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# Smart Construction Vest: A New Step Towards the Future of Occupational Health and Safety Management System for Construction in the Philippines

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**Abstract—This paper aims to identify the effectiveness of Smart Construction Objects (SCO) in the form of a smart construction vest as Occupational Health and Safety Management System for Construction in the Philippines construction. The researchers will compare the effects of using this device as a mechanism to monitor the response to construction hazards in construction sites versus projects that are not using this device. This study will provide future researchers and safety professionals the information and knowledge in this device that can help ensure the safety of the workers and integrate this to the safety and health management system in the Philippines as part of PPEs.**

**Keywords: Smart Construction Objects; Smart Construction Vest; Occupational Health and Safety Management; PPE (Personal Protective Equipment)**

# I. Introduction

The construction industry is among the dangerous industries in the world. Many lives are already lost due to the negligence of safety protocols in the site. Last 2018, the primary cause of death in the workplace is fall due to lack of personal protective equipment (PPE) and monitoring. It could be that these protocols and ways are not enough to secure the safety of the workers in the construction site.

This is why the researchers came up with an idea to implement the use of smart construction objects (SCO) in the construction site in the form of a smart construction vest that can detect hazards in the work site. This smart vest is equipped with sensors that consider the construction worker's body temperature and heart rate. Then, they wirelessly send the data to a smartphone application which will instantly alert the users to any hazards and risks. This technology is now used in the United States of America (USA), Australia, Malaysia and some parts of Europe. This paper aimed to test the effectiveness of this smart construction vest, so that this can be applied this to the safety and health management system in the Philippines and to also lessen the accidents in the construction site.

## *Statement of the Problem*

The main problem that this research was trying to solve was the hazards in the workplace using SCO-enabled devices in the form of a smart construction vest in the occupational health and safety management system in the construction in the Philippines.

With this global pandemic, the construction industry is one of the industries that is trying to implement social distancing in its workplace. This is impossible since this job requires teamwork and social interaction within the co-workers. The main problem that this research was trying to solve was the problem of social distancing and other hazards in the workplace using SCO-enabled devices in the form of smart construction vest in the occupational health and safety management system in the construction in the Philippines.

The main objective of this study was to assess the effectiveness of the smart construction vest as a means to improve the occupational health and safety management in the construction industry in the Philippines. Specifically, the research objectives addressing the purpose of this study were as follows:

1. Analyze the effectiveness of the smart construction vest in occupational health and safety management systems in the construction
2. Compare and contrast the advantages and disadvantages of using and not using the smart construction vest in safety management
3. Evaluate if the smart construction vest can prevent and alleviate accidents and hazardous situations in construction

Because construction work is a dangerous and hazardous workplace, this research study focused on undertaken safety measures in construction projects. It concentrated specifically on the smart construction vest and its effectivity on eliminating and minimizing the accidents on site.

The study will benefit the construction industry, specifically in terms of safety management. The safety management in construction is lagging compared to others. It still uses traditional practices when it comes to monitoring the safety of the worker in

the construction site. The study was conducted in order to determine the use of SCO-enabled devices in occupational health and safety management system in the construction in the Philippines.

## II. Methodology

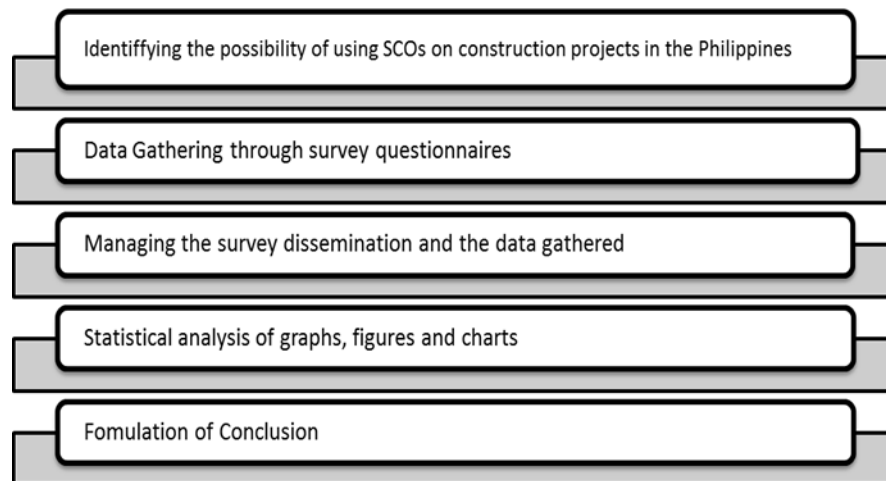
The researchers used the method of survey design. They believe that it is the best method to gather the data from the target respondents. The purpose of this study was to collect data from the respondents who fit the criteria of the study. Since the study is not part of the common practice in the Philippines, some of the data were collected from the past studies which are related to the study. The target respondents were project managers, safety officers, and safety superintendents who are currently handling high-rise constructions.

