BE CIVIL ENGINEERING

PROJECT REPORT

"APPLICATION OF BIM FOR THE SAFETY OF HUMAN RESOURCES IN BUILT ENVIRONMENT."

Project submitted in fulfillment for the requirements of the degree of

BE Civil Engineering

SUBMITTED BY

GC Maaz Rashid (Syn Ldr)	**CMS 00000281227**
GC Yazdan Javed	**CMS 00000281229**
GC Muhammad Bilal	**CMS 00000281242**
GC Wajeeh Noor	**CMS 00000281217**
GC Yahya Khan	**CMS 00000281222**

MILITARY COLLEGE OF ENGINEERING

NUST, PAKISTAN

2022

It is to certify that the

BE Civil Engineering Project titled

APPLICATION OF BIM FOR THE SAFETY OF HUMAN RESOURCES IN BUILT ENVIRONMENT

SUBMITTED BY

GC Maaz Rashid (Syn Ldr)	**CMS 00000281227**
GC Yazdan Javed	**CMS 00000281229**
GC Muhammad Bilal	**CMS 00000281242**
GC Wajeeh Noor	**CMS 00000281217**
GC Yahya Khan	**CMS 00000281222**

Has been accepted towards the fulfillment of the requirements for

BE Civil Engineering Degree

____

LT COL Dr. Rai Waqas, PhD

Syndicate Advisor

ACKNOWLEDGEMENT

Our sincere gratitude is due to all the individuals whose relentless effort and contribution to this project brought it to conclusive state. I am indebted to my supervisor, LT COL Dr. Rai Waqas, for an endless supply of intellect and continued guidance. His relentless approach to research and innovation is a source of inspiration for us. I gratefully recognize the help of Lecturer Said ul Amin for assisting us develop the software to fuel this project and worthy instructors of this institute. We also had a pleasure working with the staff of the Cadet Cell that facilitated us in installing our prototype in their facility to conduct test runs and opt out the shortcomings and lessons learnt. Furthermore, we are ever grateful to the company that supplied us the necessary equipment and sensors that we then linked together through innovation to bring about this project of ours. Most importantly, we are grateful for our family's unconditional, unequivocal, and loving support, they are the source of our inspiration, the glowing light in the distance that we follow, our biggest supporters and obviously the providers of the stepping stones that has brought us to a position where we're able to pull out tasks that otherwise we could not even perceive. This syndicate has brought across the best of us and has helped us evolve the engineering knowledge to the best of our understanding. We hope this project receives its due recognition through the due consideration of its siters and gets commercialized for the best of the people involved in the art so called science of Civil Engineering.

DEDICATION

To our beloved parents and teachers who serve as a beacon of light for us across this long journey through darkness. This project is dedicated to every life that was lost in the pursuit of construction; may this project serve as a halting barrier to that dreaded toll.

ABSTRACT

It is common knowledge that the most valuable component of any project that undergoes under any set circumstances of scale and budget is human life, but the tragedy of the system present depicts worrying negligence to the very factor when we see preventable life losses in the field of construction even in 2022, where precision in the most intricate surgeries has been in the factor of millimeters and the efficiency and consistency of the present day automated conveyor belt products is infinitimous. Under these circumstances, call it the flaw in our society or our backwardness in safety development but our ratio of deaths per annum is both unacceptable and indefinitely increasing. While there is continuous development in the quality and ease of construction, the pace of safety development has been rather slow. Present day usage of BIM and various sensors of Arduino and other interactive software provide a glimmer of hope of a way forward, the systems being automated and real-life conditions driven not only make them error free but also active at all times. This project poses as the founding stone in that direction, by using various softwares; Autodesk REVIT, Arduino UNO, Tera Term, etc. connected in integration with Arduino hardware and sensors we are able to provide the best path for fleeing individuals in the wake of catastrophe dodging any obstacles in the way. This involves a sound detection system via sensors that send the data to the project's Central Processing Unit; Arduino mini pro which in turn translates the machine language into .CSV (Comma-Separated Value) with the help of a software plugin known as TeraTerm. Once translated the data becomes readable for our decision-making software named dynamo, which with the help of a plugin named Modelical computes the decisions needed to be made and sends the necessary commands to Autodesk REVIT which in turn depicts to the user which path to opt and which to avoid in case of a

said catastrophe. For the purpose of lessons learnt and record keeping the crisis report is saved in .CSV format and is accessible by most of the main stream softwares. This is just the base line of tons of projects possible for the human resource safety, we hope this founding stone becomes the base of a huge infrastructure of more improved projects in AI and BIM.

Table of Contents

CHAPTER 1 .... **1**

INTRODUCTION **1**

1.1 Preamble 1

1.1.1 Safety 1

1.1.3 Security 3

1.1.2 BIM 4

1.2 Sustainable Development Goals 6

1.3 Research Objectives 6

1.4 Organization of Report 7

CHAPTER 2 .... **9**

LITERATURE REVIEW **9**

2.1 Background 9

2.1.1 History 9

2.2 Sustainable Development Goals Linked to the Project 15

2.2.1 Good Health and Well-being 15

2.2.2 Industry, Innovation and Infrastructure 16

2.3 Safety and Security Research Work 17

2.3.1 Previous Work 17

2.3.2 Construction Safety and Life Expectancy – A Comparison 19

2.4 Research Gap 22

2.5 Equipment 24

2.5.2 Female Headers x-40 29

2.5.3 Vero Board Prototype 30

2.5.4 Fixed voltage regulator 31

2.5.5 Heat Sink For 7805 32

2.5.6 Relay 12V DC 33

2.5.7 Resistors 33

2.5.8 NPN Transistor 34

2.5.9 Piezo Buzzer 5VPTH 34

2.5.10 KY026 Flame Sensor 35

2.5.11 Shrink tube 36
2.5.12 Female DC Jack With Connectors 37
2.6 Softwares 39
2.6.1 Arduino UNO 39
2.6.2 Tera Term 39
2.6.3 Dynamo 39
2.6.4 Modelical 39
2.6.5 Autodesk REVIT 40
CHAPTER 3 41
METHODOLOGY 41
3.1 Introduction 41
3.2 Research Methodology 42
3.5 Procedure 44
3.5.1 Identification Process 44
3.5.2 Prototype Development 44
3.5.3 Procedural Sequence 44
3.5.4 Procedure Adopted 45
CHAPTER 4 49
RESULT AND DISCUSSIONS 49
4.1 Introduction 49
4.2 Results of all Hardware 49
4.2.1 Various Sensors 49
4.2.2 Arduino Mini Pro 49
4.2.3 LED Lights 49
4.3 Results of Softwares 50
4.3.1 Arduino Backend 50
4.3.2 Tera Term 50
4.3.3 Dynamo 50
4.3.4 Modelical 50
4.3.5 Autodesk REVIT 50
4.4 Outcomes from the Project 50
4.4.1 Path Shortened 51

