"WORKERS SAFETY BY USING INTERNET OF THINGS ON CONSTRUCTION SITE"

Vaishnavi E.Kadbhane
Student, M. E. (Construction and Management) ,

Department of Civil Engineering
NDMVP's KBT College of Engineering
Nasik, Maharashtra, India.

Abstract : For a construction project to be successful, safety of the structures as well as that of the personnel is of utmost importance. Construction industry employs skilled and unskilled laborers subject to construction site accidents and health risks. To protect construction workers and prevent accident we have to propose a design for autonomous system that monitors, localizers and warns site laborers who avail within danger zone. Though labour safety laws are available, the numerous accidents taking place at construction sites are continuing. Management commitment towards health and safety of the workers is also lagging. During accident situation it is advice to wear helmet to avoid head injuries but uneducated labor usually didn't follow protocol so we have design based RFID helmet which will be in contact with the hardware device so as it will generate buzzer or warning signal if any employee doesn't have helmet during construction activity. Also we have design based PIR sensor to identify whether worker was present unman area. We have design based belt connector circuit sensor for scaffolding belt. The proposed system is user-friendly, and its architecture is based on Internet of Things (IOT).The system represents the environmental and ambient parameter monitoring using low-power wireless sensors connected to the Internet, which send their measurements to a central server. If a drought condition is identified by the monitoring system, then an alert message is sent to the user via text message or email. To accurately detect and identify construction workers, the proposed system employs three combined techniques using (1) PIR sensors (2) Helmet with PIR. (3) Alcohol detection wearable and sensors dramatically can improve worker's health, safety and avoid accident. Also smart PPE save time and improves productivity through connectivity, live updates and remote communication. This technology is not only saves life but also saves money.

Index Terms - Workers safety, Internet of things, PPE, Alcohol sensor, PIR sensor.
=

I. INTRODUCTION

Civil construction sites are considered as one of the riskiest environments where many potential hazards may occurred. In India, construction industry is the second largest employer when compared to agriculture. Throughout the world, the construction area of civil engineering is one of the most hazardous industries. The number of fatal accidents taking place at the construction sites is quite alarming and the major cause was found to be fall of persons from height and through openings. Thus the major issue of construction industry is safety. The injuries and fatalities costs much to the contractor and ultimately to the nation economy by way of time loss, cost of compensation to workers and loss in productivity. In addition to the above toll, there is addition to human suffering and pain due to loss or injury of a dear one for his family and friends. The nature of construction project itself has potential hazard of accident since its uniqueness, open space, exposure to weather, involving and working at height in confined spaces and psychological and physically vulnerable working environment. Thus there is a need for awareness among workers working at dangerous place and conditions.

As mention earlier the construction industry is highly risky occupation. The lack of prediction and identification of accidents and hazard results in losing the gear of progress of works, which may derail the whole concept and purpose of the project. The increase number of fatalities, injuries & hazard at construction site identifies the understanding critical problem related to safety.[1] Though labour safety laws are available, the numerous accidents taking place at construction sites are continuing. Management commitment towards health and safety of the workers is also lagging. So, we have to proposed system to protect construction workers and prevent accident. We have to propose a design for autonomous system that monitors, localizers and warns site laborers who avail within danger zone.

Many accidents are happening on site due to improper precaution and safety so there is need to provide safety at construction work. Previous methods were time consuming and costly so, we are providing workers safety by using internet of things.

Objective of Study

- To identify unsafe practices in labor work in construction site.
- To provide IOT based interactive platform for labor safety construction site and give warning for unsafe labor.
- To identify whether worker were present during unman areas of construction site for various purpose like digging, slab construction were heavy duty work, crane etc.

II. LITERATURE REVIEW

The main aim of this study is to helps providing increased safety for construction workers and eliminates back over accident.

A. Civil Infrastructure connected to IOT

Civil construction sites are considered as one of the riskiest environments where many potential hazards may occur. To protect construction workers and prevent accidents in such sites, this paper proposes a novel design for an autonomous system that monitors, localizes, and warns site laborers who avail within danger zones. They proposed an Internet-of-Things-based (IoT-based) safety barrier warning system to achieve a safer underground construction site. A focus of this paper is to establish a hazard energy monitoring system and use IoT to generate early warnings and alarms as dynamical safety barriers for hazard energy on underground construction sites. To ensure the performance of the proposed system, the hazard energies and their coupling mechanisms was analyzed to provide safety barrier strategies and scenarios for avoiding unsafe behaviors and unsafe status of construction equipment and workers' environment[2][3].So by using smart PPE in civil infrastructure on IOT would revolutionize humans life style.

