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USE OF INNOVATIVE RADIO FREQUENCY IDENTIFICATION (RFID) TECHNOLOGY TO MINIMISE THE RATE OF ACCIDENTS IN NIGERIAN CONSTRUCTION SITES

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***Abstract*-The construction industry has experienced several challenges in the area of health and safety. This has resulted in high accident and fatalities incidence specifically within the Nigerian construction industry and sites and thus have an effect on construction projects. In an effort to improve construction processes, the application of innovative wireless communication technology such as the Radio frequency identification (RFID) technology can be employed to minimise accident and improve health and safety on construction sites. The study aimed to assess the use of innovative radio frequency identification technology (RFID) in minimising accidents in Nigerian construction sites. A well-structured questionnaire was used to assess health and safety practice, rate of occurrence of accident & fatalities on construction sites and also construction site safety as well as on the use of the RFID wireless technology on site. A total of 45 questionnaires were distributed to various construction companies and sites in Nigeria. Out of the 45 distributed questionnaires, 34 were returned and used for the analysis with return rate of 75.5%. The data obtained was analysed using relative importance index (RII) in order to determine the relationship between the influencing factors of various respondent. Furthermore, the RFID is an innovative wireless communication technology which if implemented on site can reduce lots of fatalities and improve productivity by providing solutions and remedy to health and safety problems and also providing workers on site with potential occurrence of existing danger on construction site. However, there is need to integrate such modern technology in construction so as to address many challenges within the industry as well as reducing frequent causes of fatalities and accidents on sites.**

KEYWORDS: **Health, Safety, RFID, Sites, Wireless, Communication, Nigerian construction industry**

1.0INTRODUCTION

`The construction industry has been identified with the highest occurrence of accident and life endangering fatalities compare to other industries on an annual basis, management of construction site with effective communication within personnel is challenging due multifaceted layout of the construction sites. However, effective site communication between personnel on construction site is essential in terms of safety of workers and staff. The industry has play a significant role in the global economic growth worldwide, the use of wireless information technology has been put into practise in construction industry and site such as the use of mobile radio systems, local area wireless network and tablet computers has been applied on various construction site to increase and improve communications between various construction workers onsite and offsite collaboration (Elvin 2003, Kheni et al. 2008).

In Nigeria, the construction industry is a significant and vital sector of the economy, according to (CBN 2007), the construction industry provide 12% of gross domestic product (GDP) in Nigeria. On the other hand, workers in the industry face injury and fatality risk compare to workers in other field of profession and one (1) out of five (5) place of work, fatality includes a construction worker (William 2002). In addition, constructions such as site work consist of numerous hazards and dangers with the potential of producing hundreds of injuries and deaths. Construction sites are made up of heavy equipment, toxic substances and other hazardous materials, of which can have various effect on construction personnel, also construction site are party to injuries due to fires, falls from scaffolding, and explosion.

Information technology and communication solutions are regarded as tools which contribute and aid in the management of safety in numerous projects. According to (Lee et al. 2009) he design and develop a mobile safety monitoring system which sense staff and workers safety via radio frequency technology for potential accidents due to fall on construction sites. Similarly, (Teizer et al. 2010) build up an autonomous pro-active system which enhance safety management with the assistance of radio frequency remote sensing technology and put into action by notifying equipment operators and employees. In addition, the radio frequency identification technology (RFID) has been acknowledged by the department for business innovation and skills (DTI), as a prospective vital technology for developing the construction industry. Also, (Carbonari et al. 2011) and (Lo 2011) proposed and develop an RFID system for health and safety management on construction site. Furthermore, (Chae and Yoshida 2010) create an accident prevention system by means of RFID system to avert collision on site with plant equipment. Therefore, the application of the radio frequency technology (RFID) is rather increasing in a variety of industries and it has result in several literature sources to build up structure for the operation of the RFID technology.

The need to integrate information technology and communication in construction industry is necessary as a result of the current poor performance of the industry, specifically the Nigerian construction industry. Wireless sensing technology such as the Radio Frequency Identification technology (RFID), can be used to examine health and safety of individuals and equipment on site. The RFID tags transmit wireless data to a system with RFID reader which in turn develops a warning system that alerts construction workers of potential treats.