4.4.2 People Saved ... 51
4.4.3 Guidance to Safety Workers ... 51
4.4.4 Avoiding a Stampede ... 51
4.4.5 Smooth Traffic Flow ... 52
4.4.6 Data Recording ... 52
4.5 Discussion ... 52
4.6 Comparison ... 54
CHAPTER 5 ... 57
CONCLUSIONS AND RECOMMENDATIONS ... 57
5.1 Introduction ... 57
5.2 Conclusions ... 57
5.3 Recommendations ... 57
5.3.1 Poisonous Gases Detection ... 58
5.3.2 Concrete and Column Failure Detection using Arduino ... 59
5.3.3 Terrorist Attack Detection in Schools/Colleges/Universities Manually ... 61
5.3.4 Environmental Parameters Determination Based on Low-Cost Sensors ... 61
5.4 Limitations ... 62
5.5 Future Research Directions ... 63
References ... 64
Annexure ... 66
1. Programming in Arduino UNO ... 66
2. Flowchart of the Fire Hazard Programming via Modelical ... 69

List of Figures

Figure 1.1: Organization of Report....……………………….…………………………….9
Figure 2.1: History of Construction Safety as per OSHA……..…...………………………...11
Figure 2.2: Sustainable Development Goals by UN.....………….……………………………15
Figure 2.3: Deaths from Fire related Incidents throughout the Years………………………19
Figure 2.4: Earthquake related fatalities against Population……….……..………………20
Figure 2.5: Terrorism related Deaths in Pakistan....…………………………………………20
Figure 2.6: Life Expectancy in Pakistan over the Years...…….……………...…………..21
Figure 2.7: Report on collapse of Sundar Estate.......………………………………………23
Figure 2.8: Negligence of safety; A Gamble putting 56 million at Risk…....……………….24
Figure 2.9: Label of Female Headers on an Arduino Circuit...……………………………...30
Figure 2.10: A Generic Vero Board...……………………………………………………......30
Figure 2.11: Outputs of LM7805...…………………………………………………….......31
Figure 2.12: A 12V DC Relay Switch.………………………………………………………33
Figure 2.13: Typical Resistors...……………………………………………………………..33
Figure 2.14: A Typical 5V Piezo Buzzer...…………………………………………………34
Figure 2.15: Flame Sensor KY-026...………………………………………………………35
Figure 2.16: Shrink Tubes for Electric Wires...……………………………………………..36
Figure 2.17: Typical DC Connectors.....……………………………………………………38
Figure 3.1: Research Design……………………..……………………………………41
Figure 3.2: Research Methodology Framework……………………………………………43
Figure 3.3: Procedural Sequence of Software Work………………………………………..45
Figure 3.4: Tera Term File Saving Window....……………………………………………..46
Figure 3.5: Algorithm Section of Dynamo...…………………………………………………47
Figure 3.6: Modelical's Program made Algorithms...……………………………………47
Figure 4.1: Expert Response on Project Need....……………………………………………53
Figure 4.2: Expert Response on Project Implementation...…………………………………53
Figure 4.3: Expert Response on Project Effectivity...………………………………………54
Figure 4.4: Comparison Radar for both Systems...…………………………………………56
Figure 5.1: AO General Connectivity...….…………………………………………………60

List of Tables

Table 2.1: Technical Specifications of Arduino Pro Mini……………………………………..28
Table 2.2: Details of Pins and their Functions of 7805 IC……………………………………..32
Table 2.3: Peizo Buzzer Values………………………………………………………………..35
Table 2.4: Tube Sizes against Wire Gauges………………………………………………………37
Table 4.1: Expert Feedback on Project……………………………………………………………54
Table 4.2: Points out of 10 for Selected Factors of both Systems..……………………………55

CHAPTER 1

INTRODUCTION

1.1 Preamble

It is known that the price of human life is unparallel to any other costs incurred in any said construction project in the world. Moreover, even the most expensive infrastructures when it comes to a catastrophe the first priority is always to save lives. Thus, its protection and safeguard are the prime responsibility of the client.

1.1.1 Safety

The term safety refers to the assurance that the individuals working in closed proximity are protected from any kind of hazard that may occur. When the term safety is brought into conversation it always points towards protection against non-living this and natural conditions that may occur. This term remains relevant to mostly- under construction structures as they are the ones prone to most shortcomings in terms of safety.