B. IOT based safety barrier system

The study will collect data from general contractors, who are involved in major types of construction. Collected data include information regarding organizational safety policy, safety training, safety meetings, safety equipment, safety inspections, safety incentives and penalties, workers' attitude towards safety, labor turnover rates and compliance with safety legislation. The study will also reveal several factors of poor safety management. Thus the paper will conclude by providing a set of recommendations and strategies to contractors for improving their safety performance[4]. The concept of sensor network which has convergence of micro electro-mechanical systems technology, wireless communications and digital electronics. The realization of sensor networks needs to satisfy the constraints introduced by factor s such as fault tolerance, scalability, cost, hardware, topology change, environment and power consumption. we studied about smart helmet for protection of head and also studied about alcohol sensor that is MQ-3,we also get for detection of alcohol which sensor to be used. In that paper to avoid fall accident they developed a mobile phone application was developed for the managers/foremen for onsite balance monitoring of the construction workers using the 20-second test at different times of the day and establishing their corresponding balance performance profiles. This would results plan mitigation scheme before a fall accident happens and ultimately help reduce falls in the construction industry.{[5],[6],[7]}Also we studied briefly discussed about what IOT is, how IOT enables different technologies, about its architecture, characteristics & applications, IOT functional view & what are the future challenges for IOT[6].

C. Wireless sensor network

Some applications of Wireless Sensor Networks (WSNs) to the automobile are identified, and the use of Crossbow MICAz motes operating at 2.4 GHz is considered together with Tiny OS support. These WSNs are conceived in order to measure, process and supply to the user diverse types of information during an automobile journey. Aspects of the definition of the architecture and the choice/implementation of the protocols are identified[7]. Not all safety systems in the construction industry involve monitoring or fatality avoidance only, but training and education are also considered for safety matters in construction sites. Compared to theoretical safety training sessions, training simulators and game-based training are more realistic where trainees acquire and apply skills interactively. The workers can experience accidents along with resulting implications. Such approaches like game-based education and on-site simulator software may offer more hands-on training and more flexibility in hazard identification on construction site[2].

III. METHODOLOGY

The entire process has been divided into 3 parts : Use of hardware and software, implementation on site, analysis and cost comparison between PPE using IOT and without IOT. first we found which hardware and related sensors to be used to detection of person, helmet and alcohol. Then design hardware and sensors as per requirement. This work addresses the management of resources in the internet of thing. preparation of smart PPE like helmet with RFID tag, person identifying using PIR sensor, alcohol detection . This system will prevent accident and injuries to workers. The proposed system is user-friendly, and its architecture is based on Internet of Things (IoT). Lastly cost comparison between smart PPE with total expenses of IOT and manual cost of PPE generally used with accident cost. After comparison between accident cost with PPE and IOT based PPE with safety precaution, we will get which safety method more preferable with minimum cost and safety.

A. **Hardware details**:

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically[8].

B. **Sensor details**:

Sensors are one of the key building blocks of the Internet of Things which can be deployed everywhere from military battlefields to vineyards. A sensor is an electronic device, which detects senses or measures physical stimuli and responds to it in a specific way. A sensor is a device which is capable of converting any physical quantity to be measured into a signal which can be read, displayed, stored or used to control some other quantity. This signal produced by the sensor is equivalent to the quantity to be measured. Sensors are used to measure a particular characteristic of any object or device Some can be as small as four millimeters in size, but the data they collect can be received hundreds of miles away. Sensors complement human senses and have become indispensable in a large number of industries, from health care to construction.

a) **PIR Sensors** : A passive infrared sensor (PIR sensor) is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. They are most often used in PIR-based motion detectors. PIR sensor detects a human being moving around within approximately 10m from the sensor. This is an average value, as the actual detection range is between 5m and 12m.PIR are fundamentally made of a pyro electric sensor, which can detect levels of infrared radiation. In this project PIR senor used to detects helmet and person while unman area.

b) **MQ-3 Semiconductor Sensor for Alcohol**: Sensitive material of MQ-3 gas sensor is SnO_2, which with lower conductivity in clean air. When the target alcohol gas exist, The sensor's conductivity is more higher along with the gas concentration rising[9].This sensor used to detects consumption of alcohol by person or worker. MQ-3 gas sensor has high sensitivity to Alcohol, and has good resistance to disturb of gasoline, smoke and vapor. The sensor could be used to detect alcohol with different concentration, it is with low cost and suitable for different application[10].

C. **SOFTWARE DETAILS** :

A. MYSQL

The most popular Open Source SQL database management system, is developed, distributed, and supported by Oracle Corporation. A database is a structured collection of data. It may be anything from a simple shopping list to a picture gallery or the vast amounts of information in a corporate network.