2.0 LITERATURE

2.1 RADIO FREQUENCY IDENTIFICATION TECHNOLOGY (RFID)

The radio frequency identification technology (RFID) represents an automatic identification technology which operate by the use of radio frequency to pick up and transmit data information. (Karygiannis et al. 2006) described automatic identification technology as a process of identifying, collecting as well as processing data by means of a computer system with negligible and minimum human intervention. The RFID technology is one of the fastest rising and developing automatic data collection technologies that make use of wireless radio communication to identify objects, people by the use of radio frequency signals (Bhuptani and Moradpour 2005). The use of the RFID is rising in several industries and therefore has make possible for researchers to build up models and outlines for its implementation. According to (McCarthy et al. 2003) he defines RFID technology as a wireless sensor technology which is based on electromagnetic signal detection. The RFID technology operates in a similar way to bar code but on the other hand, the RFID has the ability to recognise and track items and equipment without contact with the tags having the ability to withstand environmental conditions. (Yin et al. 2009) proposed that the radio frequency technology (RFID) is a projection of radio waves and signal which transmit information as well as manage wireless information recovery and storage to find and recognise the position of workers and objects.
The RFID system is made up of three major components, which involves the use of RF tags (transponder), antenna, and transceiver which are programmed with specific data. Radio signal are produce by the transceiver via the antenna, and transmission between the RF tags (transponder) and transceiver are made possible by the antenna. The tag which is responsible for data transfer becomes active due to signal emitted by the antenna and the transceiver acquires the data by transferring it to any connected host computer for processing (Domdouzis et al. 2007).

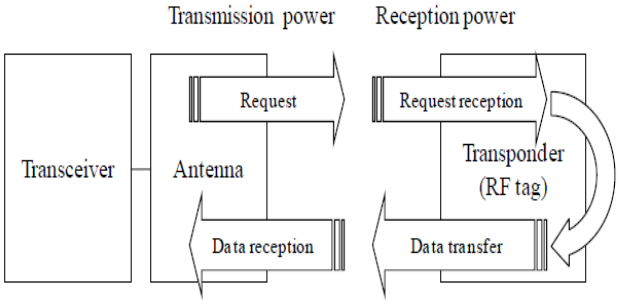

Figure 2.1: Typical RFID system (Chien-Ho 2010)

The RFID have been present since the 1950's and it was make known to serve as a substitute to the use of bar codes, the RFID technology in contrary to the bar code has the ability to read, transmit, store and give up to date information.

2.2 ARCHITECTURE AND COMPONENT OF THE RFID SYSTEM

The components and architecture of the RFID system operates using the concept of radio waves as a substitute to the use of light waves in reading tags. As shown in fig 2.1, the components comprises of RFID tags, reader and antenna, the RFID tag transmit the data's via transponders and the reader which has the ability to retrieve the data from the tags (CII 2002). Similarly, according to (Finkenzeller 2003) and (Sandip 2005), a simple RFID system comprises of three major components which include; RFID tag or transponder, antenna, and a reader, as well as a combination of software components such as software, host application and middleware that are expected to communicate, linking the applications and hardware for example readers and tags.

The RFID tags contains contain data which are transmitted to a remote reader by means of radio frequency waves of definite wavelength as shown in Fig. 2.2. Data's identified by the tag are characterised to a particular material or equipment using an establish application, the reader which encloses usually an antenna or scanner depending on its design is used to communicate with the tag when it's within range of an electromagnetic field, thus triggering the RFID tag to execute user functions.

Figure 2.2: RFID communication (Sangyong et al. 2013)

2.3 RFID TAGS

The RFID tag is also identified and known as transponder and comprises of a semi-conductor chip, the chip which contain a unique electronic code fixed to the material or object to enable the identification of target objects. Information that are been stored in the RFID tag are transmitted by means of radio frequencies to the radio frequency reader as shown in fig 2.3 (Bhuptani and Moradpour 2005). Basically, antenna creates the communication between the RFID tags and the readers, also the signals are radiated by the RFID readers via the antenna. The RFID tags are classified mainly as active and passive tags and the two tags differ based on the radio frequency emitted by the antenna, and passive tags has short reading ranges while the active tags has have high reading ranges and memory with better protection against noise. Though, the tags are larger and heavier, have shorter life (3-10years) when compared to passive tags.