To collect information, electronic questionnaires were used. These were only answered by project managers, safety officers, and safety superintendents. This technique primarily evaluated interaction. The survey form was employed to evaluate the effectiveness of using smart vests in construction (versus the projects which are not implementing this device in constructing high-rise buildings, with considerations for the current pandemic). To collect information, electronic questionnaires were used. These were only answered by project managers, safety officers, and safety superintendents. This technique primarily evaluated interaction. The survey form was employed to evaluate the effectiveness of using smart vests in construction (versus the projects which are not implementing this device in constructing high-rise buildings, with considerations for the current pandemic).

The purpose of this study was to analyze the effectivity of the smart construction vest in improving the safety management of the construction industry in the Philippines. To achieve this objective, the data were gathered through surveys and interviews. The surveys and interviews contained questions that were related to smart construction vest and its possible uses and benefits in safety management. The gathered data were analyzed and interpreted using the statistical treatment, analytical hierarchy process. Using this treatment, the problem of this study was analyzed in three parts. In the first part, the main problem in this study that needs to be solved was identified. For the second part, possible solutions to the problem were identified. Lastly, how these solutions will be evaluated were identified.

This study was conducted in Uptown Bonifacio, Taguig and in Kuala Lumpur, Malaysia where the projects the researchers chose was located. Almost all construction injuries and fatalities were caused by negligence of the safety protocols in the site. Hence, this location since there are a lot of construction is happening which is the focus of the study. The researchers chose Kuala Lumpur, Malaysia as one of the research locations since it is the only country in Southeast Asia that is using this device.

**Fig. 1** shows the conceptual framework of this study that give emphasis to the procedures and phases to address the objective of this study.



**Figure 1.** Conceptual Framework

The first phase of this study was to identify whether or not the smart construction vest is applicable to use in the Philippines and if the contractors and companies can adapt to it through literature review. In the next phase, the researchers disseminated survey questionnaires to safety officers or project managers who are also in charge of the safety protocols on site. Then, the data gathered from the surveys were analyzed statistically and was interpreted graphically. After which, the researchers used the results and formed the conclusion and recommendations of the study.

### III. Results and Discussion

In this chapter, the researchers interpreted the data that they have gathered and discussed its results. The accomplishment of every phase and its component in the methodology, analysis, interpretation and recommendation of the research was delivered in order to understand the study. This study consisted of interviewing three experts from Malaysia and three experts from the Philippines who specialize in occupational safety and health. The criteria of the study were about identifying if smart construction vests can potentially be used in the construction industry in the Philippines. The researchers compared the statements of the safety professionals from two different countries, assessed if they were helpful in the implementation of safety in the construction site, and evaluated the prioritization of judgment. The researchers introduced and explained the smart construction vest to the Philippine experts, and then compiled them for their viewing before answering the survey forms that were sent to the respondents.

**Table 1.** Characteristics of the Experts

		Nationality		Years of Experience		Position		
		PH	MY	15	30	Safety Officer	Safety Engineer	Project Manager
Male	4	3	1	3	1	2	1	
Female	2	0	2	2	0	2	0	
Total	6							

The experts were asked these questions in order to gather their opinions regarding this device as part of their occupational safety and health protocols in their construction site.

**Table 2.** Criteria for evaluating the smart construction vest

No.	Criterion	Impact				
		1	2	3	4	5
1	Simplicity	1	2	3	4	5
2	Ease of usage	1	2	3	4	5
3	Level of effectiveness	1	2	3	4	5
4	Practicability	1	2	3	4	5
5	Environmental friendliness	1	2	3	4	5