B. SQLOG

SQL yog is the most powerful manager, admin and GUI tool for MySQL, combining the features of MySQL Query Browser, Administrator, PHP MyAdmin and other MySQL Front Ends and MySQL GUI tools in a single intuitive interface. SQLyog is a fast, easy to use and compact graphical tool for managing your MySQL databases. SQLyog was developed for all who use MySQL as their preferred RDBMS. Whether you enjoy the control of handwritten SQL or prefer to work in a visual environment, SQLyog makes it easy for you to get started and provides you with tools to enhance your MySQL experience.

C. Eclipse

The ESP8266 is a low-cost Wi-Fi microchip with full TCP/IP stack and most widely used java IDE. Eclipse uses plug-ins to provide all the functionality within and on top of the run-time system. Its run-time system is based on Equinox, an implementation of the OSGi core framework specification. In addition to allowing the Eclipse Platform to be extended using other programming languages, such as C and Python, the plug-in framework allows the Eclipse Platform to work with typesetting languages like Latex and networking applications such as telnet and database management systems. In this project eclipse used for run program and then result get automatically as shown fig.4.

D. PROPOSED SYSTEM

Arduino Uno work on +5 volt and ATmega 328 microcontroller**.** The Arduino Uno can be powered via the USB connection or with an external power supply. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Ground and Vin pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. The power source is selected automatically.[8] power supply gives to UNO it will run and after that it continuously check the sensor status means it's check any unwanted situation occurred or not at construction site. It's sense the human being detect/present at construction site PIR sensor check the worker wear helmet or not, if helmet is not wear then alarm is generated and give intimation to supervisor, And also MQ3 Sensor detects consumption of alcohol by person or worker. after detection it gets buzz or alarm and then that MSG will send to server or system (laptop). Last that MSG will send to project manager by IOT, That is manager get MSG to the mobile before accident.

