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A Review of Reliability Tests on Safety Technologies

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Abstract. A road maintenance employee is someone who ensures that roads and highways are safe, clean, and accessible. They perform a variety of tasks that demand physical exertion, such as repairing damaged automobiles, performing routine check-up procedures, or performing restoration work, among others. As a result, these workers may be exposed to hazardous situations, as there have been multiple accidents involving highway workers on the road recently. Signal Warning Detector casing structure was designed as part of a safety system to provide early warning to highway workers as traffic accidents among highway workers have become a concern. This study reviews the different reliability tests done on casing structure by previous researchers. Therefore, this study applies laboratory

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experiments to further test the reliability for the SWAD transmitter and receiver casing structure as a development step towards producing a reliable SWAD system.

INTRODUCTION

The protection mechanism is now one of the most important measures to ensuring that workers remain safe and secure. Factories, ports, warehouses, and other industries are not the only ones that utilize protection devices. However, roadways should be given special attention on the roadside. The safety of road construction workers is significantly more endangered in this circumstance. When an employee is involved in an accident, the employee may get significant injuries or perhaps die. Highway construction and maintenance crews are regularly faced with heavy traffic and, in certain situations, fast-moving traffic. A large number of events in work zones show that the contact is hazardous and evident[1,3].

On the road nowadays, there are several construction worker injuries. Road safety was a primary issue for expert traffic engineers, and it was extensively investigated. The degree of safety while working is one factor that contributes to the increase in the number of injuries on a daily basis[4]. The safety of road workers cannot be guaranteed simply by putting up a safety cone and a hazard light to keep them safe in the event of an accident. By designing a safety system that improves their safety, the safety mechanism must be enhanced.

A highway maintenance worker is responsible for keeping highways and roads safe and accessible to the public[5]. In the realm of highway service, there are a variety of professionals that specialize in normal operation, maintenance, and parking problem repair. This job necessitates a high level of physical fitness, and much of the time is spent outside. Furthermore, road maintenance workers are exposed to hazardous situations such as driving long distances in high-speed automobiles, working in inclement weather, and using a variety of machines, tools, and heavy machinery on a regular basis[6,7].

The Signal Warning Detector is capable of detecting hazards coming in the opposite direction through a programmed sensor within a defined range[4]. The device is accompanied by an alarm system and a vibrator attached to the employee's hand. In order to ensure that the device is operated properly, a reliability test will be carried out to assess the level of operation of the transmitter and receiver as well as the impact test. Reliability is the degree of accuracy of the measure; the measurement would be accurate if it provides the same repeated outcome under the same conditions.

The issue of security is extremely essential, and there have been several security issues. Many of the highway accidents involved a public vehicle and a construction vehicle inside the work zone, such as the possibility of a vehicle being involved in a rear-end collision. According to several previous reports, the rate of rear-end accidents in the work zone was higher than in the non-work zone[8,9]. According to the Kentucky accident data, approximately 80% of all work zone accidents occur in the workplace[10]. The primary location for work zone accidents, regardless of road type, is the activity area, and the most common type of accident is a rear-end collision[9]. As a result, highway concessionaires enable researchers to assess and implement a work zone protection policy to improve the safety of work zones at construction sites. These highway concessionaires also require the Secretary to keep a detailed record of all incidents, including fatalities, injuries, and specific types of accidents, such as work zone accidents. According to the current studies mentioned above, one of the most effective methods of accident risk analysis using historical data is to use data of high quality and reliability. It's worth remembering that poor-quality or unreliable historical records might lead to erroneous or biased outcomes.

In the case of a collision, the main causes of the incursion into the working area must be considered. A number of factors that contribute to workplace injuries includes dangerous driving, visibility obscured by sunlight or dust, following construction vehicles into the work area, bad weather conditions, driver inattentiveness or impairment and poor or damaged traffic control devices[10,11]. There were two leading causes of worker death in work zones identified. First, workers struck by passing vehicles and workers struck by moving machinery within the working zone are the second[12,13]. Study of intrusion accidents in the Highway Construction Work Area in New York State over a six-year period found that while vehicle intrusions were not common, they resulted in a substantial proportion of casualties and severe injury to workers, as seen in the Table 1.