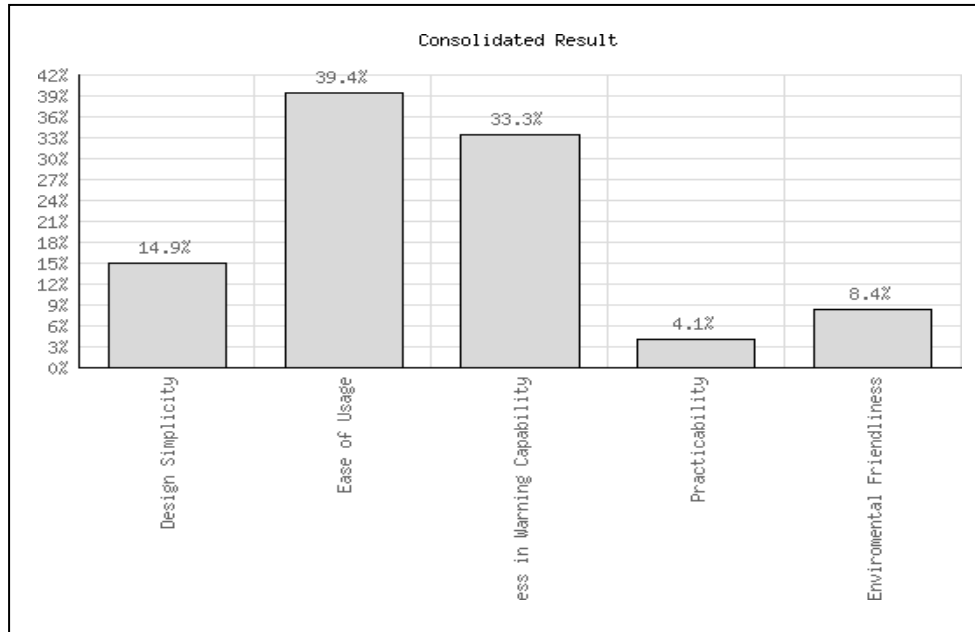
This part of the study showed the analytical hierarchy process that was used to rank and grade the vest according to the respondents' opinions and expertise. There were three experts from the Malaysian Public Works Department for the Malaysian experts who participated in this study and three experts from the Monocrete Construction Philippines who became the Filipino experts. They ranked the criteria which were the design simplicity, ease of usage, effectiveness in warning capability, practicability, and environmental friendliness.

**Table 3.** Consolidated Decision Matrix from the Philippine Experts

Criterion	DS	EU	EFC	P	EF
<b>Design Simplicity (DS)</b>	1	0.33	0.50	6.00	1.00
<b>Ease of Usage (EU)</b>	3.00	1	1.00	7.00	7.00
<b>Effectiveness in Warning Capability (EFC)</b>	2.00	1.00	1	7.00	5.00
<b>Practicability (P)</b>	0.17	0.14	0.14	1	0.50
<b>Environmental Friendliness (EF)</b>	1.00	0.14	0.20	2.00	1

**Table 4.** Consolidated Priorities from the Philippine Experts

Criterion	Priority	Rank
<b>Design Simplicity (DS)</b>	14.9 %	3
<b>Ease of Usage (EU)</b>	39.4 %	1
<b>Effectiveness in Warning Capability (EFC)</b>	33.3 %	2
<b>Practicability (P)</b>	4.1 %	5
<b>Environmental Friendliness (EF)</b>	8.4 %	4



**Figure 2.** Weight of the experts' priorities in the criteria

Using the AHP in this study, the following hypotheses were proven:

1. Smart construction vest is effective in the safety management in construction
2. Smart construction vest device can prevent accidents and hazardous situations in the construction sites
3. Smart Construction Vest can lessen the physical contact between the workers on the site.

Since the results showed that the experts were prioritizing ease of usage and effectiveness of warning capability because they got the highest percentages which were 39.4 % and 33.3%, respectively, among the other five criteria, the smart construction vest was presented to them. The smart construction vest is equipped with Lily Pad Arduino sensors. These sensors can measure the temperature and the vital signs of the workers which can detect early signs of heart attack or stroke that can occur during work. It is also equipped with Raspberry Pi sensors (1.00 m – 4.00 m range) that detects if the worker is in imminent danger like falling hazards, or if the worker is entering a potentially dangerous zone. The vest will send a signal and alert the worker to evacuate or to proceed with caution. The smart construction vest can prevent and alleviate accidents and hazardous situations on construction sites.

Meanwhile the design simplicity (14.9%) was ranked third because the smart construction vest is slightly heavier than the generic smart vest since it is equipped with sensors and light-emitting diode (LED) lights for warnings, batteries, etc. Since the smart construction vest is still a new innovative PPE in construction, the experts expected that it can be improved with a slicker design than the normal design which is currently being distributed by the manufacturers.