a) System Architecture

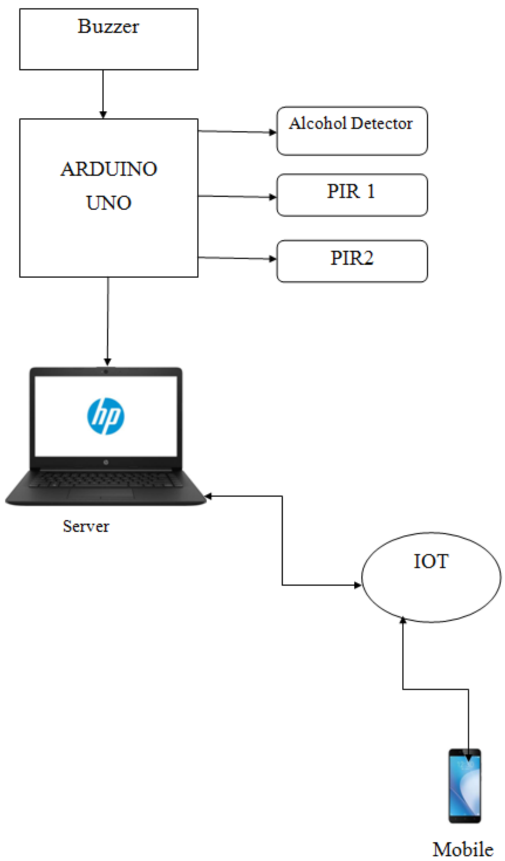


Figure 1. System Architecture

b) Hardware with sensors

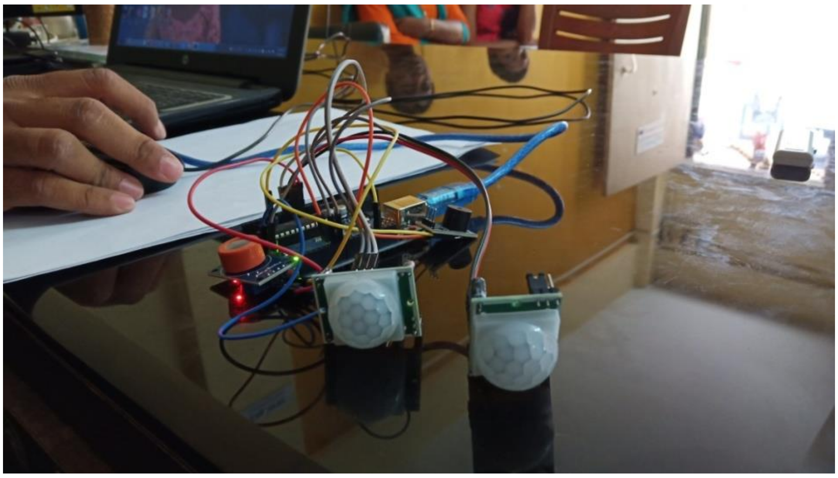


Figure 2 Hardware with Sensors

A. Project Flow Chart :-

i. Helmet detection flow chart

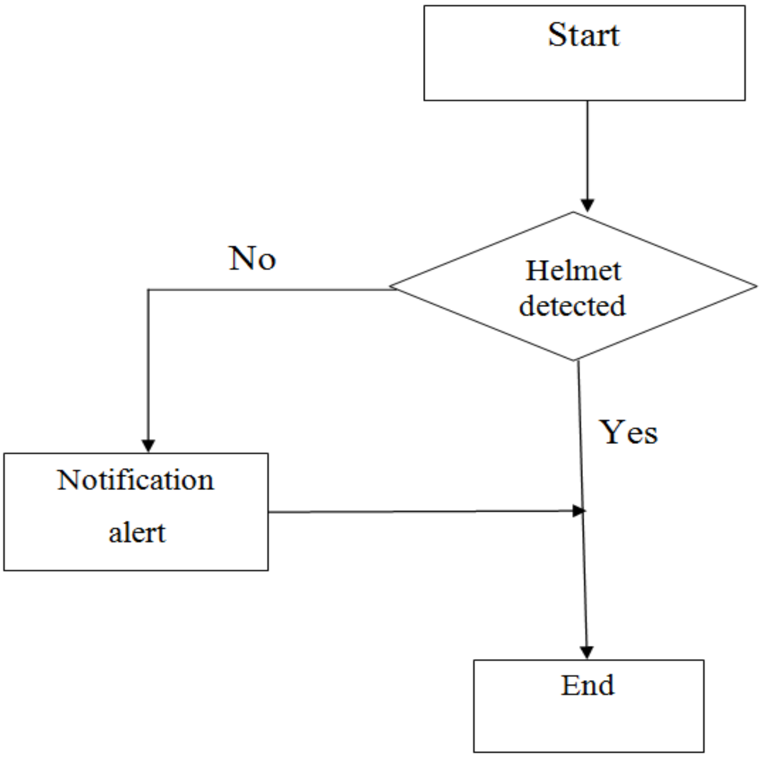


Figure A IOT based Helmet detection

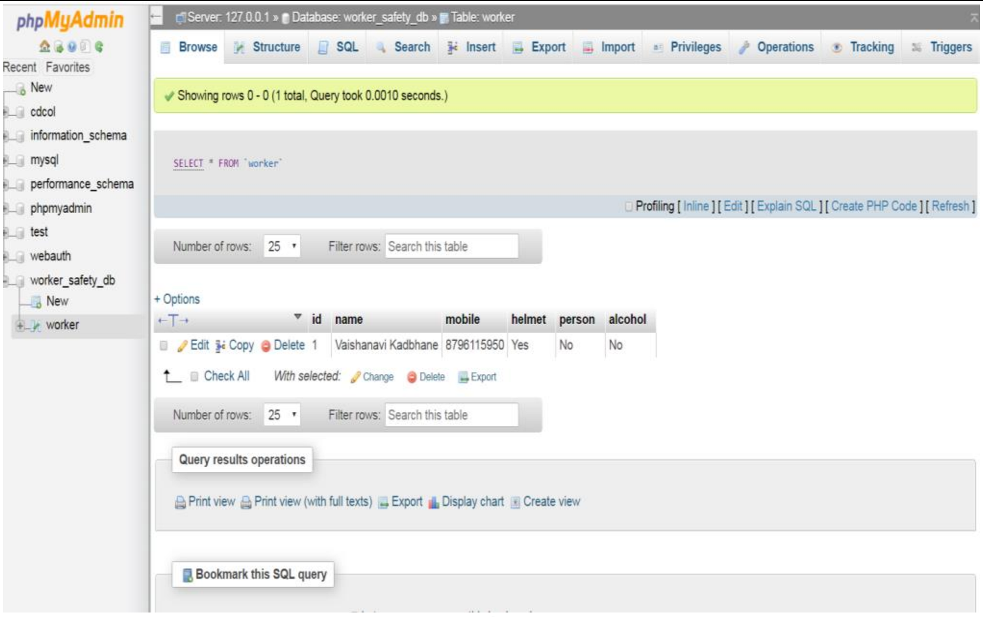


Figure 4 .Results on server

IV. DATA COLLECTION -

The ongoing project of Jaikumar construction is of high-rise residential mass-housing project of PARKSYDE HOMES at Adgaon, Nasik. In this project they have total 5 phases of construction. They have handed over or we can say fully constructed 3 phases out of total 5 phase. The 4th phase is about 90 percent completed and last phase is under construction. There are total 27 building is going to be construct some of 2bhk and some of 3bhk, So from this study we get most probable injuries occurred due to accident at various activities during construction. we have specified all probable injuries in table no 1.