Table 1. Number of Accidents based on Accident Categories

Accident Category	Number of Accidents

	Fatal	Non-fatal Injuries	Total
Traffic Accidents	58	3189	3247
Intrusion Accidents	4	286	290
Traffic Accident – Worker Involved	6	560	566
Intrusion Accidents – Workers Involved	-	131	131
Intrusion Accidents – Pedestrian Workers Involved	-	29	29
Non-Traffic Accidents – Workers Involved	3	1188	1201

The use of technology to improve administrative safety measures has recently gained a lot of attention. In terms of training, technology has been used in a variety of ways to improve safety training programs[5]. Therefore, in order to produce a good quality technology, it must undergo mechanical testing to ensure that the technology produced is safe and suitable for the users. Mechanical testing is a required aspect of every design and production process. Whether it's determining material qualities or giving validation for finished goods, maintaining safety is critical. Testing is also important for assuring a cost-effective design as well as technical advancement and supremacy.[14] This section discusses and reviews several technologies that had undergo mechanical testing for different technologies.

Electro-Mechanical Safety Testing of Portable ECG Device

The electro-mechanical safety test of portable belt type ECG equipment was evaluated as a necessary medical gadget. Home healthcare goods are frequently utilised in settings where there is no trained supervisor or well-defined information, as well as a lack of technological facilities and safety. Furthermore, because home healthcare customers are typically old, they are inept at handling electromechanical equipment and are unaware of the dangers of electricity. As a result, these tests are essential to ensure a safe working environment. By connecting to the chest, this belt-style gadget measures the electrocardiogram (ECG) and heart rates. Examinable items were chosen based on common criteria for electro-mechanical safety (IEC 60601-1) and environmental testing (IEC 60068-1, IEC 60068-2) of home-healthcare equipment[15]. The RS300G3 is an important electrical safety, which was required as a medical equipment, was assessed, and the majority of the examination lists were chosen based on the users' conditions. All of the chosen examinable lists that are relevant to the Korean environment were passed by the gadget.

MEMS Pressure Sensor Packaging Test

The influence of epoxy-based moulding compound packaging on the performance of a micro-electro-mechanical system (MEMS) pressure sensor is studied in this study. By monitoring output voltage signals, a series of tests were carried out to characterise the MEMS sensor through temperature and pressure fluctuations. To explore the stress developments, the sensor was modelled using the finite element approach. To investigate the material modelling influence on the calculation findings, the moulding compound was assumed to be elastic and viscoelastic. By comparing the computed findings to experimental data, the model was confirmed. The stress caused by the moulding compound was shown to have a considerable impact on sensor performance, and the accuracy of the calculations was found to be highly reliant on the modelling of the moulding compound[16]. The EMC was represented as a viscoelastic material in this study. To acquire the time-temperature dependent material characteristics of the EMC, a series of stress relaxation experiments were undertaken. Simulating the process temperature profile yielded the process generated residual stress. Three distinct pressures at four different temperatures were evaluated after the process triggered stress calculations to approximate actual pressure measurements. To ensure that the modelling was correct, the simulation results were compared to experimental data[17].

Road Vibration Test Schedules from Pavement Profiles for Packaging Optimization

The cost of protective packaging for transportation, as well as the environmental cost of disposing of it, is significant, and there is a compelling case for more research into better packaging design and reducing the amount of material required to protect goods and products during storage and distribution[18,19]. This research looks at the methodologies for validating package performance in terms of road transport vibrations, and it proposes an innovative and practical way for more precisely simulating random vehicle vibrations in the lab. There's also a rundown of the procedures for measuring and analysing pavement profile data. The approach described here is based on research that

used observed longitudinal pavement profile data to develop statistical models for the projected vibratory response of various transport vehicle kinds and travel speeds. The study describes how to utilise these statistical characteristics to generate vibration simulation plans that are tailored to the vehicle type and route. The research demonstrates how statistical models may be used with ordinary random vibration controllers to provide a practical but upgraded way for providing more realistic simulations of road-related vibrations in the laboratory for package performance evaluation.[18]

METHODOLOGY

Structural analysis is a comprehensive test to ensure that structural deformation of the structure is sufficiently lower than the permissible limits and that structural deformation does not occur. The purpose of the structural analysis is to design a structure that has the appropriate strength, rigidity and safety. Deformations in the structure may be either elastic that is fully recoverable or inelastic that is irreversible. Structural analysis helps design systems that meet their practical, economical and desirable requirements. Structural analysis incorporates the fields of physics, geometry and instability theory to estimate intrinsic strengths and tension on the systems to be constructed. Signal Warning Detector (SWAD) was designed as part of a safety system to provide early warning to highway workers as traffic accidents among highway workers have become a concern. By reviewing previous researches, it is understood that the reliability evaluation of SWAD transmitter casing and receiver casing needed to be done.