Regarding environmental friendliness (8.4%) and practicability (4.1%), since the smart construction vest is solar powered, they thought that it will be advantageous to be used during the day when there is plenty of sun rays but will be unfavorable at night or in tunnels or undergrounds because its source of power will be primarily low. The vest's practicability is ranked low because this device is relatively new in the global

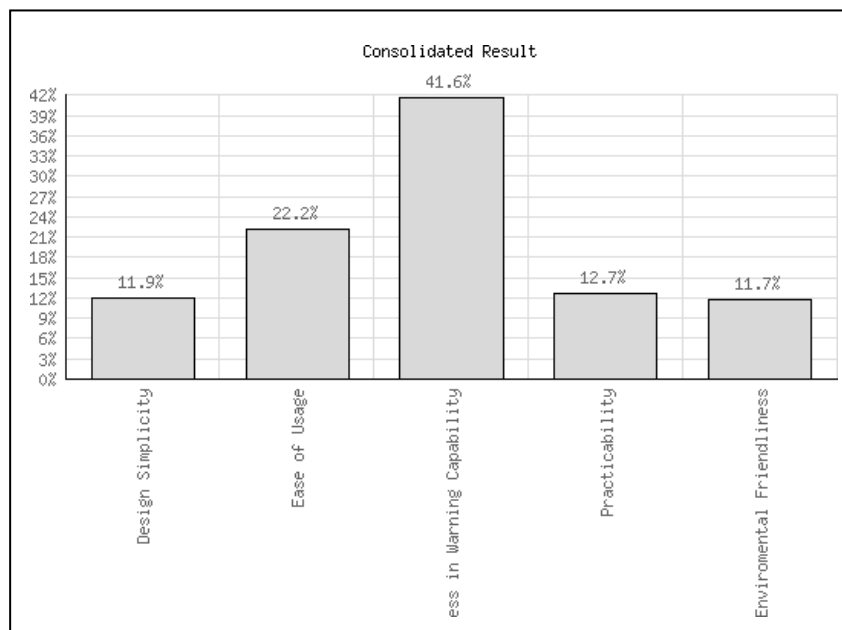
market and has a higher price compared to the generic safety vest that is available. It costs around Php 125.00 - Php500.00, depending on the manufacturer, which is closely triple the amount of the typical vest, whereas the generic safety vest costs around Php 60.00 - Php120.00 making it impractical for small construction companies to purchase this device.

**Table 5.** Consolidated Decision Matrix from the Malaysian Experts

Criterion	DS	EU	EFC	P	EF
<b>Design Simplicity (DS)</b>	1	5.00	0.11	0.14	0.33
<b>Ease of Usage (EU)</b>	0.20	1	0.11	9.0	9.00
<b>Effectiveness in Warning Capability (EFC)</b>	9.00	9.00	1	1.00	9.00
<b>Practicability (P)</b>	7.00	0.11	1.00	1	0.17
<b>Environmental Friendliness (EF)</b>	3.00	0.11	0.11	6.00	1

**Table 6.** Consolidated Priorities from the Malaysian Experts

Criterion	Priority	Rank
<b>Design Simplicity (DS)</b>	11.9 %	4
<b>Ease of Usage (EU)</b>	22.2 %	2
<b>Effectiveness in Warning Capability (EFC)</b>	41.6 %	1
<b>Practicability (P)</b>	12.7 %	3
<b>Environmental Friendliness (EF)</b>	11.7 %	5



**Figure 3.** Weight of the Malaysian experts' priorities in the criteria



Based from the results of the survey of the Philippine experts, ease of usage and effectiveness of warning capability got the highest percentages which are 39.4 % and 33.3%, respectively, among the other five criteria that was presented to them for the smart construction vest. The Smart Construction Vest is equipped with Lily Pad Arduino sensors along with a Raspberry Pi Sensors (1.00m – 4.00 m range) that greatly improves the functionality of the vest letting it send a signal and alert worker to evacuate or to proceed with caution. The smart construction vest is a step to prevent and alleviate accidents and hazardous situations on construction sites.

Since the Malaysian experts are well versed in using this device in their construction sites, ease of usage (22.2%) and effectiveness in the warning (41.6%) got the highest percentages on all the criteria for the smart construction vest since it is well tested in their occupational safety and health management.

In terms of design simplicity (11.9%), they have the same concerns as the Philippine experts. Given that there are additional components to the vest it is slightly heavier than the generic smart vest since it is equipped with sensors and LED lights for warnings, batteries, etc.

In terms of practicability and environmental friendliness, although the price is higher than the generic safety vest, the Malaysian safety professionals still use this in their construction sites since it is effective in preventing and alleviating accidents and hazardous situations on construction sites.