Site details-

Name Of Company	: Jaikumar construction LLP. Nasik
Project Name	: Parksyde Homes
Owner	: Mr. .Gopal Atal and Mr. Manoj Tibriwala
Safety officer	: Mr. Tushar suryawansi
Location	: Parksyde Homes, Hanuman Nagar, Opp. Rasbihari High School, Adgaon, Nasik.
Area Of Site	: 25 acres
Type of Building	: High-Rise Structure
Type of Structure	: G+ 15 RCC Constructions
RCC consultants	: J.W. Consultants
Architect name	: Mr. Umesh Bagul

Figure4.1Workers doing work without safety belt

Figure 4.2 Worker doing work without safety Helmet

Figure 4.3 Workers work without safety belt, gloves and any precaution

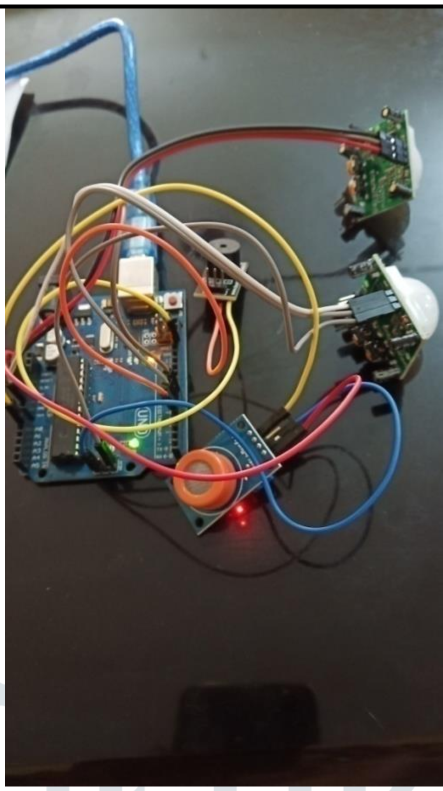


Figure 4.4 Ardiuno with sensors used in project

B. ACCIDENT COST,PPE COST & PROBABLE INJURIES FOR BUILDING CONSTRUCTION

➢ *For Helmet Detection .*

The work was carried out on PCC for foundation, Plinth work, RCC work plumbing activities. For calculation of accident cost the monthly wages were considered as Rs 8000/(according to WCA 1923), depending upon the type of injury caused to the injured person. Also by considering direct cost and indirect cost of accident or injuries. Relevant Factor is an age-based multiplier defined in Schedule IV, here we considered RF is 197.06 for 35 age group. Calculate total cost by addition of accident cost and PPE cost with multiply by relevant factor. one of calculation of activity as shown below.

1) Foundation PCC Work :-

Step 1 :For Permanent Injuries:

I. Amputation at hip (90%) = 90 % **x** 8000= 7200

II. Loss of fingers of right or left hand

Cost of Compensation

- (a) Whole (14%) = 14 %x 8000= 1120
- (b)Two phalanges(11%)= 11% x 8000= 880
- (c) One phalanx(3%),=3%x8000= 720
- (d) Loss of bone(5%)=5%x8000= 400

Step 2 :(a)+(b)+(c)+(d)=1120+880+720+400=3120
Total compensation cost=[I]+[II]= 7200+3120=10320
Total compensation cost +PPE cost =10320+300=10620
Total compensation cost x RF=10620x197.06=2093077

Note: This calculations for permanent disablement & same steps followed for temporary disablement and death for each and every activities.

Table..IV.1 Calculations Of Accident Cost & PPE Cost For Helmet Detection

SR NO	List of activities	Probable accident	PPE used	Most probable injuries	Calculation of accident cost	PPE Cost in rs.	Total cost of accident cost and PPE cost
1	Foundation PCC Work	Sliding of earth	Helmet	**Permanent injuries:** i. Amputation at hip (90%)	7200	75-300	2093077
				ii. Loss of Fingers of right or left hand a)Whole (14%)	1120		
				b)Two phalanges (11%)	880		
				c)One phalanx (3%)	720		
				d)Loss of bone(5%)	400		
				Temporary injuries i. Through metatarsophalangeal joint(14%)	1120	75-300	721539
				ii. part, with some loss of bone(3%)	240		
				iii. any other (head injuries) (25%)	2000		
				Permanent disablement= Death	#1086624	75-300	1992444
2	Plinth work	Defective scaffolding .	Helmet	**Permanent injuries:** i. Amputation at hip (90%)	7200		
				ii. Loss of Fingers of right or left hand			2093077
				a)whole (14%)	1120		
				b)two phalanges (11%)	880		
				c)one phalanx (9%)	720		
				d)loss of bones(5%)	400		
				Temporary injuries: i. Through metatarsophalangeal joint(14%)	1120	75-300	721539
				ii. part, with some loss of bone, any other toe(3%)	240		