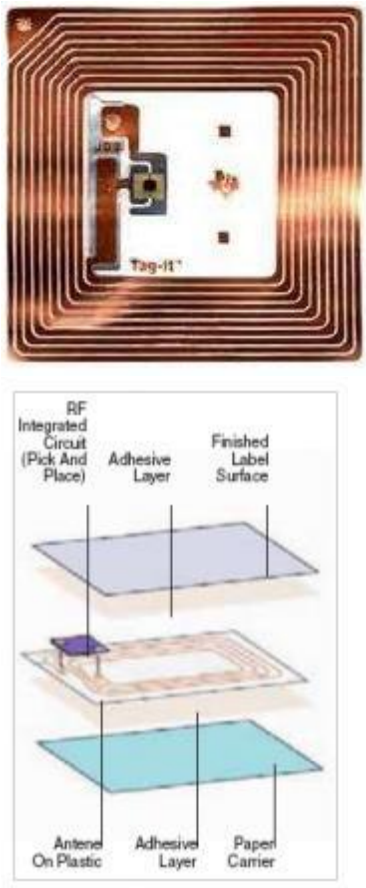

Figure 2.3: Structure of RFID Tag (UPM 2006)

According to (Frank et al. 2006), he suggested that the RFID tags can be integrated in a range of material depending on the demand of the environment. The tag is fixed in plastic label in the form of a microchip and the selection is based on the tag size, shape and the material.

2.4 CURRENT APPLICATION OF RFID IN THE CONSTRUCTION INDUSTRY

According to (Hillebrandt 1984), the construction industry has features that are shared separately by other industries but in combination appear in construction only. The areas considering the application of the RFID in other industries can also be found in construction although with variation. The Radio frequency identification technology (RFID) is not a new kind of technology in construction, although (Jaselskis et al. 1995) foresee its potential application in construction such as in concrete processing and handling, cost coding for labour and equipment, and in materials control. Further research has been conducted to explore the potential application of RFID in the construction industry.

A system for tracking construction assets which include materials and equipment was develop by (Jang and Skibniewski 2009), which involve the both the use of radio and ultrasound signals. Also, a similar system was implemented for tool tracking in construction job sites. (Domdouzis et al. 2007) explore the potential application of RFID in construction involving automatic tracking of structural steel members at construction site, tracking of item on the construction sites and on-site inspection support system. However, not much application of the RFID have been realised in real construction practice regardless of the desire for the RFID technology. Some of the current scenario in which the RFID technology is been used in the construction industry are as described below.

2.5 CONSTRUCTION HEALTH AND SAFETY PRACTICE IN NIGERIA

Construction industry is indubitable as a result of its clear importance in the economy of several countries. In spite of this, poor safety performance of construction has continued to raise concern globally including Nigeria. However, as stated by (Ioannides et al. 2004), every single year several people fall victim to injury, harm and also death as a results of accidents on construction sites. Similarly, (Adeniye 2002), also relate this as a result of numerous situations in which construction activities are carried out in multi-employer construction sites, where employees from numerous companies managing various tasks of construction projects. Therefore, under such conditions which at times may be chaotic, and lack of proper communication among workers can cause or result in life-threatening injury as a result of unsafe work practice by workers. Over the years, a construction industry in Nigeria has been increasing effort towards enhancing its health and safety practice. (Hinze 2005), propose that for safety performance to be effective, construction companies and industries have to structured and positioned to make modifications when it is regarded suitable.

Additionally, it was suggested that to be very positive in terms of safety, it entails a safety approach be implemented and also ought not to be subject to monitoring of injuries as soon as it occurs and instead of establishing safety actions on extents of failures as is usual and common with emphasis on injury incidence. Hence, there is need to concentrate on those actions that can result to good safety practice.

Construction health and safety practice deals with ensuring the health, safety and welfare of individuals involve in work employment. According to (Ferris and Buckley 2006), the construction health and safety protect co-workers, employers, customers, suppliers and members of the public influence by the workplace environment. Therefore, it is clear that it is the obligation of the management to avoid accidents and eliminate health and safety hazards so as to reduce the difficulty of employees as well as minimising their loss. In a study conducted by (HSE 2000), it projected that in the UK only, an estimate of 500 individuals are killed yearly and some hundred thousand are either injured or experience work related poor health and safety conditions. (Idoro 2011), discloses that all categories of contractors working in Nigerian construction industry does not perform better than one another as regards health and safety and therefore calls on stakeholders within the industry to develop and enhance their health and safety performance. This on the other hand, denies the construction industry the chance to make proper and suitable changes when necessary. The outcome of non-performance of health and safety in the Nigerian construction industry can be seen in the number of fatalities and injuries resulting from activities of construction throughout the country (Awodele and Ayoola 2005).