Safety hazardous events are the most common in Construction industry (Huang & Hinze, 2006; Melzner, Zhang, Teizer, & Bargstädt, 2013; Statistics, 2012). In spite of the fact that the construction industry represents 4% of the absolute U.S. utilized workforce, the industry experienced 19% of the fatalities (BLS 2014). Despite the fact that the quantity of fatalities on building projects has reduced in recent times, the pace of working environment fatalities has levelled of as of late (OSHA 2011a). 874 deaths were recorded in the construction industry in 2014, accounting for 20.6% of all deaths in US private institutions (BLS 2014). These grades were slightly lower in 2013 with 856 deaths accounting for 18.7% of all US private construction deaths (BLS 2013). Although the most negative safety events are death, injury, and illness, the opposite, also affects the completion of a construction project 12. The United States Department of Labor Statistics (BLS) noted 117 record cases from the construction industry per 10,000 professionals. The average number of days off work in 2013, due to accident or illness, was about eight days (BLS 2014). The construction industry experienced 200,900 nonlethal injuries which was imperceptibly lower than the nondeadly injuries revealed in 2013 (BLS 2013). Construction industry employs 7% of the world's labour but claims responsibility for 16.4% of occupational injuries and fatalities (Azhar & Behringer, 2013; Kulkarni, 2007; Lingard, 2013; Sunindijo & Zou, 2011), i.e. the highest injury and fatality rate (Huang & Hinze, 2006; Melzner et al., 2013; Waehrer, Dong, Miller, Haile, & Men, 2007; Yim, Hwang, & Choi, 2005). Estimated cost of major work-related accidents is 5 billion US $ worldwide (Ajslev et al., 2017). Along with this an incalculable suffering is caused to workers and their families (ILO, 2010). This situation is even worse in developing countries (Council, 2013; Gangolells, Casals, Forcada, Roca, & Fuertes, 2010) such as Pakistan (Zahoor, Chan, Choudhry, Utama, & Gao, 2015), India (Koehn, Kothari, & Pan, 1995) and Srilanka (Priyadarshani, Karunasena, & Jayasuriya, 2013). Pakistan has 7.3% of the total workforce employed in the construction industry, with an accident rate of 14.1%, higher than any other sector (PBS, 2014). Research shows that the main causes of accidents relate to a variety of human behaviors, unsafe construction processes, unpredictable site conditions, hazardous operations, nature industry-specific and lack of knowledge of what to do in case of havoc. The use of comprehensive safety programs and implementation of Information and Communication Technology (ICT) should be emphasized to enhance the safety performance of construction industry (Bowden, Dorr, Thorpe and Anumba, 2006; Oloufa, Ikeda and Oda, 2003). Consequently, in developed countries, safety has been integrated as an integral part of the built environment, where accident categories and safety zones are recorded and monitored (European Commission, 2013; Occupational Health and Safety Management, 2013). As a result, the accident trend in developed countries is decreasing (Hallowell, 2011; Huang & Hinze, 2006). However, much work remains to be done in the construction sector, which remains one of the most lethal (Perttula et al., 2006; Pinto et al., 2011). Security statistics imply developments in security planning and management. These record waves can negatively affect the well-being of a construction mission due to lost work time, reduced profits, increased medical bills, and sometimes, death toll. In case of deaths from catastrophes like earthquake, fire or structural collapse, it’s a common observation that the construction companies as well as the owners of the structures don’t pay heed to investment in that particular direction leading to deaths and injuries unaccounted for.

The presence of leading indicators is scarce in construction industry and the presence of lagging indicators is dominant but not in any way efficient. There have been incidents of all scales where due to absence of guidance of even the basic level has caused deaths to plummet to even greater proportions.

1.1.3 Security

The term security refers to safeguard against tangible threats from living things (human or non-human) and is generally focused on buildings that involve public usage (schools, malls, etc). This term is dominantly relevant to constructed not under construction projects because the threat of security in constructed structures is manifolds more than in under construction building. A simple and practical example to support this claim is by observing the pattern of security allocation on an under-construction and constructed project, a couple of guards might suffice the security of an under-construction shopping complex but once constructed whole teams are employed for the protection of the same premises.

In the 2017-18 school year, 95% of public schools reported controlling access to school buildings by locking or patroling doors during class hours. Other safety measures reported by public schools include the use of surveillance cameras to monitor schools (83%), the requirement for faculty and staff to carry identification or photo ID (70%), and strictness. Includes enforcement of clothing regulations (49%). In addition, 27% of public schools randomly check for smuggled goods, 20% require students to wear uniforms, 9% require students to wear badges or photo IDs, and 5% randomly. Reported that he used a metal detector check (nces.ed.gov) but still unfortunate cases are on a rise. In case of shopping malls, according to one survey, about 28% of shoppers in the city center are seriously concerned about violent crime. (Savard, Dennis & Kennedy, DB., 2014). For hotels, risks include fires, floods, natural disasters, terrorism, and more. Even if the system is in place, it is important to carry out regular inspections and adjustments and to continuously check that all alarms etc. are functioning properly. (fastguardservice.com).

1.1.2 BIM

BIM has been described as one of the pioneer advancements in modern construction industry due to its ability to provide the ability to plan, map, and track project phases throughout the construction lifecycle. plan. Stakeholders in construction projects use BIM to facilitate various elements of an engagement, including the building's life cycle, design, planning, construction, and operations. Due to the hazardous nature of the construction sites, safety and security are essential parts of a successful construction project. For example, BIM provides a step to help manage safety and ultimately improve the safety performance of field personnel.

Information Modeling (BIM) can be used as an ICT step and is seen as an inevitable ICT arrangement. BIM innovation was created as a standard practice to represent design, construction, construction and support data. While it is a modeling and documentation tool, BIM offers a step towards improving joint interdisciplinary efforts, information sharing, change tracking, and data-driven scalability. throughout the life of the structure. Probably the last BIM focus published by Lee et al. (2018), the ability to enable constructive data collection through model information, thus enabling easy institutionalization and management of information sources, while empowering leaders to direct and collect information through 3D modeling, in addition to the correspondence between the aggregates associated with their building and the sharing; improve interoperability and data management. Therefore, BIM is considered to move the idea of the construction industry from a linear nature to one of the goals shared among the project partners. BIM has done a lot of important work to improve various areas of construction management. Creative use of BIM since company inception and adherence to all acclaimed record-keeping practices will provide a 5-part lead-in information based on security breach information The confidentiality associated with the 3D model will facilitate future correspondence and modification. The use of information-rich BIM models allows choices to be made on an increasingly informational and logical basis, as practices and features can be transformed into BIM models where functions capacity is assessed and quantified. The conceivable element of BIM perceptual evidence to talk about safety violations would make it a suitable device for the construction industry to use for safety management. The interest in using the continuous representation of 3D BIM stems from the need to exchange between different actors in the field of construction, construction and management. Such a match gradually becomes meaningful during the secure registration process. For the researcher's information, BIM has yet to be used to its full potential. BIM itself does not provide secure file management functionality. This examination is, along these lines, planned for using the 'I' for example data of BIM to propose a framework for using BIM in construction safety record management. Consequently, an Application Programming Interface (API) is utilized to build up a C# module in the most customarily utilized BIM programming (for example Revit), to set up a framework and stage for announcing and recording safety disregarded events in virtual and community-oriented condition to conquer the issues in safety record management procedure distinguished through writing survey.