				Permanent disablement # death	=905520#=1086624	**75-300**	**1992444**
3	RCC work (scaffolding)	Improperly assembled scaffolding.	Helmet	**Permanent injuries:** i. Amputation at hip (90%) **ii.** Loss of Fingers of right or left hand	7200	**75-300**	**2093077**
				a)Whole (14%)	1120		
				b)Two phalanges (11%)	880		
				c)one phalanx (9%)	720		
				d)loss of bones(5%)	400		
				Temporary injuries : i. Through metatarsophalangeal joint(14%)	1120	**75-300**	**721539**
				ii. part, with some loss of bone, any other toe(3%)	240		

				iii. head injuries (25%)	2000		
				Permanent disablement # death	*905520 #1086624	**75-300**	**1992444**
4	Plumbing work	Fall from ladder	Helmet *Table IV.2*	**Permanent injuries** i. Amputation through shoulder joint(90%)	**7200**	**75-300**	**2266190**
				ii. Amputation of one foot resulting in end bearing (50%)	**4000**		
				Temporary injuries loss of fingers /s of the left or right hand (14%)	**1120**	**75--300**	**279825**
				Death Permanent disablement	***=**905520 #=1086624	**75-300**	**1992444**

C. Cost of IOT based PPE Cost :

Table.IV.3 calculation of IOT based PPE Cost.

Sr. no.	**PPE Used**	**Hardware used**	**IOT COST (Hardware cost + Sensor cost+ implementation cost)**	**Total Avg. cost**
1.	Helmet with PIR	Microcontroller PIR Sensor	(10000-15000) +(1000-2000)+(5000)=	32000 Rs/-
2	Alcohol detector	Alcohol Sensor Microcontroller	(10000-15000)+(2000-5000)+(5000)=	35000Rs/-
3	Person detector	PIR Sensor Microcontroller	(10000-15000) +(1000-(2000)+(5000)=	32000 Rs/-

D. The Various types of PPE available in market along with price range

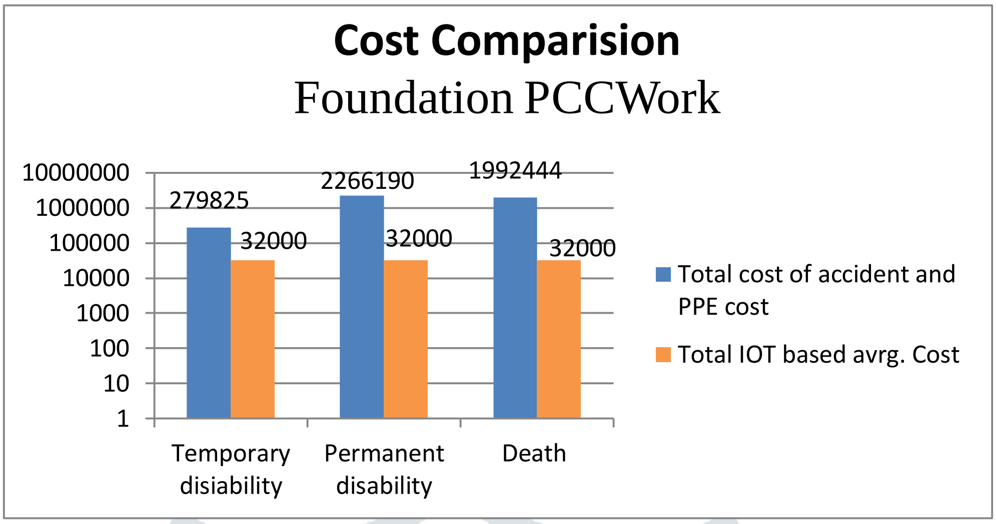
Table 4 Cost of PPE in market

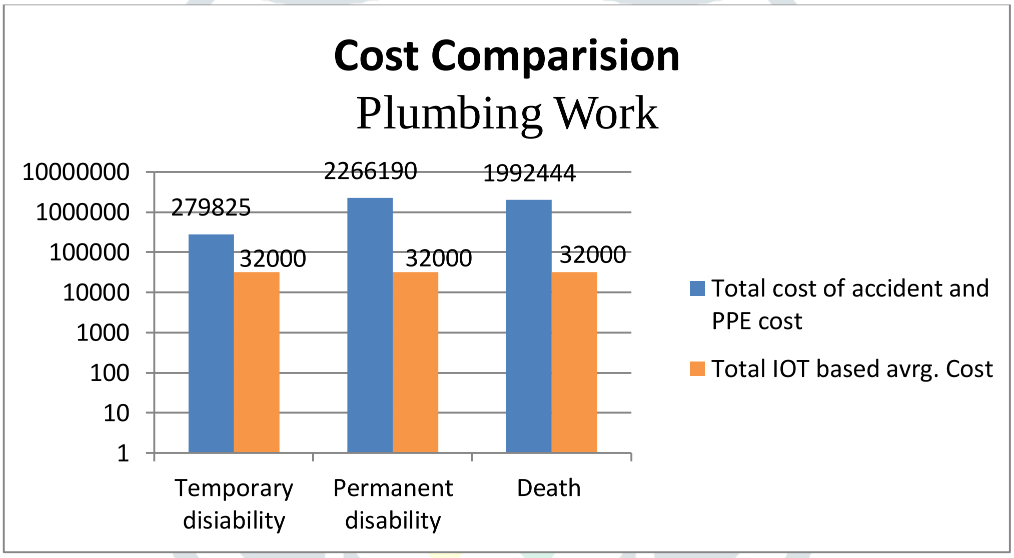
Sr.No	Name of PPE	Cost
1	**Helmet** a)Pin lock b)Ratchet belt	75-140 240-500
2	**Goggles** a)china made b)Std. quality	75-250 400-700
3	**Hand gloves** a)Cut resistant b) Rubber gloves	140/pair-750/pair 40-300
4	**Safety belt** a)fall arrestor	350-200000
5	**Safety shoes** a)Gum boots b) Doubles density	200-700
6	**Respiratory** a) Dust mask	9-50