**Table 7.** Comparing the Criteria of Judgement of Philippine and Malaysian Safety Experts.

Criterion	PH	Rank	MY	Rank
Effectiveness in Warning Capability (EFC)	33.30 %	2	41.60 %	1
Ease of Usage (EU)	39.40 %	1	22.20 %	2
Design Simplicity (DS)	14.90 %	3	22.20 %	3
Practicability (P)	4.10 %	5	12.70 %	4
Environmental Friendliness (EF)	8.40 %	4	11.70 %	5

In this table, the priorities of the experts were almost the same. They prioritize the effectiveness in warning capability of the smart construction vest since it can prevent potential accidents which makes the smart construction vest effective in the construction sites in the Philippines.

Using the AHP in this study, these hypotheses were proven:

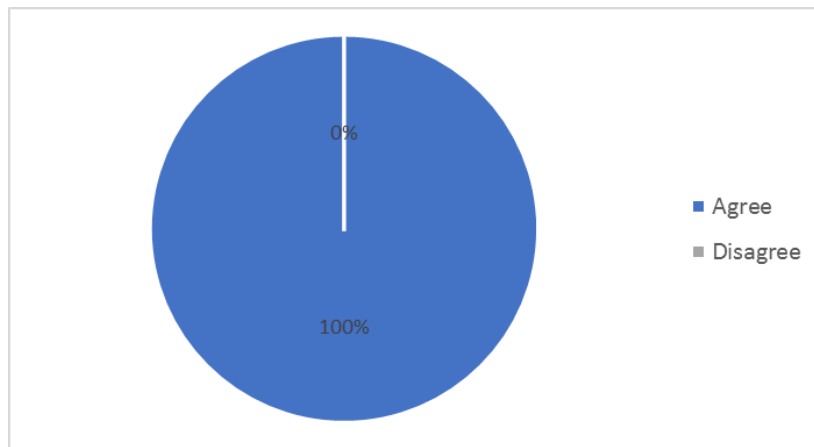
Smart Construction Vest is effective in the safety management in construction

The smart construction vest is an effective tool in safety management. From the criterion one of the priorities of the smart construction vest is effectiveness. With the different sensors incorporated into the vest it ensures that the wearer is safe and in good condition to perform their task. Compared to the typical vest that is being used in the Philippines the smart vest informs the user if they are in a hazardous area where they need to be on top of their toes and also alerts them when their condition is no longer in

top shape, informing the safety officer that the worker may encounter an accident effectively alleviating possible unwanted situations from occurring.

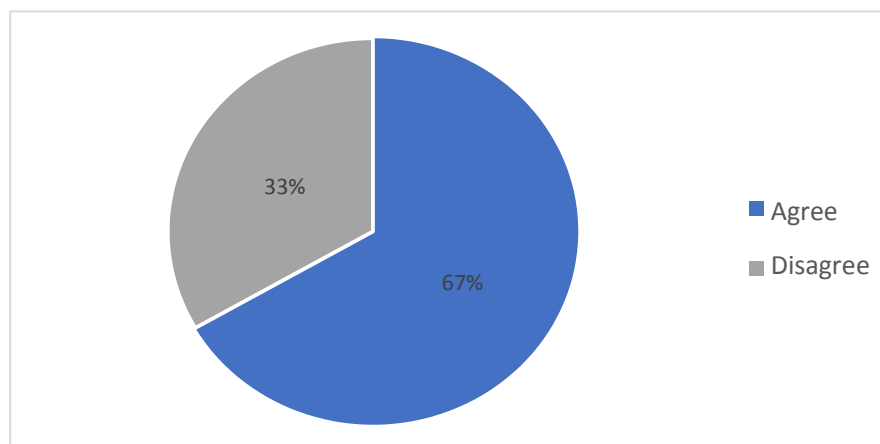
Smart Construction Vest device can prevent accidents and hazardous situations in the construction sites

The sensors incorporated into the vest along with transmitting the data it has to the safety officer or project manager in charge would ensure that accidents and hazardous situations are avoided. In the event of an accident the person in charge would also be informed ultimately preventing more damage and accidents to occur as well as ensuring help could be contacted right away. Giving a warning signal to the workers when they are in an area where it is more accident prone will allow them to calculate and plan better their course of action, it will also allow them to be informed of the possible dangers that may occur in an area making them aware of their surroundings.