Reliability is defined as the calculation that can be repeated is consistency[20].This test can be considered to be the indicator for calculating a reliable outcome. In other words, if the test is done to get any data, the next test will get identical data. There are some potential explanations for this if the reliability test does not have consistent results, one of which is environmental. Differences in types of environments, such as distance, velocity, presence and sound pressure levels, can affect test output due to the time of testing. In this study, there is an alarm and a vibrator as a warning to save the maintenance worker before the crash occurs. In certain situations, warning systems may be unreliable even though they do not emit signals where those emissions are justified. The data transmitted are the basis for optimising the structure and reliability of the vehicle[2].

One of the tests that will be done is impact test. A handheld impact hammer with a load cell mounted on the system frame is the most commonly used means of conducting transient experiments. The load cell measures the input force and the accelerometer on the structure measures the reaction. This method calculates a series of transfer functions by mounting a stationary response transducer that is an accelerometer and moving the input force around is similar to adding a mechanical exciter to the structure and moving the response transducer from point to point[9].

Next, water resistance test will be conducted to test the SWAD system at different rain conditions as the SWAD system will be placed outdoors on the PLUS Ronda vehicle as in Figure 1.

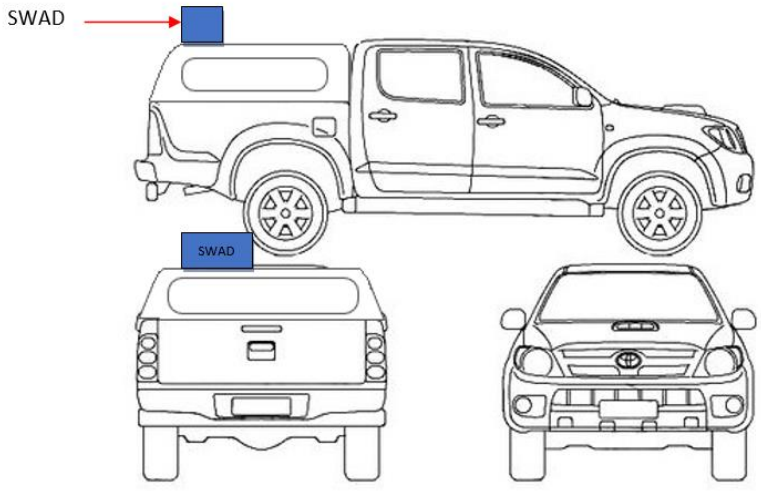

Figure 1. SWAD placement on PLUS Ronda vehicle

For this study, the water resistance test will be conducted using the wet test chamber. The wet test chamber consists of Nylex UV Protection Rain Gauge, Pipe System, Water Pressure Control Gauge, Transmitter Placement Slot and

Receiver Placement Slot. Two transmitters will be placed at the slots. Next, the water pipe will be turned on to allow water flow. The water can be controlled by the pressure gauge. The results will be based on Malaysia Average Rainfall Data [21] for heavy, moderate and light rain.

Other than that, battery performance test is also essential in order to acknowledge the capability of the battery life for the transmitter and receiver. The receiver battery life performance will be indicated by the indicator colour that shows the voltage capacity or battery life.

Lastly, tensile test will be done to complete the reliability test of the study. The test will be done using Universal Testing Machine. First, the machine switch and computer will be turned on. Tensile test will be selected on the computer. The position of the test material on the selected test equipment will be adjusted to start the testing. After finishing the testing, the results will be recorder on the computer. The results that will be analyzed are the maximum force, displacement, stress, strain and yield force that can be endured by the receiver and transmitter casing of SWAD.

DISCUSSION OF FINDINGS AND FUTURE NEEDS

Based on the reviews, there are a several steps that can be taken into consideration for the study. This includes a detail study and analysis on the Signal Warning Detector System (SWAD) concept. The Signal Warning Detector System concept is still fresh and not many research and study on it. Most of study is about signal or sensor concept for simple uses not for highway safety user, but the SWAD system will be an innovation as a device for the maintenance worker at the highway/any site for upgraded their safety level. The efficiency of it can be suggest to study in details. Next, verifying the material usage. For further research, different types of material can be applied to the design such as stainless steel and other non-metal materials. Lastly, fabricate the products. For further study, it suggests to fabricate the project and it will be easier to observe the design operability on the real application.

CONCLUSION

Based on this research, several steps should be taken in order to produce a reliable and quality SWAD system. Previous researches had proven that reliability testing on a product should be done to ensure a quality performance of the technology produced. Upon completing the development of the SWAD system, the methods that will be used as part of the reliability test are battery performance testing, tensile testing, vibration testing and lastly, waterproof test. By conducting this study, the safety level of highway workers can be upgraded. Other than that, different types of materials can be tested to ensure that it is suitable for the receiver and transmitter casing at different weathers. By conducting this study, real time application can be done at the highway to improve the system as well as providing a safety alternative for the users.

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