In Nigerian industrial economy, laws are not put into effect and as a result of lack of correct data, the record may be very high. There has been several reports of industrial accidents in construction sites and factories mostly equipped with extremely bad safety standards leading to death and disability of workers.

2.6 IMPLEMENTATION SCENARIO OF RFID IN CONSTRUCTION SITE

The above architecture and component of the RFID system as illustrated in figure 2.1 can be implemented on construction site. Devices such as routers are positioned to give a network coverage in the form of a ZigBee system. The basic areas of scenario implementation on site include; monitoring of vehicles/equipment, monitoring of workers and construction materials. The ultra-high frequency (UHF) passive tags are positioned on the equipment or vehicle so as to enable accurate reading on coming into the construction site. However, for monitoring of workers the tags can be fix to safety helmets and also in other construction materials in which the tags can be attached as well.

Therefore, when a worker or staff intends to trigger or activate a specific equipment, the access control reader fix to the equipment reads the tag on the safety helmets of the worker and also the detected ID transferred signal to the local server for authorisation, if the worker is given permission to operate such equipment the server will send a feedback with the equipment activation permitted. If not, the feedback access will be declined. The server provides a database whereby specific information workers, equipment's as well as construction materials are saved, all information feedback from various reader nodes within the system are registered. Though, the feedback information can be used as the servers monitoring safety system which consist of safety policies and also produces alarm when required. Furthermore, the system can be implemented for health and safety scenario such as hazard notification of potential accidents on site as illustrated in fig 2.4 whereby tags are been position in areas which are prone to potential danger on construction site. Probable occurrence of accident or hazards related danger can be collected and stored within the tag, hence it can be easily retrieved by the safety or site manager.

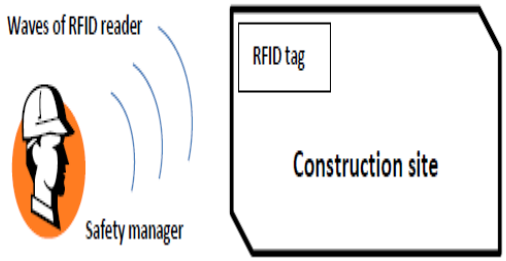

Figure 2.4: Hazard notification of potential accidents

Therefore, it can also be adopted in another health and safety scenario case when dealing with dangerous areas on site such as excavation process, in the protection of heavy vehicles and equipment on site. The tag which can be fixed on heavy equipment and vehicles is identified upon approaching a highly prone dangerous areas by an existing positioned RFID tag alerts the operators of potential threats.

3.0 RESEARCH METHODOLOGY

The research methods adopted involve both primary and secondary. Questionnaire survey was conducted for the primary research thereby aiding management and employees in understanding the concept of exploring the use of wireless technology to improve health and safety in the Nigerian construction industry.

The secondary research, involve conducting review of literature from sources such as electronic database, websites, journals, books and other publications, so as to understand the factors influencing and affecting health and safety, as well as identify health and safety hazards and its impact on construction project in Nigeria. A total of 45 questionnaires were disseminated to various construction companies and sites in Nigeria from different technical and professional background and was made up of three sections: section (1) consist of information about the profile of various respondent as well as stakeholders in the construction company and site, section (2) consist of the employers assessment on Health & Safety on the construction site while section (3) consist of employers assessment on the use of the RFID wireless sensor technology on site. The response of the survey were analyse by the use of the relative important index (RII) in order to determine the relationship between the influencing factors of various respondent. The result for the data analysis was presented in the form of bar and pie charts, also using tables.

4.0 RESULTS AND DISCUSSION

Table 4.1: Fatalities & Accident occurrence on site

TYPE OF FATALITIES/ACCIDENTS ON SITE	NEVER 1	LOW 2	AVERAGE 3	HIGH 4	RII (%)	FATALITIES/ACCIDENT RANKING
Scaffolding and formwork accidents	5	7	10	12	71.3	5th
Accident due to slip, trip and falls	4	6	8	16	76.5	3rd
Electrocution and electrical accidents	3	5	15	10	72.1	4th
Crane accidents	10	6	10	8	61.8	7th
Accident due to heavy equipment's and tools	2	7	9	16	78.7	1st
Fire and explosion on site	2	10	15	7	69.9	6th
Collision between workers and heavy operating equipment	5	4	8	17	77.3	2nd