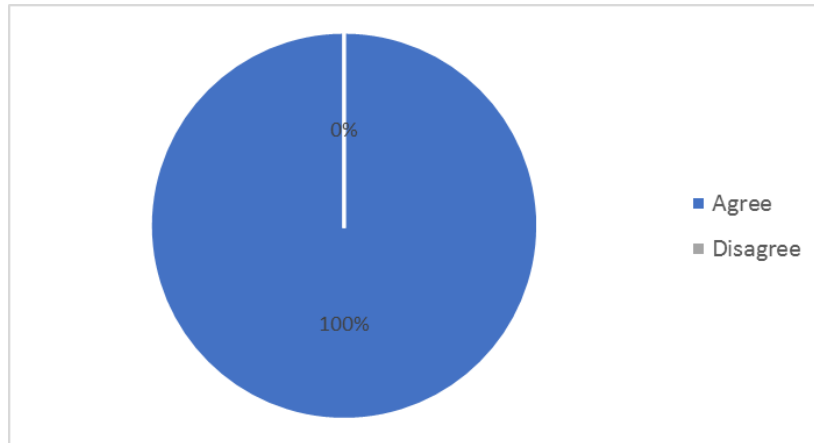
**Figure 4.** *Weight of the Malaysian and Filipino experts' agreement on whether the smart construction vest is beneficial in alleviating the number of accidents*

Figure 4 shows that all respondents agreed that the smart construction vest is beneficial in alleviating the number of accidents that happens on the site. It shows that the respondents were aware of the positive effects that the smart construction vest can offer when used in the site. The respondents were aware that using this type of vest in the site will help in lowering the number of accidents that happens in the site.



**Figure 5.** *Weight of the Malaysian and Filipino experts' agreement on whether the smart construction vest can provide better protection than the conventional safety vest*

Based from Figure 5, 67% of the respondents agreed that the smart construction safety vest that can sense danger can provide better protection than what the conventional safety vest can offer. Meanwhile, 33% of the respondents disagreed to this statement. This shows that the current safety professionals knew that the smart construction vest has features that can provide a better layer of protection than what the conventional safety vest has. It was proven that the additional features of the smart construction vest were able to help the workers from being exposed to hazards.



**Figure 6.** *Weight of the Malaysian and Filipino experts' willingness to incorporate the smart construction vest*

Based from Figure 6, it can be seen how all the safety experts agreed that they are willing to use the smart construction vest. This goes to show how beneficial and advantageous the vest is to the workers and, possibly, the construction industry. The upgrade from the typical vest to the smart construction vest would indeed incur an additional cost, but it would also be cost-effective to have it if it will be able to minimize the accidents occurring on site and to possibly save the contractors or project owners from the cost of having to pay for damages on property and to their workers who would get injured. As the saying goes, prevention is better than cure. It is best to spend a little, ensuring that less to no accidents occur, than to pay for damages. This was able to prove one of the hypotheses which was the experts having positive responses to adapting smart construction vest for occupational safety and health in construction.

**Table 8.** *Summary of the Advantages and Disadvantages Listed by the Safety Experts from both the Philippines and Malaysia*

<b>Advantages</b>	<b>Disadvantages</b>
The vest would help avoid accident in dark places. It is robust, light, and environment friendly.	The smart vest can only sense danger in a close distance. Sound produced is not loud.
It provides warning signal to the potential accidents that we might face in the construction which the conventional ones are not able to do so.	It is more costly than the conventional vest.

It is a high-technology wearable device that can be an additional measure for you to be safe.	The devices inside the vest have the worst effect if they malfunction while the worker is wearing it.
Global Positioning System (GPS), LilyPad Arduino Sensors (LAS), and Rasberry Pi Sensors (RPS) are much better for PFD's instead of the construction setting.	Its initial cost could be a drawback, and it might not be getting enough power source if inside the structure that is being constructed.
The vest still maintains its use as a high-visibility vest with added illumination. Other features can be helpful if its users are well informed or trained.	With metal detectors - most likely the "alarm" won't be off during the actual working time, especially during the layout phase.
The sensor for imminent danger is a good thing for workers who are prone to high-risk work such as working on heights at high-rise buildings. The GPS setting is a good thing to track the workers' position if they leave the premises of work and to possibly see if they are doing their assigned duties. And it can also help to boost the confidence of the worker to wear the safety vest at work which is usually not implemented on other companies.	
It helps a lot when it comes to safety purposes.	

