steep enough to prevent accidents, fixed objects suchas bridges, and waterways.Road barriers can also be used with medians, to prevent vehicles from skidding and causing more serious accidents.

Figure 2.5: Examples of barriers on the road

2.1.8 Median Barrier

Median barriers are used to prevent vehicles from crossing the barrier and colliding with vehicles coming from the opposite direction. Unlike roadside barriers, they must be designed to be on both sides.

Figure 2.6: An example of a median barrier

2.1.9 Barrier Bridge

Bridge barriers are designed to prevent vehicles from striking the side of a bridge and falling onto the road, river or train below. They are usually taller than normal curbs to prevent trucks, buses, pedestrians and cyclists from tripping or rolling over the curb and falling over the side of the structure. Bridge rails are usually multi-rail tubular steel barriers or parapets and reinforced concrete barriers.

Figure 2.7: Examples of barriers bridge

2.1.10 Work Zone Barriers

Work zone barriers are used to protect traffic from hazards in the work zone. Their distinguishing feature is that they can be moved when conditions change in road work. Two commonly used types of concrete barriers temporaryand barrier containing sand. The latter consists of steel- reinforced plastic boxes placed where needed, linked together to form longitudinal barriers, then loosened with water. This has the advantage that they can be installed without heavy lifting equipment, but they cannot be used in freezing weather. These roadbarriers are very portable and can be quickly installed on the side of the road. (Grzebieta, 2001).

Figure 2.8: Example of a work zone barrier

Figure 2.9: Example of a work zone barrier

2.2 TYPES OF CONNECTIONS

The weakest part in most structures most often occurs in the joint area (Bickford, 1995). A barrier connection is defined as a barrier that connects a barrierto an adjacent barrier according to the required length. Connection area able to transmit and share the momentum force applied when a vehicle crashes along the road barrier section. Different connection methods are used to connect road barriersdepending on the condition of the road. Each type of connection has advantages anddisadvantages.

2.2.1 Pin Connection

The first type of connection is pin connection through pin intermediate. This type consists of parts *"female-male"* which is connected using a cylindrical rod as illustrated in diagram 1. (Thiyahuddin, 2014) believes that pin connections are often made of steel material and placed perpendicularly or parallel to the ground dependingon the design of the road barrier. Pin joints are designed for high-speed impact and general characteristics on highways with speeds above 40 km/h. This type of connectorrequires additional materials such as iron pins for the installation of road barriers.

Figure 2.10: Example of pin connection.

2.2.2 Direct Connection

The second type of connection is direct *"female-male"* from the road barrier as shown in diagram 2. This type of connection is integrated with the road barrier and is made of the same material as the road barrier itself, usually polyethylene. Connectors made of polyethylene are more susceptible to catastrophic failure. Direct connectors areeasy to manufacture because they are included with the main blocking part. These connectors contain little resistance and often fail when receiving impacts at high speeds.If this connector fails, the road barrier's function as a traffic diversion and diversion system will fail to function as a road safety tool. (Thiyahuddin, 2014).

Figure 2.11: Example of direct connection betweenbarriers

2.3 CONSTRUCTION TECHNOLOGY

Automation and robotization of the construction activities have been studied by manyresearchers in order to enhance work productivity and improve workers' safety (Cai et al., 2019). Although different in manyways, one may expect the construction industry to follow a path to automation similar to theone that took place in the manufacturing industry (Kahane et at., 2004).

A literature review shows that the repetitive and the riskier construction activities are good candidates for automation (Wetmore et al., 2019). There are many potential and benefits of using automated systems for roadway furniture for construction sites. These include increased worker safety, reduction ofconstruction cost, and standardization of construction zone setups.

2.4 SUSTAINABLE CONSTRUCTION

Due to the rapid global expansion of sustainable building in recent years brought about by resource conservation, this industry has encountered numerous administrative, strategic, and operational difficulties. Additionally, by enhancing quality of life, the construction industry contributes significantly to addressing society's requirements (Hwang et al., 2017). However, this industry is responsible forbetween 45 and 65% of the garbage dumped in landfills and 35% of the world's CO2 emissions. Additionally, the building industry and its related activities generate a sizeable quantity of harmful emissions, specifically roughly 30% of the planet's greenhouse gas emissions are generated by operations throughout the construction process, with 18% of these emissions being created by transportation.

Since firms and industry sectors are becoming more aware that ensuring a competitive edge depends on more than just achieving customer satisfaction based on cheapprices or the quality of the product or service given, the relevance of the study of sustainability in the civil construction sector is obvious. Customers anticipate businesses to uphold moral principles, be ethical, and exhibit social responsibility (Alencar et al., 2017).

By preserving energy, water, and natural resources through reuse, recycling, innovative design, and minimising waste and pollution, sustainability in the construction sector may assistsatisfy the demands of both the present and the future generations. To achieve this, proactive actions are taken to rectify or reduce the negative environmental effects of construction activities (Aigbavboa et al., 2017).

The environmental impact caused by the construction industry is striking. Therefore, sustainability practices have been sought in recent years throughout the chain in this industry. To highlight these practices and trace the evolution of the studies in the different areas, asystematic review of the literature was carried out for the period between 2000 and 2017.

2.5 INDUSTRIAL REVOLUTION 4.0

Construction is one of the largest worldwide industries, and the foundation it creates isthe cornerstone of competitiveness and economic success. According to the World Economic Forum, the construction industry contributes 6% to global GDP and more than 8% to GDP in emerging countries (WEF, 2016). Global building investment was $11 trillion in 2017 and is expected to reach $14 trillion by 2025, according to (McKinsey, 2018). The construction industry is at a crossroads because it plays a crucial role in our everyday lives and is economically vital to the development of a nation. Despite this, the industry is characterised bylow efficiency, little computerization or automation, and the usage of robots, among other things.

Convergence, automation, and digitization provide greater productivity in both design and development (Global Industry 4.0 Survey 2016). However, automation and new technology are not readily embraced in the construction sector. The construction industry, in general, faces a number of significant challenges, including resistance to reform, growth barriers, low competitiveness, predictability, and income, as well as issues with professional worker recruitment and retention that are exacerbated by the industry's poor reputation (Gerbert et al., 2017).

As a result, the effective adoption of new technology will significantly impact economicgrowth. But compared to other major industries, the construction industry lags behind in termsof technological development (Nassereddine et al., 2020). However, in the next three to ten years, it is anticipated that several digital advancements, like BIM, Machine Learning, 3D printing, and robotics, will be incorporated into its business processes.

2.6 SOLAR PANEL ENERGY

It is acknowledged that energy is the driving force behind economic growth worldwide.Three major categories of energy resources exist in the world: fossil (oil, gas, coal, etc.), nuclear, and renewable (wind, solar, geothermal, air power, biomass, hydrogen, ocean, etc). Energy derived from non-fossil and renewable sources, such as wind, solar, geothermal, ocean,hydropower, biomass, and biogas, etc., is referred to as a renewable energy source (Sholikha, 2019).

It is also stated that most of the energy sources that are currently relied on are limited and will run out due to increasing demand (Zoghi et al., 2017). To utilise the available renewable resources, renewable energy systems and integrated renewable energy systems are used (Vishnupriyan et al., 2018). Due to their ability to reduce reliance on non- renewable resources, renewable energy sources are crucial for the production of electrical energy (Garca et al., 2014). The best alternative for meeting the demand for electricity is to use renewable energy (Raheman et al., 2020).

Due to their beneficial qualities, including as availability, dependability, and environmental friendliness, RE sources are becoming more and more popular for home and industrial uses. Solar energy is regarded as a trustworthy, profitable, and promising energy source. According to Gupta et al. (2016), it has many benefits including being pollution-free, having a long lifespan, and requiring little upkeep. The most plentiful source of energy that cansatisfy community demands resulting from sustainable economic development is solar energy(Husain, 2018).

The trend of PV energy use growing quickly is related to advancements in solar panel manufacturing technologies as well as higher solar cell efficiencies (Dondi et al., 2008). Desalination plants using fossil fuels frequently use fossil fuel energy to run solar generators, which contributes to environmental pollution and greenhouse gas emissions (Elmaadawy et al.,2020).

Since voltage interactions in a network distribution can be effectively controlled by realpower regulation, this is true (Safayet et al., 2017).

One of the most crucial components of electrical energy for human progress and economic prosperity has received widespread acclaim (Vishnupriyan et al., 2018). A lot of study is being done on the idea of renewable-based power generation in order to keep upwith the ever growing demand for electricity (Gupta et al., 2020). One of theleast expensive, cleanest, and most abundant sources of renewable energy is solar energy. It has various advantages such as pollution free, long life, low maintenance etc. (Gupta et al., 2016).