1.2 Sustainable Development Goals

SGD identifies precise objectives for every goal, alongside signs which can be getting used to degree development towards every goal. The goal is supposed to be performed is commonly among 2020 and 2030. To facilitate monitoring, numerous applications/tools exist to track the progress and visualize development closer to the goals. All aim is to make more and more data available in a simpler form and easily understandable. For example, the online book SDG Tracker, released in June 2018. The SDGs take note of many critical issues around the world, like human rights throughout all the SDGs. Relating our own work to SDGs is important to clarify which goals we are assisting to accomplish.

1.3 Research Objectives

The objectives of the project are as mentioned.

- To devise a BIM based automated system for provision of safe path for occupants of a buildings in case of catastrophe.

- To provide a platform to record and access catastrophes in a database using sensory data as input.

1.4 Organization of Report

Figure 1.2 summarizes the sequence of this write up. The report henceforth is presented as follows:

1. The first chapter of this write up serves as the introduction, background and motivation of this write up.
2. Second chapter serves the purpose of elaborating the previously done research and world progress in the field of our project's interest.
3. Third chapter discusses the methodology and equipment involved in the project's bring up.
4. Fourth chapter discusses the results that we gathered after the application of the project in field.
5. While the fifth and the last chapter opens the door to project's flexibility in terms of application in the region of construction safety and consequently the lessons learnt and outcomes of the project.
6. The project terminates with the references to rightful authors of the content.

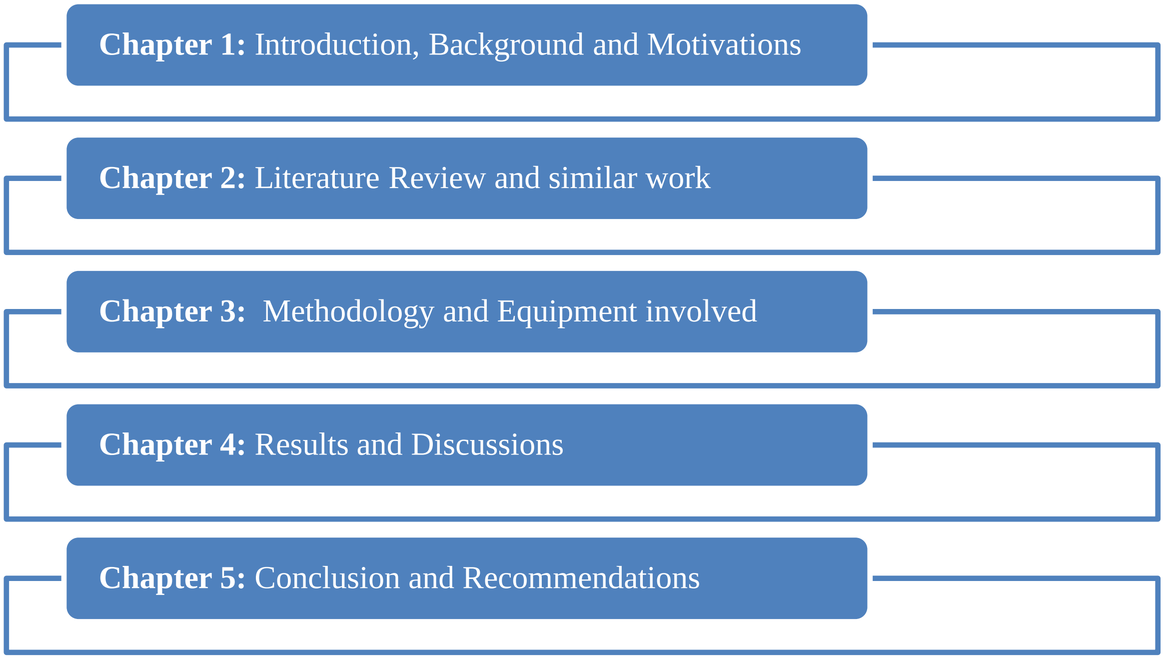


Figure 1.1: Organization of Report

CHAPTER 2

LITERATURE REVIEW

2.1 Background

This project itself is a product of research in terms of history and progress in the said field as forementioned.

2.1.1 History

So many lives have been wasted in construction industry throughout the world and in Pakistan the situation has been even worse. Take the example of collapse of Sunder Estate in 2015 or the fire in Baldia Town factory.

In terms of safety and security of constructed buildings multiple cases of shortcomings can be mentioned. The very recent case of fire at Paces Mall in 2022 that caused havoc in the early hours where loss of lives prevented by the finest margins. In case of security, it is to mention the incident of APS Peshawar in 2014, the case of collapse of Margalla towers in 2005 earthquake.

These are only some events out of plenty more where life loss could have been prevented had there been a proper automated system of evacuation and therefore, these events have begged for a system of automation that could assist the people escape when the mere printed pamphlets and sirens lose their affectivity.

Attempts of evolution in the field of safety in construction projects have dated back to the 19th century. But the progress has been slow and there's still a long way to go. Figure 1.1 is a brief summary by OSHA (Occupational Safety and Health Administration) regarding the progress made in the field of safety in construction projects.