The safety professionals from Malaysia and the Philippines were asked about some of the advantages and disadvantages of incorporating the smart construction vest. The Malaysian experts cited based from experience, while the Filipino experts based their opinion from the data that were presented to them by the researchers taken from the response of the Malaysian experts. The participants mostly listed a lot of the positive impacts that the smart vest would be able to contribute in the construction industry. They cited how this technology will be beneficial to the workers on site. It would mitigate some of the risks typically experienced on site and would not be an additional burden on the workers at least physically because it is light, robust, is incorporated into the vest, and would not be a separate item that they have to carry around. Aside from its safety benefits, the experts also cited that with this technology, one could track if the workers are where they are supposed to be and are performing the assigned work to them. This would also be advantageous to the safety engineers and supervisors on site. If they were looking for a person on site, as long as they are wearing the vest, they would be able to locate the person right away. For the negative impacts, most experts commented on how the smart vest will be pricier compared to the typical vest used on site. They also raised the concern on how the incorporated technology, such as metal detectors, will affect the workers when they are using it, especially when it does malfunction. The smart vest may also not be as functionable as it is designed to be, especially when it is located on areas on site where signal may be bad such as

underground constructions. The smart vest also functions within a short range of distance and the sound it emits is not as loud.

Although the experts failed to mention another benefit of this smart vest which is when an accident does occur, such as when the building unfortunately collapses and buries some workers, locating them will be easier as they have a tracker within them in the form of the vest. Search and rescue will be much easier, helping the police and rescue team in looking for survivors and helping those whom are trapped. Though from the concerns raised by the experts, it goes to show that the technology can still be improved and further enhanced to make it function better and worth the penny spent

#### **IV. Conclusion**

The construction industry is known for being a hazardous workplace. Working with different materials and equipment on different heights poses risks to the workers on site. This is the main reason why the construction industry has the highest rate of injuries and fatalities compared to other industries. For the past years, the Occupational Health and Safety has been continuously improving the safety management through safety equipment and trainings. However, these improvements are still not enough in lessening the accidents and deaths happening on site. Aside from human errors, the limitations of the traditional safety management are also causing accidents. The continuous development of technologies increases the possibility of improving safety management. Technology widens the range of protection that a normal safety equipment can offer. Smart construction objects utilize different technologies to offer more functions for a typical construction object.

The smart construction vest is one of the SCO-enabled devices that is slowly being incorporated into the safety management. It is similar to the design of a conventional vest, but it has more features that help in ensuring the safety of the user in the construction site. Similar with the conventional vest, it is light and is still highly visible with added illumination to avoid accidents in dark places on the site. It is also robust which adds more protection to the user as well as the sensors and other technologies that were added in the vest. The high technology placed in the vest, such as GPS, LAS, and RPS, increases the protection that the vest can offer. These technologies are used to provide warning signals when the user is close to any imminent danger and to check the status of the user. Despite its effectiveness as a safety equipment, it still has a drawback for the safety professionals. There is a limitation when it comes to the distance that the smart vest can sense as well as the sound that it produces. Since the sensors and devices are inside the vest, there is a high possibility that they will malfunction and that the alarm will stay on during the time of work. The biggest drawback for the smart construction vest is its cost due to the technologies that were added in the vest.

The smart construction vest will prove to alleviate and possibly prevent accidents and hazardous situations from occurring as it is a preventive tool. The smart construction vest sends out a signal before something could even happen and warns the workers about the possible dangers they might encounter. The vest gives out a warning in the form of lights and sounds emitted from the vest when they are in an area on the site that is prone to accidents. It also senses if the condition of the user is overfatigued to prevent them from overexerting themselves and possibly passing out, leading to unwanted events. In the event that an accident occurs, it will help rescuers to locate the workers as it also has GPS tracking, and they could also see the vitals of the workers

and would know who to better prioritize. This makes the smart construction vest an effective tool in occupational health and safety management system. It is beneficial to the company and the workers.

In this study, the effectiveness of the smart construction vest as a safety equipment for the workers in the construction site was proven. It was analyzed and interpreted based on the different criteria, depending on how it affects the quality of work of the user.

### ***Design Simplicity***

Safety equipment should be able to protect the user and help avoid any harm. Therefore, safety materials and equipment are made in a way that it will be easy for the user to move within the site and that the safety of the user, as well as the people within the vicinity, will be ensured. The smart construction vest uses the same design as the conventional safety vest that is being used in the construction. The only difference is that the former has more features that expand the protection for the user. Despite adding features to the vest, it does not hinder the user from moving with ease. The added features are of small sizes and weight which do not affect the overall weight of the vest.

### ***Ease of Usage***

From the Malaysian experts' perspective, ease of usage is the most important factor in the smart construction vest, having 39.4% among the five categories they had to choose from. The vest was innovative, but it did not make it different from how a usual construction vest is and only heightened the functions of a typical vest. The additional components and functions of the vest are hidden inside it and do not interfere with the worker's work. It has LilyPad Arduino sensors that can detect the vital signs of the workers, Raspberry Pi sensors that alert the workers when they are near an area that is eminently hazardous, and GPS that could easily locate users. Most notably, in case of accidents, the GPS function would be of great use. Despite these additional components, it remains light, robust, and does not hinder the functionality of the user.