2.7 CONCLUSION

In conclusion, the literature review on road barriers reveals several key findings and insights. Road barriers play a critical role in enhancing road safety and minimizing the risks associated with vehicular accidents. The literature highlights various types of road barriers, including concrete barriers, steel barriers, and cable barriers, each designed to address specific safety requirements.

The effectiveness of road barriers in reducing the severity of accidents has been extensively studied. Research consistently demonstrates that road barriers significantly reduce thelikelihood of vehicles crossing over into oncoming traffic, preventing head-on collisions and providing vital protection for motorists. Additionally, barriers are effective in containing errant vehicles within their designated lanes, reducing the risk of rollovers and other potentiallycatastrophic incidents.

Studies also examined the impact of road barriers on traffic flow and driver behavior. Overall, findings suggest that well-designed barriers have minimal adverse effects on traffic operations and driver performance. Proper placement and installation of road barriers, consideringfactors such as visibility and geometric design, are crucial for ensuring their optimal functionalityand minimizing any negative consequences.

The literature emphasizes the importance of regular maintenance and inspection of road barriers to ensure their continued effectiveness. Periodic assessments of barrier conditions,including integrity and stability, are necessary to identify any deficiencies and facilitate prompt repairs or replacements. Furthermore, advancements in barrier design, such as the development of energy-absorbing systems, are continually being explored to further enhance their performance and mitigate crash forces.

While road barriers have proven to be effective safety measures, the literature acknowledges that no single solution can address all potential road hazards. Integrated approaches, combining barriers with other safety features such as improved signage, rumble strips, and intelligent transportation systems, are recommended to create a comprehensive road safety framework.

In conclusion, the literature review affirms that road barriers are essential components of road safety infrastructure. Their deployment, when properly designed, installed, and maintained, significantly contributes to reducing the severity of accidents, protecting motorists, and improvingoverall road safety. Further research and advancements in barrier technology are needed to continually enhance their effectiveness and adapt to evolving transportation needs.

CHAPTER 3

METHODOLOGY

3.0 INTRODUCTION

Human behavior is the universal and ingrained behaviors that people have in a particular situation; it is shown through dynamic interactions rather than a static, unanimated environment. In 2004 (Jung et al.), It can be presumed that people behave similarly in comparable circumstances based on Wolfgang Preiser's observation from 1972 that most people choose to take a particular path by choosing a road where they can avoid obstacles andfind the fastest shortcut. (Jung, 2009). This could lead to dangerous and hazardous pathways especially in the construction area whereas there are many dangerous and uneven roads.

The methodological study is a process and method that will be carried out to achieve the objectives that were set at the beginning of this project. The idea of the innovation began with the ideation of a visible problem within the construction site areas. In this methodology will also start with the study design and followed by the study process. In addition, the components involved in this study will also be discussed in more detail. This includes discussions on the innovation of temporary road barriers to improve visibility at night.

In addition, the production process according to step by step should be prioritized to geta quality project result. The explanation will be explained in the methodology of this study

3.1 PROJECT IMPLEMENTATION PROCEDURES

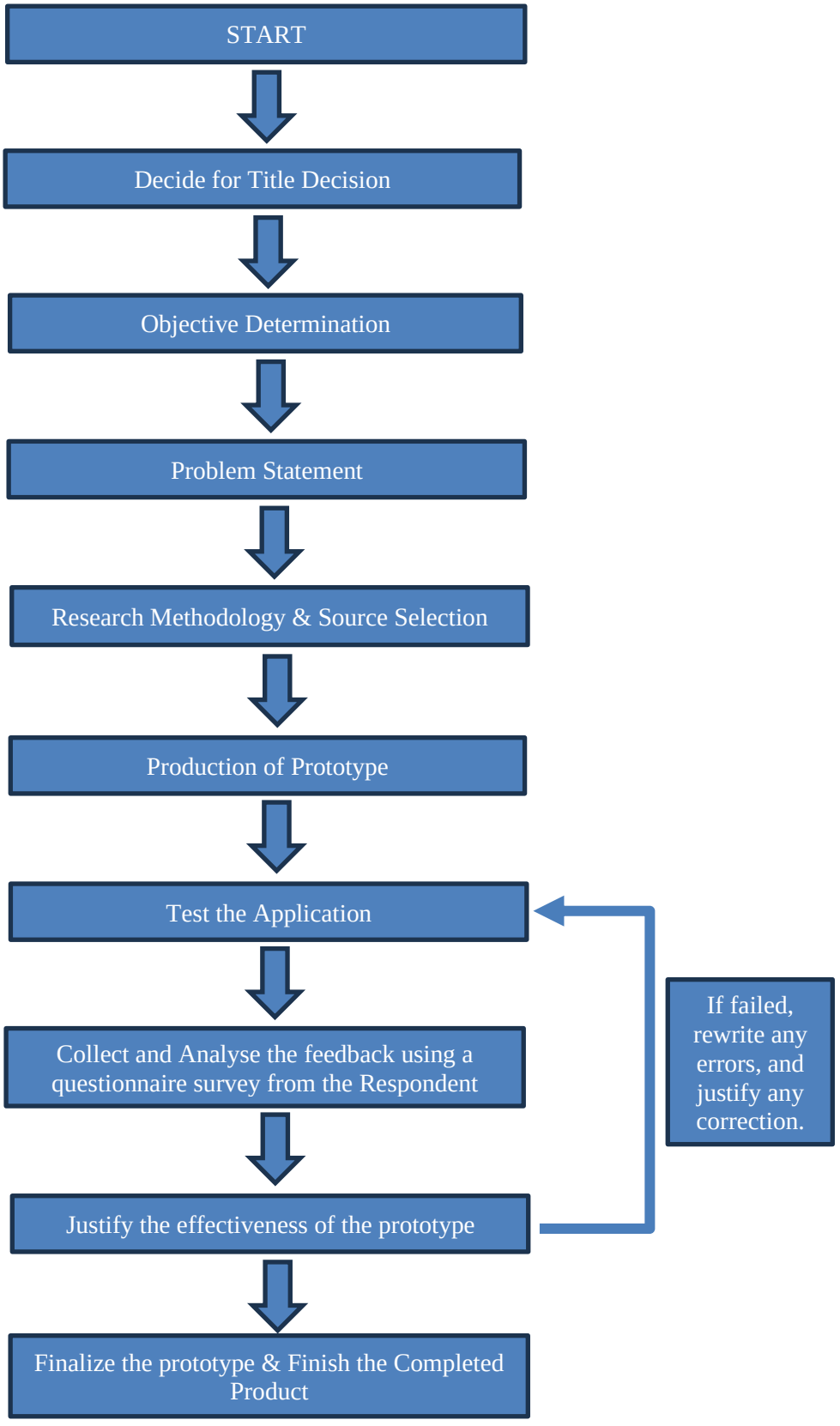

Figure 3.1: Project Procedures Flowchart

3.2 DATA COLLECTION METHOD

Data collection in this study can be obtained through two source methods namelyprimary and secondary sources.

3.2.1 Primary Sources

Primary sources are sources that mean data that comes from original or first sources. This data is also data collected by the researcher himself to test the hypothesis in his study. Sources of information are often collected through experiments or field studies.

3.2.2 Secondary Sources

Secondary sources are sources of information that can be found through scientific materials such as journal books, textbooks or bulletins. These resources can also be found through official websites or websites and also journal articles.

3.3 STUDY METHOD

The research method in this study is to innovate these temporary road barriers to increase their visibility at night by placing lights that use solar energy and electronic circuits. In addition, conducting tests on temporary road barriers that have been modified using the Luxi application to assess the level of visibility. The test is conducted at KTC Park at night. Next, provide feedback from site staff and machine operators to compare between *Automated Solar-Powered Road Barrier* and existing temporary road barrier.

3.4 MATERIAL SELECTION

Material selection for *Smart Road Barrier* is selected based on thedurability factor in a long period of time and the quality of the material.

Figure 3.2: Plastic Road barriers

The road barrier that wants to be innovated measures 0.8m high, 0.48m wide and1.23m long. The materials used are based on plastic, rubber (Elastomer), PVC and PE. The material used is very suitable because it has high UV resistance properties. In addition, the original weight of this road barrier is 13kg.

Figure 3.3: LED lights

Lights are an important ingredient because they can increase the visibility of temporary roadblocks. The size of the lamp used is 5.25 x 4.25 x 5inches. The lamp isheat resistant and has a dust cover allowing for easy maintenance. This lamp is able to work on directly and can flicker.

Figure 3.4: Solar Panel

Solar panels absorb sunlight as an energy source to produce electricity. Solar panels are used to generate energy efficiently and easily because they can charge the battery automatically without any maintenance. There are two pieces of solar panels that will be placed on the plastic road barrier that will be innovated.

Figure 3.5: Battery Casing

This solar energy storage source uses two rechargeable AA's battery with capacity of 2000mah per battery. This particular item battery itself will store and supplyelectricity when needed. It does not need to be maintained frequently.