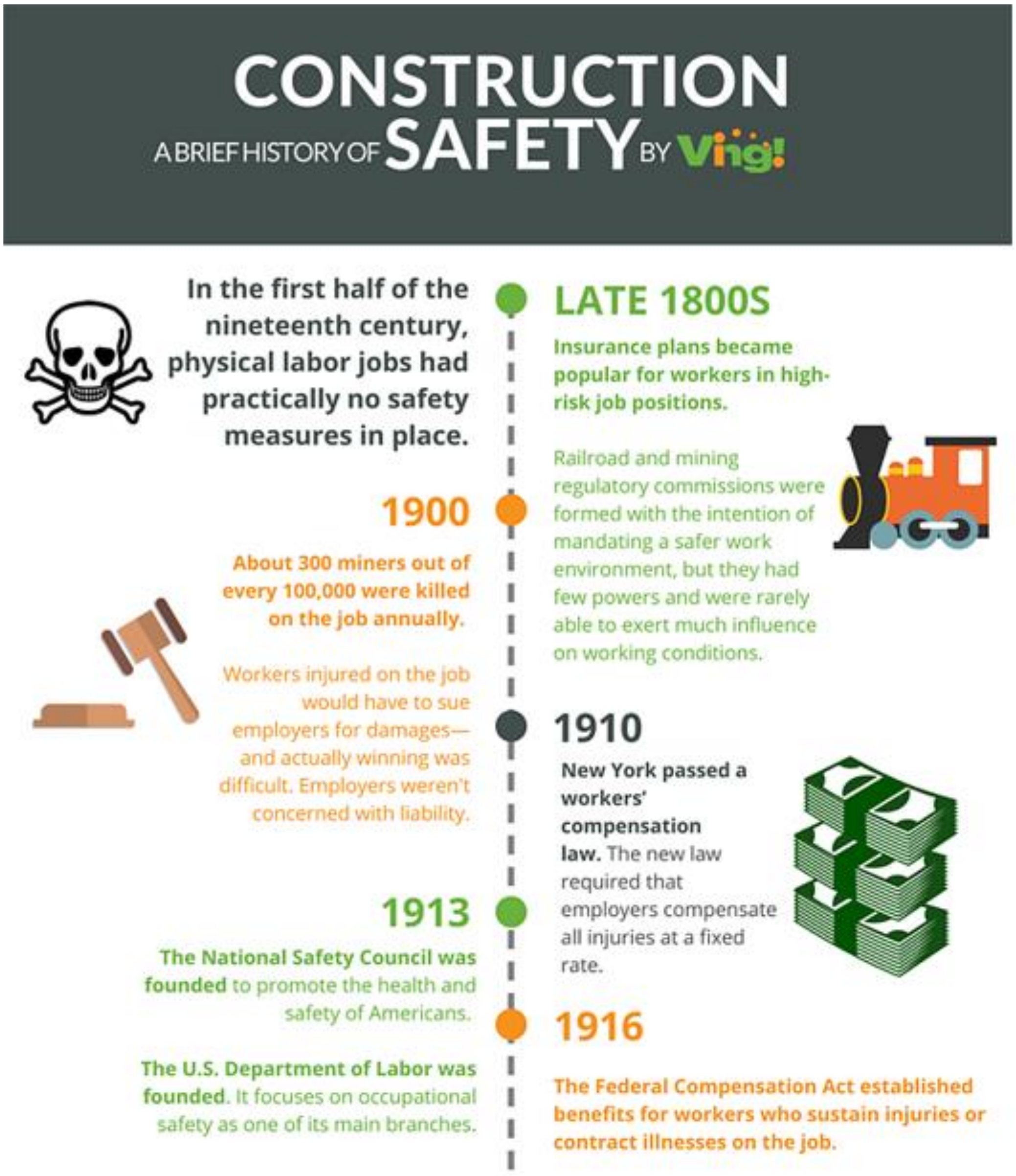


Figure 2.1: History of Construction Safety as per OSHA

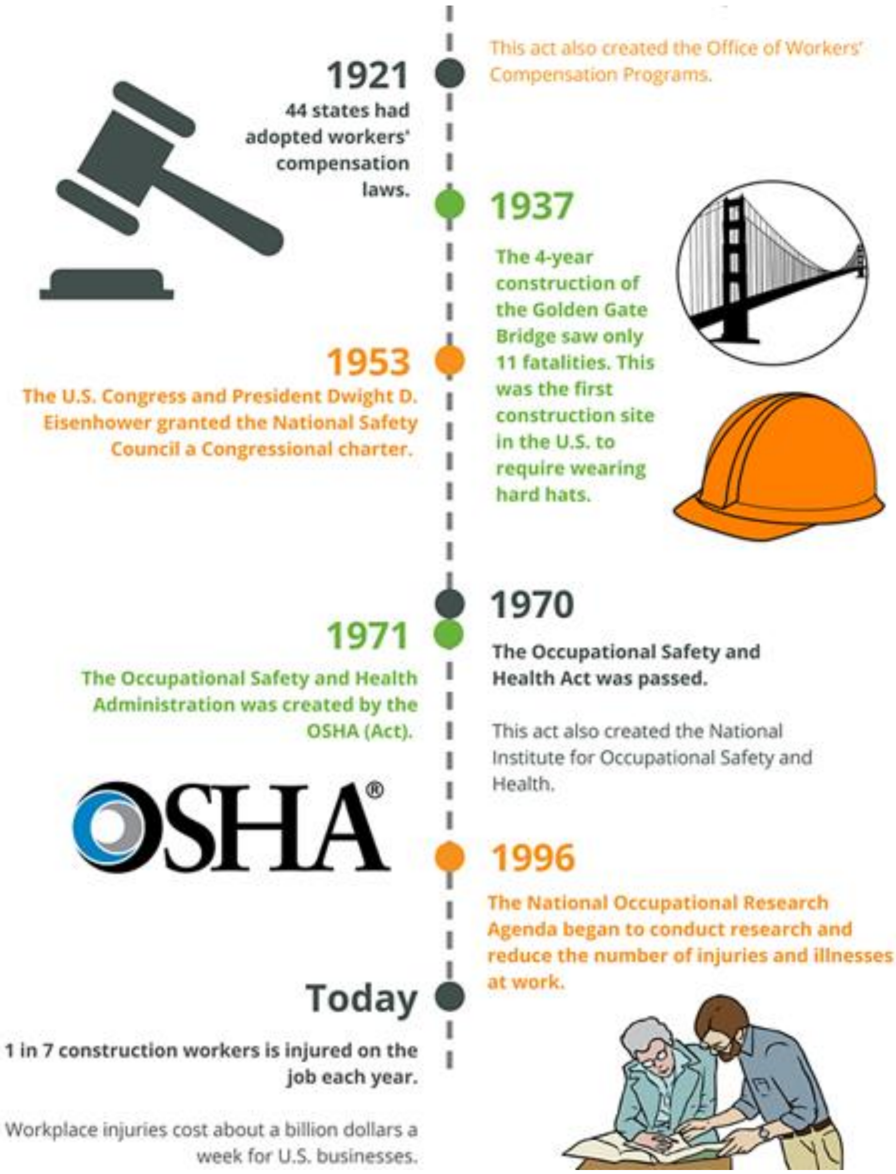


Figure 2.1 History of Construction Safety as per OSHA (Continued)

There have been times when sights of workers sitting on skyscraper girders were a common site. Just putting a ban on practice like these and making helmets a compulsion is not enough, because not every fatality or injury that occurs on the construction site is a human error. That is where BIM and AI come into need.