The smart construction vest incorporates LED lights that make it easier and safer for the worker to move along the site. When a worker does get into an accident, there is a button in the vest that they can press to alert other people, getting help to them at a much quicker rate. Therefore, the ease of use provided by the vest is advantageous to the workers. The smart construction vest can perform the additional functions without encumbering the user.

### ***Effectiveness in Warning Capability***

Throughout the whole study, it can be concluded that the warning capability is the most important factor that was considered. Since accidents are inevitable in the construction, this is one of the most important features that this personal protective equipment must have. One of the Malaysian experts, who is already employing the smart construction vest, said that it is very effective as a safety management tool since it was able to send out alerts when the one of the construction workers was near the edge of the building that they were constructing (to which everyone is aware of the narrow distance near the edge of the building). Basically, the concern of the experts is that the devices inside the vest may have a negative effect on the worker who is wearing it in the event that it malfunctions, which would impose as a problem and, in turn, make

it ineffective. When the smart vest produces a sound that is not audible enough, it would beat its purpose.

Thus, it can be concluded that the smart construction vest was able to perform one of its main uses which is to alarm the workers and safety officers whenever there is nearby risk and to prevent and alleviate accidents and hazardous situations on construction.

### ***Practicability***

Based on the results acquired in this study, it can be seen how the experts were hesitant to use this since the price is more expensive than the conventional safety vest. If the smart construction vest and the conventional safety vest were to be compared, the conventional safety vest will only around cost Php 60.00– Php 120.00, while the smart construction vest will cost around Php 125.00–Php 500.00. Since it is not being used in the Philippines and needs to be imported from other countries, one of their concerns is that the cost may go up as high as 10% from its actual value. One of their concerns is the devices inside the vest which can malfunction, therefore, incurring additional cost and being a strain in their budget. If a malfunction does occur, it may be difficult to repair it and buy parts because contacting a device expert may be difficult.

In conclusion, the experts were hesitant to use the smart construction vest for now since there is a pandemic. Companies and contractors would not be keen to the idea of additional cost, but they all agree to use this device in the near future. They hope that there is a company that could introduce this device to the construction industry here in the Philippines.

### ***Environmental Friendliness***

Out of the five criteria presented to the Malaysian experts, they ranked environmental friendliness as fourth. The smart construction vest incorporates three sensors: Raspberry Pi, LilyPad Arduino sensors, and metal detector sensors. These all function from the in-built rechargeable battery. The battery is solar powered which makes it ideal for construction workers as they typically work under the scorching heat of the sun. However, this would be uncomplimentary at night or at underground constructions because there is no sunlight.

In conclusion, the vest is relatively environmentally friendly as it does not actively produce waste. It uses the sun to power all the other additional functions in it and stores it in light batteries for it to still power through the night.

## **V. Recommendation**

Based on the research findings, the researchers came up with these recommendations that might help the future researchers regarding this project.

1. Future researchers should explore more smart construction devices that they can introduce to the construction industry in the Philippines.
2. One of the major concerns of the experts is the alarm sounds not being loud enough to alert the people around. The researchers suggest using an alarming system that has a stronger sound in the smart construction vest.
3. The researchers recommend installing a sensor that has a wider range of detecting hazards and adding more safety lights to enhance its warning

capability for other people to see the users whenever the project location is in a darker region.

4. Future researchers should explore more countries to gather more information in applying this device for the occupational and safety health protocols in the country since the scope of this study is limited to the experts from Malaysia and the Philippines.
5. The researchers recommend this device to the Department of Labor and Employment (DOLE) and Department of Public Works and Highways (DPWH) for the occupational and safety health protocols of their construction projects so other companies will be encouraged to use this device.
6. The researchers suggest that the smart construction vest's battery be enhanced so it could last longer at night.
7. The researchers suggest improving the sensors so they could also be used in underground construction because that is where falling debris and hazards are prominent.
8. It would be best if the vest also incorporates light warning signals aside from the emitted sound to avoid startling the worker when the alarm goes off.
9. The researchers recommend to regularly update the system that will be used on the smart construction vest.
10. Future researchers should focus on how to further improve the current design and system without compromising the current features of the vest.
11. The researchers recommend incorporating a system that will send real-time updates to the safety engineer present on the site to alert the user when working.
12. Future researchers should also focus on minimizing possible malfunctions and on alerting the user if there is any problem with the vest before using it.

## VI. References

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