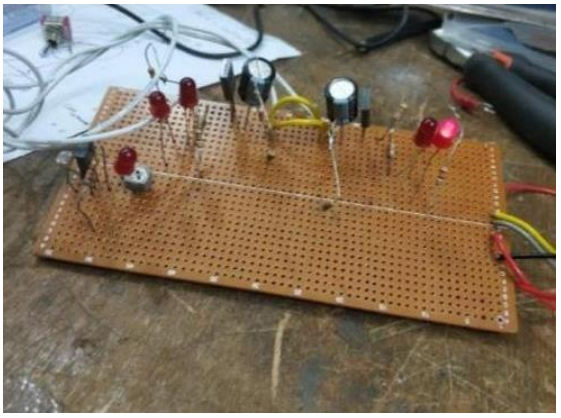

Figure 3.6: Electronic circuit components

The ultraviolet light sensor used is a light sensor that only responds when there is a change in ultraviolet light that hits it. Through this sensor, the light willonly turn on when the lux in the environment becomes low, for example at duskaround 7 pm. This means it will light up at night.

3.5 DESIGN IDEAS

The first thing is to fill the sand up to 1/3 of the road barrier and compressthe sand as much as possible. Prepare a suitable hole to insert the components of the electrical circuit. Next, the solar panel and the LDR circuit will be visible on thetop view, due to its function for collecting renewable energy and also for the functionof LDR to detect the sensitivity of light. The main board which will carry the blinking and current flow feature is hidden inside the barrier as it is vulnerable to being exposed outside of the barrier.

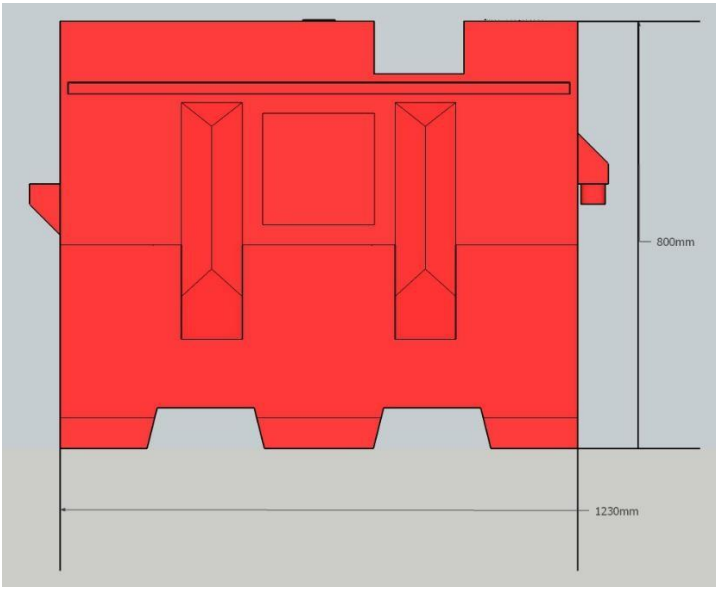

Figure 3.7: Front view

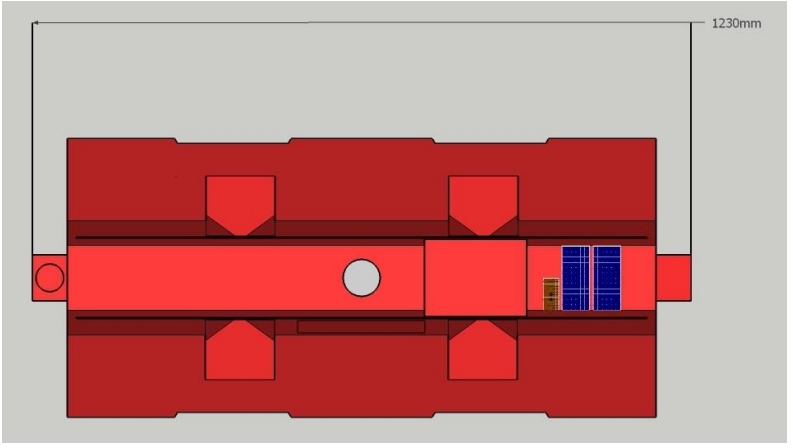

Figure 3.8: Top view

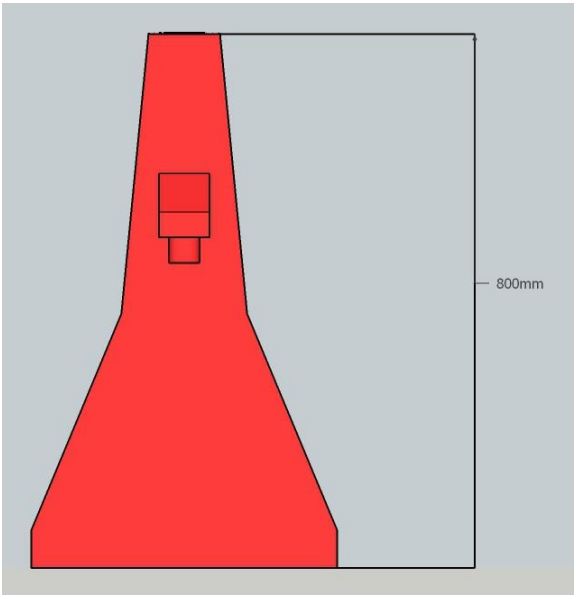

Figure 3.9: Side view

3.6 TESTING VISUAL DISTANCE ROAD BARRIER

Project testing is done to obtain the level of workability of the prototype itself. The testing of this project also takes into account the functionality and visibility of theinnovated samples. The visual distance of the sample that has been innovated is thencompared with the sample that has not been innovated. How to test it is by using the application *LUX*. This application is a device used to measure the amount of light. Lux (symbol: lx) is an SI unit derived from illuminance and luminous emittance, measuring the luminous flux per unit area. In photometry, this is used as a measure of the intensity, as seen by the human eye, of light hitting or passing through the surface of an object.

Figure 3.10: Luxi application

3.7 IMPLEMENTATION OF PROTOTYPE ON SITE

Implementing a prototype on-site vary depending on the nature of the prototype, project requirements, and also site conditions. It is crucial to adapt the process accordingly andengage with the staff on-site or professionals who can provide guidance throughout the implementation and to get the best outcome. A few steps and action need to be considered duringimplementation as follow:

3.7.1 Site Assessment

I) Evaluate the construction site to determine its suitability for implementing the prototype.

II) Consider factors such as space availability, access points, and any site-specific requirements or limitation.

III) Address any site preparation needs, such as clearing debris or levelling ground depending on the site condition.

3.7.2 Construction and Assembly

I. Evaluate the construction site to determine its suitability for implementing theprototype.

II. Consider factors such as space availability, access points, and any site-specificrequirements or limitations.

III. Address any site preparation needs, such as clearing debris or leveling the ground ifnecessary.

3.7.3 Installation and Integration

I. Install the prototype on-site as per the intended use and location.

II. Ensure proper anchoring or fixing of the prototype to the ground or existing structures,if applicable.

III. Integrate any necessary electrical or mechanical components into the prototype,following safety protocols and guidelines.

Figure 3.11: Prototype Implementation On-Site

3.8 Data Collection from Questionnaire

A set of questionnaires consisting of Pre-Test and Post-Test has been distributed towards the site staff, machine operators, lorry driver, Inspector of Work, and also Project Manager. All of the results obtained will be processed and analyzed using Statistical Package for Social Sciences (SPSS) software. Typically, the data from the questionnaire distributed to the respondent is entered into the SPSS software by the researcher. Starting with the respondent's demographic and moving on to the scale's content, which is structured in terms of a Likert scale. To analyze the data for the respondent's demographic, descriptive analysis will be used. However, prior to that, a reliability analysis was performed to determine the internal consistency of the questionnaire that was distributed to the respondents. Following that, the researcher conducted several hypothesis tests to test the relationship as well as the strength between the two variables, which are independent and dependent variables.

CHAPTER 4

DATA AND ANALYSIS

4.1 INTRODUCTION

This chapter will discuss the use of the Luxi application. Luxi is downloaded in mobile phones. It is selected from several types of light brightness measuring applications based on user feedback. Luxi works as a light brightness level measurer. On the figure below, is the example of the Solar-Powered Road Barrier lux reading for distance of 30 meter. EV stands for Exposure Value, and Lux is the unit of illuminance, equal to one lumen per square metre. The EV100 value of 0 is the combination of an aperture of f/1.0 and a shutter speed of one second. This is the adjustment of the camera itself depending on the model, whereas it may be from range of -1 and +21. Exposure values is more useful for photography in an abstract sense rather than in practical sense.

Figure 4.1: Example of Smart Road Barrier lux reading for a distance of 30 meters.