2.1.1.1 Late 1800's

During the earlier part of 19th century, manual labor boasted almost no safety measures. We start later this century because that's when things start to change towards overall betterment. After the Civil War ended, worker community began saving money and buying workers' compensation insurance. Some employers had even begun offering insurance plans to their workers and even provided alternative occupation to men who were injured. Workers quit 4,444 jobs they considered too dangerous, and many employers had to increase overall wages for high-risk occupations to intrigue enough potential workers. It is this climate that has begun to influence changes in industry policies. Railroad and mining regulatory committees have been established to enforce a safer work environment, but they have little power and can rarely influence working conditions much.

2.1.1.2 1900's

In 1900, about 300 out of 100,000 miners died on the job every year (US Department of Labor). For comparison, that number is about nine out of a hundred thousand a year today. Back then, workers injured on the job had to sue their employers for damages — and winning was tough. Only about half of all workplace deaths are due to family compensation, and even then, this is only about half a year's salary. With such low costs for employers in the event of an employee's death and virtually no legal consequences, workplace safety is of little concern.

2.1.1.3 1910s

Following Europe's example, New York passed a workers' compensation law in 1910. Instead of forcing injured workers to sue, the new law required employers to compensate all injuries at a fixed rate. For workers, this means better benefits and greater reliability. For employers, this means happier employees and more predictable costs. By 1921, all but six states had passed workers' compensation laws. The National Safety Council was established in 1913 to promote the health and safety of Americans. Recognizing the importance of this effort, the United States Congress and President Dwight D. Eisenhower granted the NSC a congressional charter. The United States Department of Labor, was also established in 1913, focusing on workplace safety as one of its main branches. In 1916, the Federal Compensation Act established benefits for workers who were injured or contracted a contract illness on the job. The act also created the Office of Workers' Compensation Programs.

2.1.1.4 1930s

During the 4 years of construction, there were only 11 deaths at work during the construction of the Golden Gate Bridge. Ten of the deaths were due to a single incident where the pylon broke, meaning 4,444 were just two fatal incidents in four years of construction. Project chief engineer cared so much about worker safety that he spent $130,000 on safety nets and was responsible for the first construction site in the United States to require helmet safety. The safety net alone saved nineteen lives.

2.1.1.5 1970s

The Occupational Safety and Health Act was passed in 1970.

> *"An Act to assure safe and healthful working conditions for working men and women; by authorizing enforcement of the standards developed under the Act; by assisting and encouraging the States in their efforts to assure safe and healthful working conditions; by providing for research, information, education, and training in the field of occupational safety and health; and for other purposes."*

-Occupational Safety and Health Act, 1970

This act also created the National Institute for Occupational Safety and Health, which conducts research and makes safety recommendations. The Occupational Safety and Health Administration was created by the OSHA (Act) in 1971, to "assure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education and assistance." OSHA's workplace safety inspections have been shown to reduce injury rates and injury costs without negative effects to employment, sales, credit ratings, or company survival.

2.1.1.6 1990s-Present

National Vocational Research Program was established in 1996 to study and reduce workplace injuries and illnesses. It was created by NIOSH to provide a research framework for collaboration between different organizations. Today, one in seven construction workers is injured in the work each year (Reese and Eidson 2006). Workplace injuries cost US companies about $ 1 billion per week (OSHA, 2022). The importance of construction workers in our society is enormous. They are responsible for our roads, our homes, our businesses, and maintaining our country`s physical infrastructure. Construction spending in 2016 is estimated at around $1.2 trillion (Bureau, n.d.). There are many dangers associated with this job, as past and current research shows. We've come a long way when it comes to safety in the built environment over the past hundred years, but we continue to improve with our goal of eliminating workplace deaths. Change is not easy, but we can continue to work towards change to keep workers safe on the job.

2.2 Sustainable Development Goals Linked to the Project

The features which are linked to our project are as follows:

- Goal No. 3: Good health and well-being.
- Goal No.9: Industry, Innovation and Infrastructure.

Figure 2.2: Sustainable Development Goals by UN.

2.2.1 Good Health and Well-being

- Our SDG has thirteen objectives and 28 signs to measure the degree development towards objectives. The first 9 objectives are "outcome target". Those outcome target includes finishing all preventable deaths beneath 5 years of age, make certain discount of mortality from non-communicable illnesses and help in growth of mental health and fitness, reduction in road injuries and deaths and decrease ailments and deaths from risky chemical substances and pollution. The four "manner to achieving" SDG three objectives are: enforce the WHO Framework Convention on aid research, improvement and supply of genuine, lower priced safety and security, enhance early caution structures for worldwide health risks.

- Significant decisive steps were made in increasing the life expectancy and decreasing some of the most common causes which lead to accidental deaths. Between 2000 and 2016, the global under-five mortality rate reduced via way of means of forty seven percent (from 78 per 1,000 deaths to 41 per 1,000).

2.2.2 Industry, Innovation and Infrastructure

Sustainable Development Goal nine (Goal nine or SDG nine) is about "enterprise, innovation and infrastructure" and is one of the 17 Sustainable Development Goals followed through the United Nations General Assembly in 2015. SDG nine ambitions to construct resilient infrastructure, sell sustainable industrialization and foster innovation.