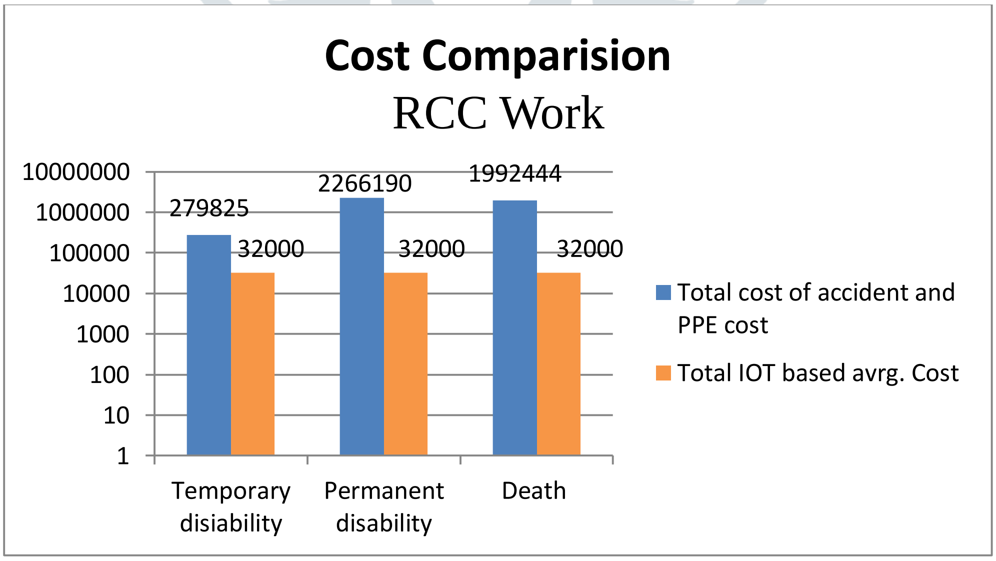
V. RESULT & DISCUSSION

5.1 COST COMPARISION BETWEEN ACCIDENT COST,PPE COST BASED ON IOT AND WITHOUT IOT

For Helmet Detection







5.2 **Discussion** :

1. From the collected accident data and PPE cost we get total cost of workers' compensation along with market values of PPE .Though in some activities PPE cost is very less than accident cost. but still workers did not follow safety policy and also didn't wear during construction.
2. Insurance doesn't keep workers healthy or saves workers lives, it only ensures the owners to transfer the financial risk against workers accident, Hence we should not be depend on insurance policy.
3. . From table and graphs, it is clear that there is significant difference in the total workers compensation cost and total IOT based PPE cost.
4. maximum cost at Death and permanent disability i.e1992444,2266190 respectively. For temporary disability cost is 279825
5. But total IOT Based safety cost is around is 32000 to 35000Rs. or may up to 50000 Rs. as per safety provision and sensors used but this technology is one time investment .We can use this technology at various sites ,activities and many time repeatedly.
6. Accident cost is maximum than the IOT based PPE Cost. so, we can provide workers safety by using internet of things with minimum cost.

VI. CONCLUSION

1. Labour safety laws are available, the numerous accidents taking place at construction sites are continuing. Management commitment towards health and safety of the workers is also lagging.
2. During accident situation it is advice to wear helmet to avoid head injuries but uneducated labour usually didn't follow protocol.
3. We have design based helmet with PIR sensor as its within range the buzzer will be blown if it detects any labour taking off his helmet.
4. The PIR sensor will also help in identifying whether or not the worker is present in unman area.
5. In addition to that we have also included the alcohol detection to ensure labour drunk or not while work on site
6. We conclude that using IOT technologies on construction site against various probable accident not only saves life of worker but also saves money and makes the project economical and safer.