4.2 FINDINGS FROM OBSERVATIONS

The visual image of the operating Solar-Powered Road Barrier in distance of below 1 meter. LDR will detect low LUX reading and will signal the PCD board to activate current flow to supply the LED strip.

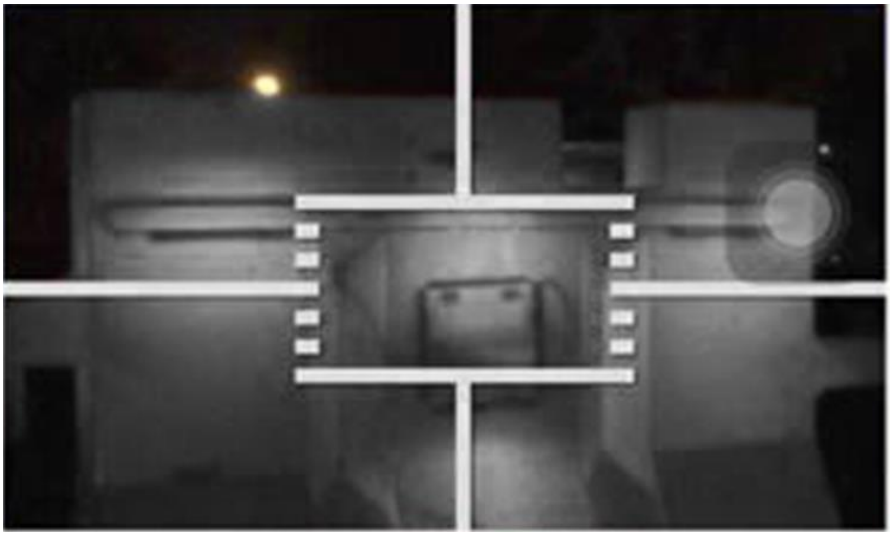

Figure 4.2: Solar-Powered Road Barrier

The visual image of the existing road barrier in distance of below 1 meter same as above. No additional feature is attached or install on the existing road barrier for comparing data and testing purposes.

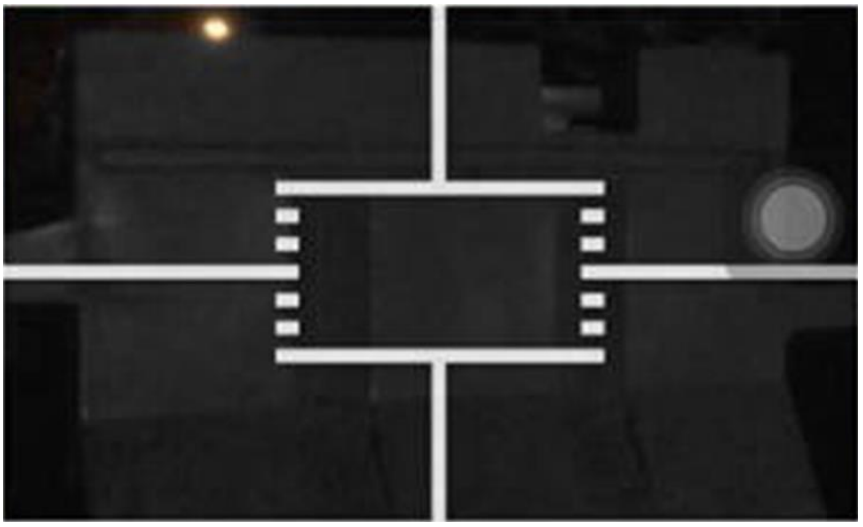

Figure 4.3: Existing Temporary Road Barriers

Based on figure 4.2 and figure 4.3, the Smart Road Barrier and existing temporary road barriers have been tested with a light distance of 150 meters. Smart Road Barrier looks more obvious than existing temporary road barriers. So, the level of visibility of the Smart Road Barrier has surpassed the existing temporary road barriers. The effectiveness of the Smart Road Barrier has been proven.

4.3 LIGHT REFLECTION TEST ANALYSIS

The following shows the lux readings for Smart Road Barrier and existing temporary road barriers. The reading difference in candela units (cd/m2) can be seen from the table. The effectiveness of Smart Road Barrier is higher than existing temporary road barriers. This makes it easier to drive to see the Smart Road Barrier ata distance. Smart Road Barrier warns in advance when passing through an area.

Table 4.1 Lux reading records for Solar-Powered Road Barrier and existing temporary road Barriers.

Distance (meters)	*Smart Road Barrier* (Cd/m2)	Temporary roadbarriers (Cd/m2)	Percentage Difference %
30	214	110	94.5
50	168	78	115.4
80	111	51	117.65
100	55	28	96.43
150	12	1	1100

4.4 LUX READING COMPARISON GRAPH

Based on Table 4.4, the initial reading at a distance of 30 meters has recorded a reading of lux 214 candela (cd/m2) which is on the Solar-Powered Road Barrier and lux 110 candela (cd/m2) which is on the existing temporary road barrier. While the final reading at a distance of 150 meters has recorded a reading of lux 12 candela (cd/m2) which is on the Smart Road Barrier and lux 1 candela (cd/m2) which is on the existing temporary road barrier. A significant difference between the Smart Road Barrier and existing temporary road barriers.

Based on Figure 4.4, the reading rate on the Smart Road Barrier is still high even though the distance between the Smart Road Barrier and the light source increases. The level of visibility of the Smart Road Barrier is higher than that of existing temporary road barriers. This shows that the use of Smart Road Barrier is more effective than existing temporary road barriers.

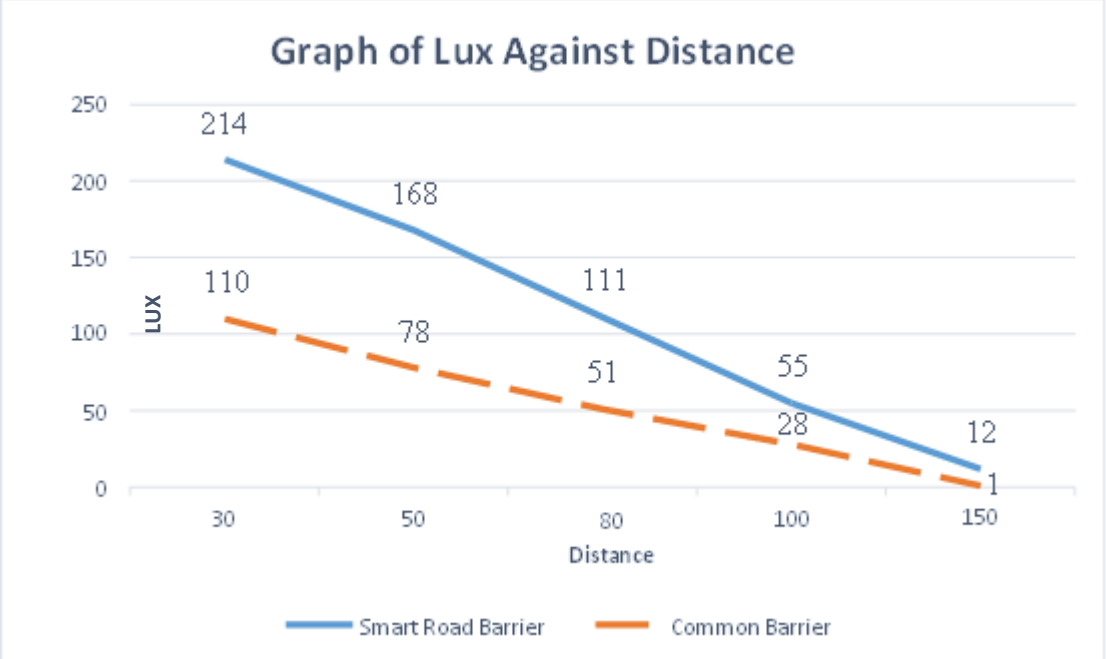

Figure 4.4 : Graph of Lux versus distance

4.5 RECORD LUX READINGS FOR SMART ROAD BARRIER AND EXISTING TEMPORARY ROAD BARRIERS AT A DISTANCE OF 30 METERS.

The lux reading for the Smart Road Barrier obtained a percentage of 66.05% while the existing temporary road barrier was 33.95%. This shows the effectiveness of the Smart Road Barrier has overcome existing temporary road barriers by 95.5%. The Smart Road Barrier can be seen more clearly when vehicles approach it. The existing temporary road barriers look unclear due to the lack of clear lighting.

4.6 RECORD LUX READINGS FOR SMART ROAD BARRIER AND EXISTING TEMPORARY ROAD BARRIERS AT A DISTANCE OF 150 METERS.

The lux reading for the Smart Road Barrier obtained a percentage of 93.31% while the existing temporary road barrier was 7.69%. This shows the effectiveness of the Smart Road Barrier has overcome existing temporary road barriers by 85.62%. This percentage proves that the visibility of the Smart Road Barrier is higher than the existing temporary road barriers as the distance gets closer.