SDG nine has 8 objectives, and development is measured through twelve indicators. The first 5 milestones are "outcome targets": Develop sustainable, resilient and inclusive infrastructures; promotion of sustainable industrialization; to gain more and more access to different markets and financial services, improve all industries and infrastructures for sustainability; promote research and enhance industrial technologies. The final 3 milestones are "way of achieving" objectives: Facilitate sustainable infrastructure, improvement for developing and under developed countries; assist in development of domestic technology, industrial diversification; provide an easy way to information and communications products and different technology used. Its aim is to construct resilient infrastructure, development of inclusive and sustainable industrialization and foster innovation. The aim of this SGD is first of all to promote financial growth, social improvement, and climate action. These aims are closely depending on investments in infrastructure, sustainable business improvement, in addition to technological development. Due to constantly changing worldwide economics, in addition to growing inequalities, industrialization have to arise so as for sustained growth. Quality handy possibilities to all people is supported through innovation and resilient infrastructure as well. SDG nine acknowledges that humanity's potential to connect and communicate effectively, and broaden our information in enterprise and technology is essential in overcoming the various interlinked financial, social and environmental challenges.

2.3 Safety and Security Research Work

The safety and security related research work related to our study is given below.

2.3.1 Previous Work

In the past efforts have been made to devise a system. In the field of designing, we have witnessed Computer Aided Design, in the field of structures we have witnessed Abacus and E-tabs and in the field of project management we have witnessed Primavera but progress line flattens when we consider technology in the safety department of the field of construction.

For this reason, ventures are there in the direction of safety and security of constructed or under construction projects but to a limited extent.

- Wonju Lee et al. developed a system for fire safety system with automatic security firm monitoring capability, their system uses sensors to detect a fire related incident and in turn sends a message alert that is displayed on all LEDs available in the building along with the setting off of alarms. This system according to their case study decreased the reaction time in case of catastrophe by 63%. (Lee, Cheon et al. 2013)

- F O Okeke, G Chendo and C G Sam Amobi discuss an architectural design approach to counter terrorism in building for the safety of occupants and draws an analogy from ancient defensive architecture. The overarching theme is terrorist attack as it involves explosives and bombs, the focus is on a damage-limiting or damage-mitigation approach rather than a counter-explosion approach. The study uses a case study approach with an extensive literature review of past and present counterterrorism approaches (Okeke and Chendo 2019). The results highlight a practical safety design strategy that would improve occupant safety in a structure if incorporated into the architectural design.
- Qi Sun and Yelda Turkan worked to

  1. Visualize the hazard zone results reflected in the fire simulation.

  2. Effective evacuation routes recommended in evacuation scenarios.

  Following the results, this paper concludes with an explanation of the challenges associated with building fires and an agent-based evacuation simulation resulting from the development of a BIM-based framework for high-occupancy building fires (Sun and Turkan 2019).
- Mingwu Ye et al. devised a systematical method for occupant evacuation towards earthquakes on network scale became evolved via way of means of using spatial evaluation strategies of Geographical Information System (GIS). The method blanketed the subsequent aspects: the distribution evaluation of emergency evacuation demands, the calculation of refuge area accessibility, and the optimization of evacuation destinations (Ye, Wang et al. 2012). It became discovered that the proposed method may be used to formulate pre-occasion making plans for earthquake catastrophe prevention and

mitigation on a network scale, specifically for organizing a fast and clean evacuation and optimizing the place allocation of shelters.