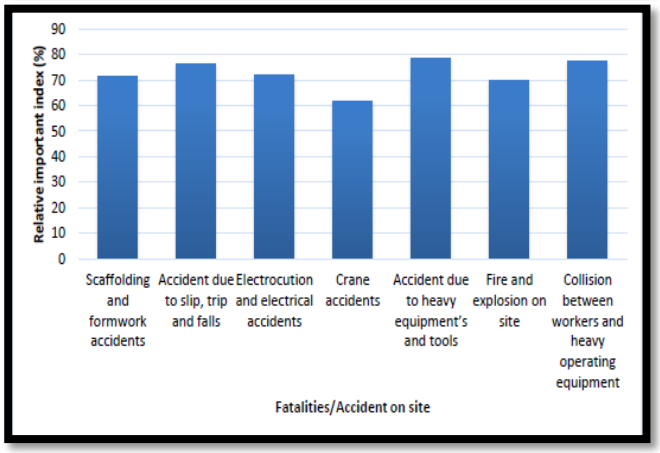

Figure 4.1: Ranking of Fatalities/Accident on site

In order to assess the main causes of fatalities and accident within the construction site as well as how the RFID technology can be applied in terms of minimising the occurrence of this fatalities and accidents, the result from table 4.1 and fig 4.1 indicated that accident due to heavy equipments and tools has the highest chance of occurrence, then followed by collision between workers and heavy operating equipments, with fire and explosion exhibiting the lowest chance of occurrence.

Table 4.2: Factors affecting construction site safety

FACTOR AFFECTING CONSTRUCTION SITE SAFETY	MOST UNLIKELY	UNLIKELY	NEUTRAL	LIKELY	MOST LIKELY	RII (%)	RATING
Poor equipment and equipment maintenance	3	2	3	14	12	97.1	2nd
Lack of experience managers	3	4	6	10	11	91.2	5th
Poor safety reliability of managers and workers	0	4	10	10	10	94.1	4th
Lack of personal protective equipment (PPE's)	3	1	7	12	11	94.9	3rd
Lack of innovative technology	1	3	6	10	14	99.3	1st

The factors affecting site safety were presented in table 4.3 which indicated that lack of innovative technology has the highest effect on construction site, followed by poor equipment and equipment maintenance with lack of experienced managers having the lowest effect.

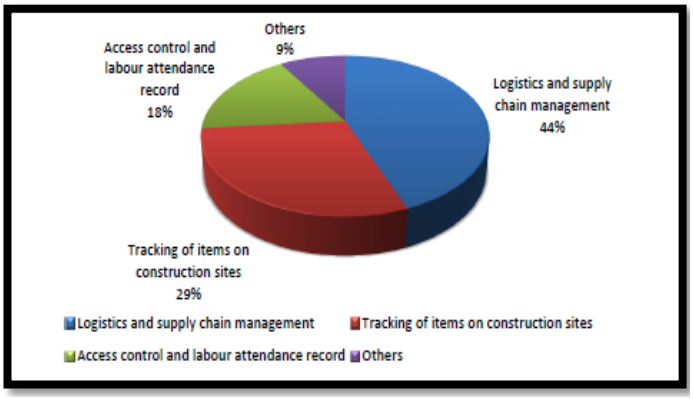

Figure 4.2: Response on areas of RFID use on site

From fig 4.2, it can be seen that RFID is mostly used in the area of Logistics and supply chain management with 44%, tracking of items on construction site with 29%, access control and labour attendance record with 29%, while others has 9%. For this reason, most of the respondent use the RFID system for logistics and supply chain management.

Table 4.3: Response of the efficiency of the RFID system

RFID SYSTEM	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE	RII (%)
Do you consider the RFID tagging system as solution to safety of workers on job site?	13	9	9	3	0	98.6
Are you satisfied and do you agree with the efficiency of the RFID system in other major areas you have use the technology in the past?	12	10	7	2	3	94.1

From table 4.3, RFID system with a relative importance index of 98.6% will provide potential solution of workers safety on job site. Also, RFID system is an efficient technology that has been used in other areas in the past with a relative importance index of 94.1%.

5.0 CONCLUSION

In most construction sites in Nigeria, lack of proper health and safety practice as well as culture of workers on sites does contributed to high occurrence of fatalities and accidents on site. However, if a number of health and safety practice such as fatalities and incidence reporting/investigation is been properly implemented with the use of the innovative communication technology such as the radio frequency identification (RFID) technology, health and safety can be improved on site and thus minimise accident occurrence, such as accident due to heavy equipment's and tools and also collision between workers and heavy operating equipment; which are considered as one of the most occurred on site.

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