When a driver passes a road with a Smart Road Barrier installed, the driver will be more aware of the road barrier that has been clearly installed on the road. Atthe same time, it can prevent the driver from entering the wrong lane. Therefore, the probability of road accidents can be reduced.

4.7 READING GRAPH OF SMART ROAD BARRIER AND TEMPORARY ROAD BARRIERS

Based on tests using the Luxi application that has been used, the percentage of Smart Road Barrier's level of visibility always reaches a higher reading compared to existing temporary road barriers.

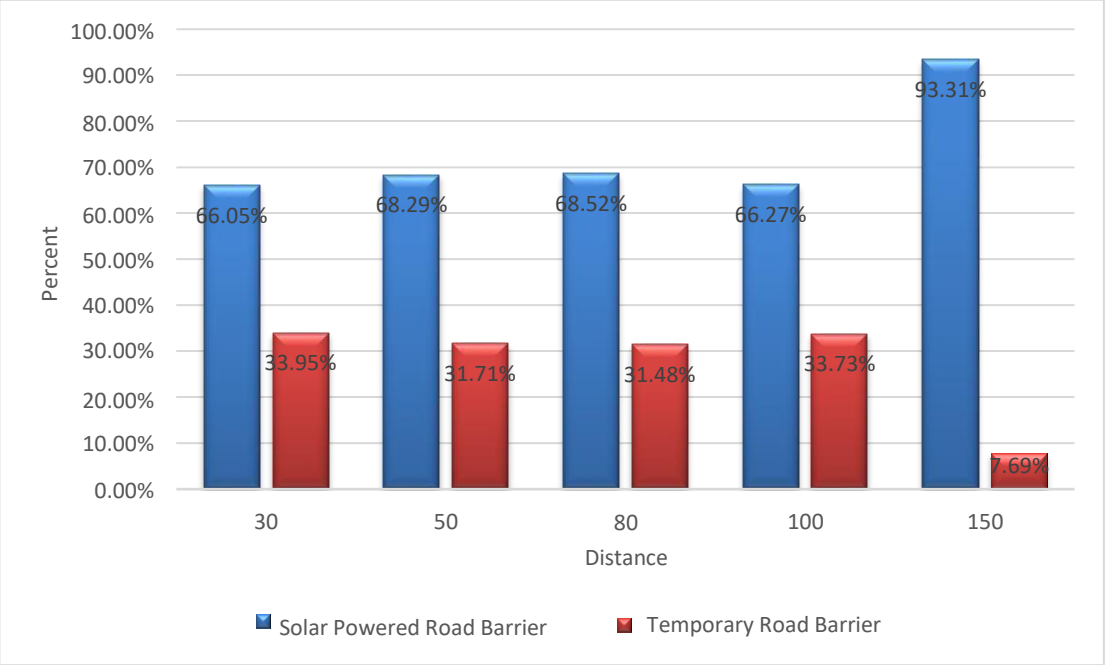

Figure 4.5: Reading graph

4.8 DATA ANALYSIS FROM STATISTICAL PACKAGE FOR SOCIAL SCIENCE (SPSS) FOR PRE-TESTING AND POST-TESTING

The respondents were given a simple form of questionnaire based on Davis's (1989)Technology Acceptance Model (TAM) which was administered to various site personnel individually. Using the TAM has gained substantial influence as a framework for understanding individuals' intentions to adopt new technologies, focusing on two key factors: perceived ease of use and perceived usefulness. The primary variables assessed in this study were aligned with TAM, which included Perceived Ease of Use, Perceived Usefulness, and User Satisfaction. All the data analyzed, and the findings shall be presented in the form of tables, graphs, and figures to provide a comprehensive analysis of the study. This presentation aims to highlight

the crucial information regarding the problems and challengesfaced by the teams, as well as the required model to be developed for the final year project. The pre-testing and post-testing questionnaires consisted of 18 questions each, aiming to identify the existing problems in industries. From these questions, the top three problems were selected as the main problem statement to be addressed in the final year project. Respondents were asked to indicate their level of agreement regarding various issues using a scale ranging from 1 to 5.

4.8.1 Demographic Information

Demographic data is the respondents' background, which contains 4 items which are Gender,Age range, Designation, and Work Experience.

i. Gender (Pre-Testing)

The table below shows the number of respondents who obtained this study. The total number of respondents was about 40 people. The figure below shows the number of respondents by gender.

Table 4.2: Gender of the respondents (Pre-Test).

Gender		
	N	%
Male	30	75%
Female	10	25%

Table 4.2 shows the data for the gender of the respondents. The data shows 30 respondents(75%) are Male, and 10 (25%) are Female.

ii. Age range (Pre-Testing)

Table 4.3 below shows the respondent age category involved in this study. The researchers divided it into four categories of age. Thus, the percentage based on age can be seen in Table 4.3.

Table 4.2: Age range of respondents (Pre-Test)

Age		
	N	%
Under 25 years old	8	20.0%
26-35 years old	26	65%
36-45 years old	5	12.5%
46 years or older	1	2.5%

Table 4.3 shows data for the age range of respondents. From the data, 8 (20%) of the respondents are under 25 years old, 26 (65%) of the respondents are between 26 to 35 years old, 5 (12.5%) of the respondents are between 36 to 45 years old, and 1 (2.5%) of the respondents are 46 years old or older.

iii. Designation (Pre-Testing)

The third item in the demographic data is the position at the procurement department andconstruction site, where there are various positions, such as Project Manager, Construction Manager, Engineer, Site Supervisor, Inspector of Works, and Operation Personnel. The table below shows the percentage of the designation.

Table 4.4: Designation of the Respondent (Pre-Test)

Position		
	N	&
Project Manager	1	2.5%
Construction Manager	1	2.5%
Engineer	4	10.0%
Site Supervisor/Assistant Engineer	4	10.0%
Inspector of Works	2	5.0%
Operator	28	70.0%

Table 4.4 show data for the designation of respondents. From the data, 2 (5%) of the respondents are Project Managers and Construction Managers respectively, 8 (20%) of the respondents are Engineers and Site Supervisors respectively, 2 (5%) of the respondents are Inspector of Work (IoW), and 28 (70%) respondents are from Operationpersonnel.

iv. Work Experience (Pre-Testing)

The fourth item in the demographic data is the duration of the current position, where there are various durations of current positions of less than 2 years, between 2 to 5 years,between 6 to 10 years, and more than 10 years.

Table 4.5: Work Experience of the Respondent (Pre-Test)

Work Experience		
	N	%
<2 years	8	20.0%
2-5 years	26	65%
6-10 years	5	12.5%
>10 years	1	2.5%

Table 4.5 shows data for the work experience of respondents. From the data, 8 (20%) of the respondents are less than 2 years, 26 (65%) of the respondents are between 2 to 5 years,5 (12.5%) of the respondents are between 6 to 10 years, and 1 (2.5%) of the respondentsare 10 years and above.

4.8.2 Identifying the existing problem in Industries (Pre-Testing)

There are 9 questions regarding the existing problem in industries. The top problem will becomethe study's main problem statement that the final year project will solve. Respondents were askedto select their level of agreement on the following issues according to a scale of 1 to scale 5. Thetable below shows the collection of issues data related to the current method.

Table 4.6: Level of Agreement.

Level of Agreement				
Strongly Disagree	Disagree	Slightly Agree	Agree	Strongly Agree
1	2	3	4	5

Table 4.7: Pre-Testing Survey Data.