VII. ACKNOWLEDGMENT

With a deep sense of gratitude I would like to thank all the people who have enlightened our path with their kind guidance .I am very grateful to these intellectuals who did their best to help me during the seminar work.
The special gratitude goes to **Mr. A S. PATIL,** Head of civil engineering Department **Dr. M.P. Kadam,** who guided me especially in academic activities and to all the staff members of the civil engineering Department for their precious suggestions and guidance in completion of this dissertation work.
I remain indebted to **Mr. R. V. Devalkar,** for their timely valuable suggestions and excellent guidance for completion of this dissertation work.
I feel proud and find privilege to express deep sense of gratitude to our principal **Dr. N. S. Patil** and vice Principal **Prof. N. B. Desale** of NDMVP'S KBTCOE, Nashik, for his comments and kind permission to complete this work.

REFERENCES

[1] S. Kanchana, P. Sivaprakash, and S. Joseph, "Studies on Labour Safety in Construction Sites," vol. 2015, 2015.
[2] B. Velumani, "The Internet of Things (IoT) Applications and Communication Enabling Technology Standards : An Overview," no. October 2017, 2014.
[3] Y. Lu, H. Ma, and Z. Li, "Civil Infrastructures Connected Internet of Things," no. March 2014, 2013.
[4] R. Kanan, O. Elhassan, and R. Bensalem, "Automation in Construction An IoT-based autonomous system for workers ' safety in construction sites with real-time alarming , monitoring , and positioning strategies," *Autom. Constr.*, vol. 88, no. December 2017, pp. 73–86, 2018.
[5] A. Hammad, F. Vahdatikhaki, C. Zhang, M. Mawlana, and A. Doriani, "Towards the smart construction site: Improving productivity and safety of construction projects using multi-agent systems, real-time simulation and automated machine control," *Proc. - Winter Simul. Conf.*, 2012.
[6] S. Thomas, "SmartHat : A Battery-free Worker Safety Device Employing Passive UHF RFID Technology," pp. 85–90, 2011.
[7] P. Taylor and J. Skibniewski, "Information technology applications in construction safety assurance," no. December, pp. 37–41, 2014.
[8] A. Carbonari, A. Giretti, and B. Naticchia, "Automation in Construction A proactive system for real-time safety management in construction sites," *Autom. Constr.*, vol. 20, no. 6, pp. 686–698, 2011.
[9] R. Kanan, O. Elhassan, R. Bensalem, and A. Husein, "A Wireless Safety Detection Sensor System," pp. 5–7, 2016.
[10] U. Lee, J. Kim, H. Cho, and K. Kang, "Automation in Construction Development of a mobile safety monitoring system for construction sites," *Autom. Constr.*, vol. 18, no. 3, pp. 258–264, 2009.
[11] J. Teizer, B. S. Allread, C. E. Fullerton, and J. Hinze, "Automation in Construction Autonomous pro-active real-time construction worker and equipment operator proximity safety alert system," *Autom. Constr.*, vol. 19, no. 5, pp. 630–640, 2010.
[12] C. Zhou and L. Y. Ding, "Safety barrier warning system for underground construction sites using Internet-of-Things technologies," *Autom. Constr.*, vol. 83, no. May, pp. 372–389, 2017.
[13] H. Guo, Y. Yu, T. Xiang, H. Li, and D. Zhang, "Automation in Construction The availability of wearable-device-based physical data for the measurement of construction workers ' psychological status on site : From the perspective of safety management," *Autom. Constr.*, no. June, pp. 1–11, 2017.
[14] F. Wu and R. Christoph, "WE-Safe : A Wearable IoT Sensor Node for Safety Applications via LoRa," pp. 144–148.

[15] T. Subramani and R. Lordsonmillar, “Safety Management Analysis In Construction Industry,” vol. 4, no. 6, pp. 117–120, 2014.

[16] K. M. I. Khan, K. Suguna, and P. N. Raghunath, “A Study on Safety Management in Construction Projects,” vol. 4, no. 4, pp. 119–128, 2015.

[17] M. A. Mir, B. Mahto, and C. Engineering, “Site safety and planning for building construction,” pp. 650–656, 2015.

[18] J. Tavares, F. J. Velez, and J. M. Ferro, “Application of Wireless Sensor Networks to Automobiles,” vol. 8, no. 3, pp. 65–70, 2008.

[19] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, “Wireless sensor networks : a survey,” vol. 38, pp. 393–422, 2002.

[20] “Internet of Things-IOT : Definition , Characteristics , Architecture , Enabling Technologies , Application & Future Challenges,” vol. 6, no. 5, 2016.

[21] D. A. Preetham, M. S. Rohit, A. G. Ghontale, and M. J. P. Priyadarsini, “Safety Helmet With Alcohol Detection And Theft Control FOR,” *2017 Int. Conf. Intell. Sustain. Syst.*, no. Iciss, pp. 668–673, 2017.