Constraint elements of thecurrent Plastic Road Barrier	Issues related to thecurrent Plastic Road Barrier	Strongly Disagree	Disagree	Slightly Agree	Agree	Strongly Agree
		1	2	3	4	5
Perceived easeof use	The existing product is easy to understand and use.	28 (70%)	12 (30)	0	0	0
	Existing product is convenient to operate and interact	23 (57.5%)	17 (42.5%)	0	0	0
	The existing product requires	32 (80%)	8 (20%)	0	0	0

Table 4.7 **(Continuation)**

	minimal effort and technical skills to operate					
Perceived usefulness	The existing product is reliablein providing its function and information	29 (72.5%)	11 (27.5%)	0	0	0
	The existing product contributes to the overall efficiency	21 (52.5%)	19 (47.5%)	0	0	0
	The existing product effectively helps in road construction	23 (57.5%)	17 (42.5%)	0	0	0
	The existing product can give drivers warning and cautions.	28 (70%)	12 (30%)	0	0	0
Attitude towards using technology	I am satisfied withthe functionality of the existing road barrier	28 (70%)	12 (30%)	0	0	0
	I feel comfortable using existing product	22 (55%)	18 (45%)	0	0	0
	I believe that existing technology can improve the efficiency and effectiveness of the plastic Barrier	25 (62.5%)	15 (37.5%)	0	0	0

Table 4.7 **(Continuation)**

	I have positive attitude towardsusing existing technology in the plastic barrier	23 (57.5%)	17 (42.5%)	0	0	0
Behavioral intention to use	I intend to continue using the existing plastic barrier	23 (57.5%)	17 (42.5%)	0	0	0
	I would recommend theexisting plastic barrier to others for on-site Construction	27 (67.5%)	13 (32.5%)	0	0	0
	Existing plastic barrier can notify driver for any road closure or Excavation	33 (82.5%)	7 (17.5%)	0	0	0
	Do you need improvement to solve the visibility of plastic barrier Existing plastic barrier is	21 (52.5%)	19 (47.5%)	0	0	0
The need of improvement for innovated road barrier in this construction site	Existing plastic barrier is systematic & efficient enough	28 (70%)	12 (30%)	0	0	0

Table 4.7 **(Continuation)**

	Do you agree thatexisting method is adequate enough to the driver & operator in construction site?	19 (47.5%)	21 (52.5%)	0	0	0
	Existing plastic barrier is easy tosee and aware of its existence?	27 (67.5%)	13 (32.5%)	0	0	0

4.8.3 Reliability Test for Pre-Testing Method (Pre-Testing)

Reliability analysis may be used to investigate the properties of measuring scales and the items from the scales. The reliability analysis procedure computes several commonly used scale reliability metrics and information on the correlations between scale items. Intraclass correlation coefficients can be used to calculate interrater reliability estimates.

Table 4.8: Reliability Test Table.

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.660	.658	18

4.8.4 Descriptive Test of Average Mean (Pre-Testing)

Descriptive statistics are those that describe or characterize the characteristics of a data set. It also categorizes measurement into two types: measures of central tendency and measures of variability (or spread). Additionally, central tendency measurements describe the focal point ofa data set. The dispersion of the data within a collection is described by variability or spread measurements.

Table 4.9: Issues related to the Pre-Testing Method.

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
The existing product is easy to understand anduse.	40	1	2	1.48	.506
Existing product is convenient to operate and interact	40	1	2	1.43	.501
The existing product requires minimal effortand technical skills to operate	40	1	2	1.30	.464
The existing product reliable in providing function & information	40	1	2	1.30	.464
The existing product contributes to the overallefficiency	40	1	2	1.45	.504
The existing product effectively helps in road construction	40	1	2	1.30	.464
The existing product cangive drivers warning and cautions.	40	1	2	1.43	.501

Table 4.9 **(Continuation)**

I am satisfied with the functionality of the existing barrier	40	1	2	1.20	.405
I feel comfortable usingexisting product	40	1	2	1.28	.452
I believe that existing technology can improvethe efficiency and effectiveness of the plastic barrier	40	1	2	1.38	.490
I have a positive attitudetowards using existing technology in the plastic barrier	40	1	2	1.43	.501
I intend to continue using the existing plastic barrier	40	1	2	1.33	.474
I would recommend the existing plastic barrier to others for on-site construction	40	1	2	1.18	.385
Existing plastic barrier can notify driver for any road closure or soil excavation	40	1	2	1.48	.506
Do you need an improvement to solve the visibility of plastic barrier	40	1	2	1.30	.464
Existing plastic barrier is systematic and efficient enough	40	1	2	1.48	.506
Do you agree that existingmethod is adequate enough to the driver and operator in construction site?	40	1	2	1.52	.506

Table 4.9 **(Continuation)**

Existing plastic barrier is easy to see and aware of its existence?	40	1	2	1.33	.474

4.8.5 Demographic Data (Post-Testing)

Demographic data is the respondents' background, which contains 4 items which are Gender,Age range, Designation, and Work Experience.

ii. Gender (Post-Testing)

The table below shows the number of respondents who obtained this study. The total number of respondents was about 40 people. The figure below shows the number of respondents by gender.

Table 4.10: Gender of the respondents (Post-Test).

Gender		
	N	%
Male	30	75%
Female	10	25%

Table 4.10 shows the data for the gender of the respondents. The data shows 30respondents (75%) are Male, and 10 (25%) are Female.

iii. Age range (Post-Testing)

Table 4.11 below shows the respondent age category involved in this study. The researchers divided it into four categories of age. Thus, the percentage based on age can be seen in Table 4.11.

Table 4.11: Age range of respondents (Post-Test)

Age		
	N	%
Under 25 years old	8	20.0%
26-35 years old	26	65.0%
36-45 years old	5	12.5%
46 years or older	1	2.5%

Table 4.11 shows data for the age range of respondents. From the data, 8 (20%) of the respondents are under 25 years old, 26 (65%) of the respondents are between 26 to 35 years old, 5 (12.5%) of the respondents are between 36 to 45 years old, and 1 (2.5%) of the respondents are 46 years old or older.

iv. Designation (Post-Testing)

The third item in the demographic data is the position at the procurement department andconstruction site, where there are various positions, such as Project Manager, Construction Manager, Engineer, Site Supervisor, Inspector of Works, and Operation Personnel. The table below shows the percentage of the designation.

Table 4.12: Designation of the Respondent (Post-Test)

Position		
	N	%
Project manager	1	2.5%
Construction Manager	1	2.5%
Engineer	4	10.0%
Site Supervisor/Assistant Engineer	4	10.0%
Inspector of Works	2	5.0%
Operator	28	70%

Table 4.12 show data for the designation of respondents. From the data, 2 (5%) of the respondents are Project Managers and Construction Managers respectively, 8 (20%) of the respondents are Engineers and Site Supervisors respectively, 2 (5%) of the respondents are Inspector of Work (IoW), and 28 (70%) respondents are from Operation personnel.

v. Work Experience (Post-Testing)

The fourth item in the demographic data is the duration of the current position, where there are various durations of current positions of less than 2 years, between 2 to 5 years,between 6 to 10 years, and more than 10 years.

Table 4.13: Work Experience of the Respondent (Post-Test)

Work Experience		
	N	%
< 2 years	8	20.0%
2-5 years	26	65%
6-10 years	5	12.5%
>10 years	1	2.5%

Table 4.13 shows data for the work experience of respondents. From the data, 8 (20%) of the respondents are less than 2 years, 26 (65%) of the respondents is between 2 to 5 years,5 (12.5%) of the respondents are between 6 to 10 years, and 1 (2.5%) of the respondentsare 10 years and above.

4.8.6 Identifying the Needs of the Automated Solar-Powered Road Barrier in Industries (Post-Test)

There are 15 questions regarding the needs of the automated solar powered road barrier in industries. Respondents were asked to select their level of agreement on the following issues according to a scale of 1 to scale 5. The table below shows the collection of issues data related tothe current method.

Table 4.14: Post-Testing Survey Data.

No	Elements for the implementation of the innovated plastic barrier in construction sites	The effectiveness of the implementation of the innovated road barrier specialized in construction sites?	Strongly Disagree	Disagree	Slightly Agree	Agree	Strongly Agree
			1	2	3	4	5
1	Perceived easeof use	The implementationof the innovated plastic barrier iseasy to understand and use	0	0	0	24 (60%)	16 (40%)
		The implementationof the innovated plastic barrier isconvenient to operate and interact	0	0	0	14 (35%)	26 (65%)

Table 4.14 **(Continuation)**

2	Perceived usefulness	The implementation of the innovated plastic barrier will bring benefits to myteam	0	0	0	24 (60%)	16 (40%)
		The implementation of the innovated plastic barrier will improve thevisibility and efficiency	0	0	0	16 (40%)	24 (60%)
		I am satisfied with the visibilityand functions of the innovated plastic barrier	0	0	0	16 (40%)	24 (60%)
3	Attitude towards using technology	I have a positive viewpoint towards using this technology for innovated plastic barrier	0	0	0	24 (65%)	16 (35%)
		I believe that implementing theinnovated plasticbarrier would improve the visibility and effectiveness	0	0	0	14 (35%)	26 (65%)
		I feel comfortable using technology, such as solar panel and sensors for the plastic barrier	0	0	0	26 (40%)	14 (60%)

Table 4.14 **(Continuation)**

4	Behavioral intention to use	I would recommend this innovated plasticbarrier to others for their construction sites	0	0	0	16 (40%)	24 (60%)
		I am motivated to adopt this innovated plastic barrier in my construction sites	0	0	0	26 (40%)	14 (60%)
		I intend to use the innovated plasticbarrier in my site	0	0	0	16 (40%)	24 (60%)
5	The efficiency of the implementation of the innovated plastic barrier in construction sites	This prototype issystematic and efficient	0	0	0	20 (50%)	20 (50%)
		This prototype solves the existing constraints	0	0	0	14 (35%)	26 (65%)
		The implementation of solar panel and battery increases the workability and practices sustainable energy	0	0	0	16 (40%)	24 (60%)
		I would recommend this innovated plasticbarrier to others due to its efficiency	0	0	2 (5%)	16 (40%)	22 (55%)

4.8.7 Reliability Test for Post-Testing Method (Post-Testing)

Reliability analysis may be used to investigate the properties of measuring scales and the items from the scales. The reliability analysis procedure computes several commonly used scale reliability metrics and information on the correlations between scale items. Intraclass correlationcoefficients can be used to calculate interrater reliability estimates. The research has developed 5 categories in the questionnaire to evaluate the effectiveness of the automated solar-powered road barrier specialized for construction sites.

The questionnaire was on the five (5) point LikertScale, with responses ranging from Strongly Disagree to Agree Strongly. The Cronbach alpha test was conducted to determine whether the questionnaire could reliably measure the latent variable, like the effectiveness of the automated solar-powered road barrier specialized for construction sites. The acceptable reliability value is 0.6. Therefore, if the questionnaire'sreliability is more than 0.6, then the questionnaire is considered reliable.

Table 4.15: Reliability test for Solar-Powered Road Barrier

Reliability Statistics		
Cronbach;s Alpha	Cronbach's Alpha Based on Standardized Items	N. of Items
.891	.898	15

4.8.8 Descriptive Test of Average Mean (Post-Test)

Descriptive statistics are those that describe or characterize the characteristics of a data set. It also categorizes measurement into two types: measures of central tendency and measures of variability (or spread). Additionally, central tendency measurements describe the focal point ofa data set. The dispersion of the data within a collection is described by variability or spread measurements.

Table 4.16: The Descriptive Test average means (Post-Test).

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
The implementation ofthe innovated plastic barrier is easy to understand and use	40	4	5	4.40	.496
The implementation ofthe innovated plastic barrier is convenient to operate and interact	40	4	5	4.65	.483
The implementation of the innovated plastic barrier will bring benefits to my team	40	4	5	4.40	.496
The implementation of the innovated plastic barrier will improve the visibility and efficiency	40	4	5	4.60	.496
I am satisfied with the visibility and functions ofthe innovated plastic Barrier	40	4	5	4.60	.496

Table 4.16 **(Continuation)**

I have a positive viewpoint towards using this technology for innovated barrier	40	4	5	4.40	.496
I believe that implementing the innovated plastic barrier would improve the visibility and effectiveness	40	4	5	4.65	.483
I feel comfortable using technology, such as solar panel and sensors for the barrier	40	4	5	4.35	.483
I would recommend this innovated plastic barrier to others for their construction sites	40	4	5	4.60	.496
I am motivated to adopt this innovated plastic barrier in construction sites	40	4	5	4.35	.483
I intend to use the innovated plastic barrier in my site	40	4	5	4.60	.496
This prototype is systematic efficient	40	4	5	4.50	.506
This prototype solves theexisting constraints	40	4	5	4.65	.483
The implementation of solar panel and battery increases workability & practices sustainable energy	40	4	5	4.60	.496
I would recommend this innovated plastic barrierto others due to its efficiency	40	3	5	4.50	.599

4.8.9 Paired Sample T-Test

In order to evaluate the effectiveness of the Automated Solar Power Road Barrier in the project,a paired sample t-test was performed. A paired sample t-test found this difference to be significantfor all variables being measured, the value of T for Perceived Ease of Use is 4.50 and the value of P is < .00001. The result is significant at p < .07. The value of T for Perceived Usefulness is 4.67 and the value of P is < .00001. The result is significant at P < .05. The value of T for Attitude Toward Using Technology is 4.33 and the value of P is < .00001. The result is significant at P < .05. The value of T for Behavioral Intention to Use is 4.67 and the value of P is < .00001. The result is significant at P < .05. From this data, it means that using the Automated Solar PoweredRoad Barrier was more effective compared with the current method.

Table 4.17: Paired Samples Statistics

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Perceived ease of use (Pre-Test)	1.00	2	.000	.000
	Perceived ease of use (Post-Test)	4.50	2	.707	.500
Pair 2	Perceived usefulness (Pre-Test)	1.00	3	.000	.000
	Perceived usefulness (Post-Test)	4.67	3	.577	.333
Pair 3	Attitude toward using technology (Pre-Test)	1.00	3	.000	.000
	Attitude toward using technology (Post-Test)	4.33	3	.577	.333
Pair 4	Behavioral intention to use(Pre-Test)	1.00	3	.000	.000
	Behavioral intention to use(Post-Test)	4.67	3	.577	.333

Table 4.17 **(Continuation)**

Pair 5	The needs of automated solar powered road barrier (Pre-Test)	1.25	4	.500	.250
	The needs of automated solar powered road barrier(Post-Test)	5.00	4	.000	.000

4.9 Result Analysis

4.9.1 Agreement Level of mean score

Mean is an essential concept in mathematics and statistics. The Mean is the average or the most common value in a collection of numbers. Statistics, it measures the central tendency of a probability distribution along median and mode. It is also referred to as an expected value.

i. 5 Points Likert Scale

A type of psychometric response scale in which respondents specify their level of agreement to a statement typically in five points: Strongly disagree (1), Disagree (2), Slightly Agree (3),Agree (4) and Strongly Agree.

Table 4.18: Interpretation of mean score (Interpretation of Mean Scores, 2015).

Mean Score	Interpretation of Mean Score
1.00-2.00	Low
2.01-3.00	Moderately Low
3.01-4.00	Moderately High
4.01-5.00	High

There are five sections that have been analyzed by using SPSS software which are Perceived Ease of Use, Perceived Usefulness, Attitude Toward Using

Technology, Behavioral Intentionto Use, and the Need for Automated Solar-Powered Road Barrier.

Table 4.19: The Usability Level Before Automated Solar Powered Road Barrier.

Variables	Mean	Standard Deviation	Interpretation
Perceived Ease of Use	1.00	0.000	Low
Perceived Usefulness	1.00	0.000	Low
Attitude Toward Using Technology	1.00	0.000	Low
Behavioral Intention to Use	1.00	0.000	Low
Need for Automated Solar-Powered Road Barrier	1.25	0.500	Low
Average	1.05	0.100	-

Table 4.20: The Usability Level After Automated Solar Powered Road Barrier.

Variables	Mean	Standard Deviation	Interpretation
Perceived Ease of Use	4.50	0.707	High
Perceived Usefulness	4.67	0.577	High
Attitude Toward Using Technology	4.33	0.577	High
Behavioral Intention to Use	4.67	0.577	High
Need for Automated Solar-Powered Road Barrier	5.00	0.000	High
Average	4.63	0.488	-

ii. Cohen's Kappa

Cohen's Kappa is always between 0 and 1 scale, with 0 indicating no agreement between the two ratters and 1 indicating perfect agreement between the two ratters (Zach, 2021). Because Cohen'sKappa considers the impact of chance, it is a more reliable method than the observed proportionof agreement (Delgado & Xavier-Andoni Tibau, 2019).

Table 4.20: Cohen's Kappa interpretation (Zach, 2021).

Cohen’s Kappa	Interpretation
0	No agreement
0.10 – 0.20	Slight agreement
0.21 – 0.40	Fair Agreement
0.41 – 0.60	Moderate Agreement
0.61 – 0.80	Substantial Agreement
0.81 – 0.99	Near Perfect Agreement
1	Perfect Agreement

4.10 Conclusion

In conclusion, the survey forms were answered by 40 respondents from the construction industry, specifically on the site of i9B Warehouse Project, providing valuable insights into theeffectiveness of the automated solar-powered road barrier specialized for construction sites. The analysis included demographic criteria such as gender, age group, work position, and experience. The data that were collected from 40 respondents were analyzed using the Statistical Package for the Social Science software, and a T-Test was also conducted to evaluatethe prototype’s effectiveness.

The analysis included two sections, namely pre-testing and post-testing, which

were interpreted based on the mean scores. In the post-testing phase, the average mean score for theeffectiveness of the prototype was 4.63, indicating a high level of effectiveness. The average standard deviation for post- testing was 0.488, which falls within the category of perfect agreement according to Cohen's Kappa interpretation table. Thus, based on the mean score and standard deviation interpretations, it can be concluded that the prototype of the road barrier has been proven to be more effective than the existing barrier.

Overall, the findings demonstrate that the prototype of the road barrier have successfully addressed the challenges identified in the construction industry, providing a more efficient andautomated feature to the existing road barrier that has been widely use on the construction site.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The Solar Powered Road Barrier innovation study has been successfully produced and designed according to the specified specifications. The Road Barrier innovation is designed to increase the sensitivity of machine operator and lorry drivers to stay in the right lane and be cautious of any road closure & excavation. The Road Barrier produced can be applied in areas with a high accident rate and risk of accidents such as sharp bends, dark areas and road construction and maintenance areas. It is one of the methods to increase the sensitivity of machine operator and lorrydrivers and reduce the risk of accidents on site. So, the first objective of the study, which is to increase the visibility of temporary road barriers especially at night as an improvement to the existing road furniture has been successfully achieved.

The implementation of automated solar-powered road barriers in construction sites offers several benefits and can greatly improve safety and efficiency. Some of the key points are to enhance safety which the automated solar-powered road barriers provide an effective means to control traffic flow and restricts access to and in construction sites. It helps to prevent unauthorized entry, reducing the risks of accident and injuries. These innovated barrier were programmed to operate automatically based on triggers by the Light Dependent Resistor sensor, ensuring consistent and reliable traffic control.

Solar power eliminates the need for electricity supply from the grid, reducing operational costs. The barriers harness solar energy through photovoltaic panels, which convert sunlight into electricity. This renewable energy source is environmentally friendly and reduces dependence on fossil fuels. Solar-powered road barriers contribute

to sustainable practices by utilizing renewable energy. They reduce carbon emissions and environmental footprint by minimizing the use of non-renewable energy sources. This aligns with the growing global focus on sustainable construction practices and reducing environmental impact.

Despite these advantages, it is important to consider a few potential challenges. Adverse weather conditions, such as heavy rain or prolonged cloudy periods, can affect the efficiency of solar panels. Therefore, it is crucial to design the system with adequate battery storage capacity to ensure continuous operation during such periods. Additionally, initial installation costs may be higher than traditional barriers, although long-term savings on electricity expenses can offset these costs over time.

Overall, automated solar-powered road barriers offer a sustainable, efficient, and safer solution for traffic control in construction sites. Their implementation can improve safety, reduce costs, and promote environmentally friendly practices.

5.2 DISCUSSION

A light brightness test was carried out. The visibility level of Smart Road Barrier is very clear at a distance of 100m which is a reading of 55 in candela units (cd/m2) while the level of visibility is less clear at a distance of 150m with a Lux reading of 12 cd/m2. For road barriers that have not been innovated it is clear at a distance of 100m which is a Lux reading of 28 in candela units (cd/m2) while the level of visibility is less clear at a distance of 150m with a lux reading of 1 cd/m2. Ithas been proven that the Smart Road Barrier can make drivers more aware of these road barriers. The percentage of Smart Road Barrier's visibility level for the set distance is higher than the road barrier that has not been innovated. So, the second objective of testing the effectiveness of the visibility of the roadbarriers that have been innovated has been implemented.

Two sets of surveys were developed to evaluate the effectiveness of the road barrier prototype. The initial questionnaire focused on gathering feedback and ideas regarding the existing road barrier and their effectiveness during nighttime. The subsequent questionnaire focused on gathering feedback and ideas regarding the

existing road barrier and evaluating the data by using SPSS. The existing road barrier posed a low interest and difficulties for employees, especially M&E worker whereas they need to manually install and dismantle the light when the is a night work operation. In addition, the new innovated barrier is more user friendly and easy to use in terms of operation of it.

5.3 RECOMMENDATION

Due to the constraint factor to obtain this tool while conducting the research visibility test for the next proposed action in the future is that the researcher uses light meter tools for the lighting test. Light meter tools were specially created to measure more accurate readings. So, it is suggested that researchers use light meter tools. This is because the use of smartphones has itsown weaknesses.

About this prototype for the long term is that researchers can further improve this prototype in terms of portability such as putting wheels on the base. This can facilitate the removal work without havingto lift it so that the Smart Road Barrier is easy to maintain. This is because the Smart Road Barrier is easy to move and makes maintenance easier.

In addition, the researcher can improve on the side of the prototype by placing 3M Reflective Sticker. With this improvement, the visibility of the Smart Road Barrier can be increased. Further action, researchers can test the level of visibility of the Smart Road Barrier in the dark such as cloudy, rainy,and nighttime. The researcher can also distribute a survey form to get a response from users on the effectiveness of the prototype that has been developed.

Solar Powered Road Barrier has an electric circuit available in it and has a solar panel on top. However, if the researcher wants to improve the tidiness and increase the protection of the circuit and solar, this is highly encouraged. This is because it can help facilitate the maintenance work on the barrier.

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APPENDIX

Appendix A **Project Cost**

Appendix B **Final Year Project Questionnaire**

APPENDIX A

COST FOR DEVELOPMENT OF THE PROJECT			
No	**Item**	**Quantity**	**Price (RM)**
1	Plastic Road Barrier	1	RM120.00
2	Solar panels	1	RM30.00
3	LED strip	2	RM25.00
4	Electronic Component	25	RM15.00
	Amount	=	RM190.00

APPENDIX B

THE EXAMPLE OF QUESTIONAIRE FOR FINAL YEAR PROJECT

Title:

THE EFFECTIVENESS OF THE AUTOMATED SOLAR-POWERED ROADBARRIER SPECIALIZED FOR CONSTRUCTION SITE

The Respondents Point Of View Regarding Automated Solar Powered Road Barrier

5.3.1 A part of my study of Final Year Project for Bachelor of Civil Engineering Technology (BCT) at Politeknik Ungku Omar (PUO), Ipoh, Perak. I am MUHAMMAD YUSRI BIN MOHD SALIM LIM (01BCT30F3020) conducting a survey to evaluate **THE EFFECTIVENESS OF THE AUTOMATED SOLAR-POWERED ROAD BARRIER SPECIALIZED FOR CONSTRUCTION SITE**

SECTION A :
TICK (/)
DEMOGRAPHY

a) Gender

Male	
Female	

b) Age

Under 25 years old	
26-35 years old	
36-45 years old	
46 years or older	

c) Position

Project Manager	
Construction Manager	
Engineer	
Site Supervisor / Assistant Engineer	
Inspector Of Works	
Operation	
Others	

d) Work Experience

< 2 Years	
2-5 Years	
6-10 Years	
> 10 Years	

SECTION B:
TICK (/)PRE-TEST

No.	Constraint elements of the current Plastic Road Barrier	Issues related to the current Plastic Road Barrier	Level of Agreement				
			Strongly Disagree	Disagree	Slightly Agree	Agree	Strongly Agree
			1	2	3	4	5
1	Perceived ease of use	The existing product is easy to understand and use.					
		Existing product is convenient to operate and interact					
		The existing product requires minimal effort and technical skills to operate					
2	Perceived usefulness	The existing product is reliable in providing its function and information					
		The existing product contributes to the overall efficiency					
		The existing product effectively helps in road construction					
		The existing product can give drivers warning and cautions.					
3	Attitude towards using technology	I am satisfied with the functionality of the existing road barrier					
		I feel comfortable using existing product					
		I believe that existing technology can improve the efficiency and effectiveness of the plastic barrier					
		I have a positive attitude towards using existing technology in the					

		plastic barrier					
4	Behavioral intention to use	I intend to continue using the existing plastic barrier					
		I would recommend the existing plastic barrier to others for on site construction					
		Existing plastic barrier can send notification or notify driver for any road closure or soil excavation					
5	The need of improvement for water tank level detector in this construction site	Do you need an improvement to solve the visibility of plastic barrier					
		Existing plastic barrier is systematic and efficient enough					
		Do you agree that existing method is adequate enough to the driver and operator in construction site?					
		Existing plastic barrier is easy to see and aware of its existence?					

SECTION C:
TICK (/)POST-TEST

No	Elements for the implementation of the innovated plastic barrier in construction sites	The effectiveness of the implementation of the innovated road barrier specialized in construction sites?	Level of Agreement				
			Strongly Disagree	Disagree	Slightly Agree	Agree	Strongly Agree
			1	2	3	4	5
1	Perceived ease of use	The implementation of the innovated plastic barrier is easy to understand and use					
		The implementation of the innovated plastic barrier is convenient to operate and interact					
2	Perceived usefulness	The implementation of the innovated plastic barrier will bring benefits to my team					
		The implementation of the innovated plastic barrier will improve the visibility and efficiency					
		I am satisfied with the visibility and functions of the innovated plastic barrier					

3	Attitude towards using technology	I have a positive viewpoint towards using this technology for innovated plastic barrier					
		I believe that implementing the innovated plastic barrier would improve the visibility and effectiveness					
		I feel comfortable using technology, such as solar panel and sensors for the plastic barrier					
4	Behavioral intention to use	I would recommend this innovated plastic barrier to others for their construction sites					
		I am motivated to adopt this innovated plastic barrier in my construction sites					
		I intend to use the innovated plastic barrier in my site					
5	The efficiency of the implementation of the innovated plastic barrier in construction sites	This prototype is systematic and efficient					
		This prototype solve the existing constraints					
		The implementation of solar panel and battery increases the workability and practices sustainable energy					
		I would recommend this innovated plastic barrier to others due to its efficiency					