2.3.2 Construction Safety and Life Expectancy – A Comparison

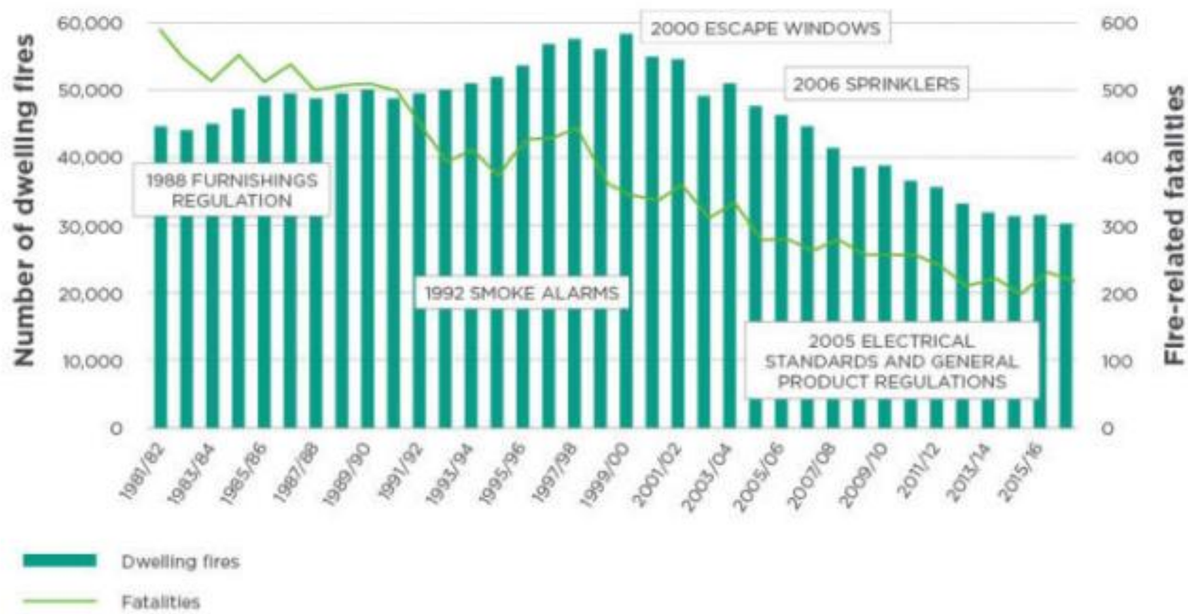


Figure 2.3: Deaths from Fire related incidents throughout the years

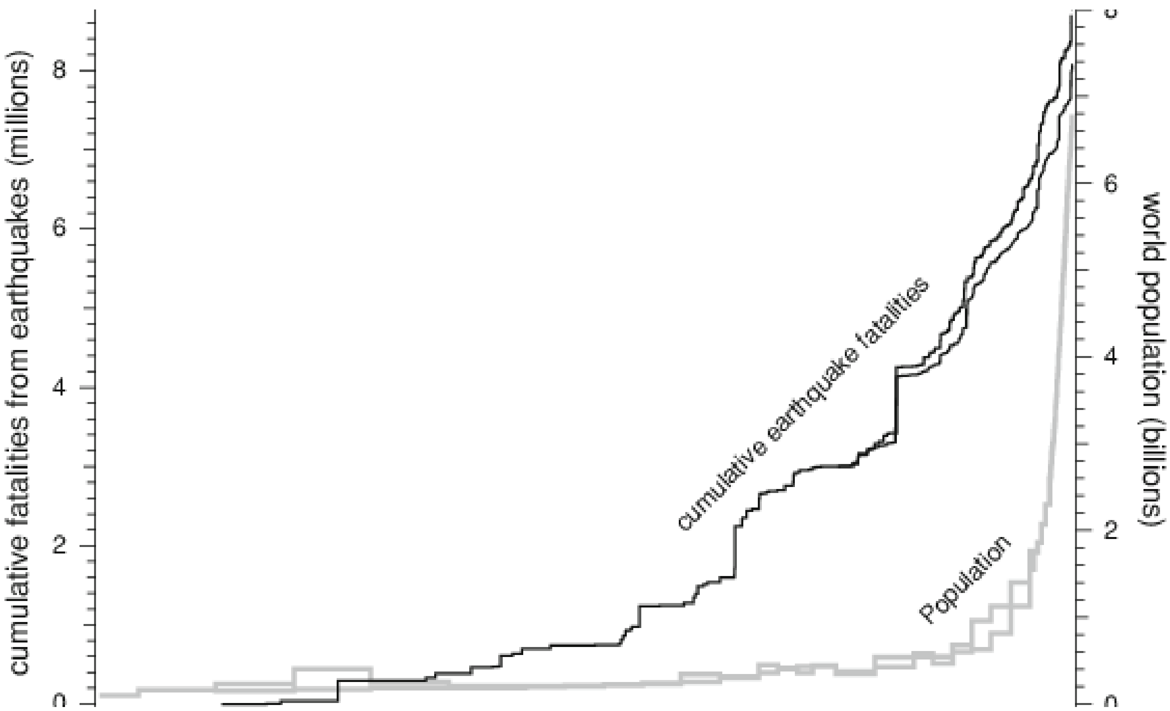


Figure 2.4: Earthquake Related Fatalities against Population

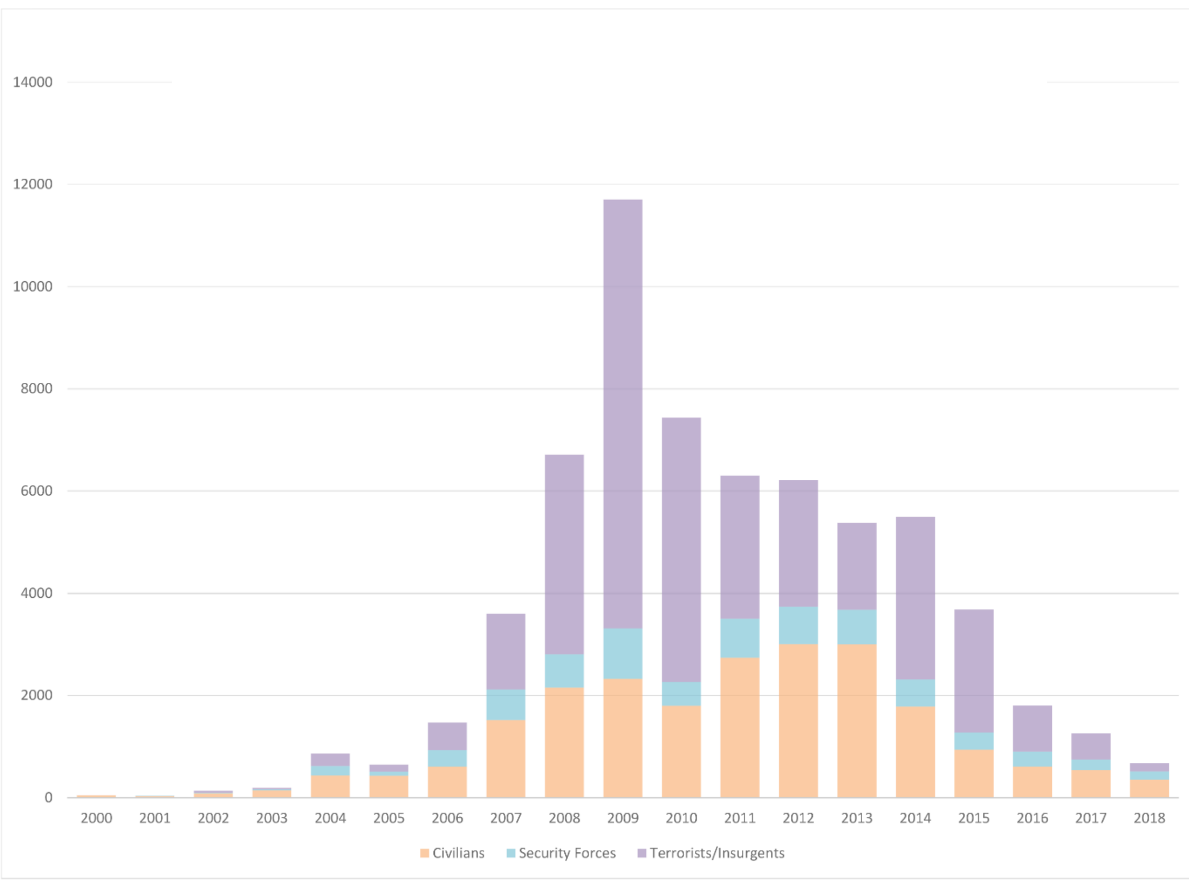


Figure 2.5: Terrorism related Deaths in Pakistan

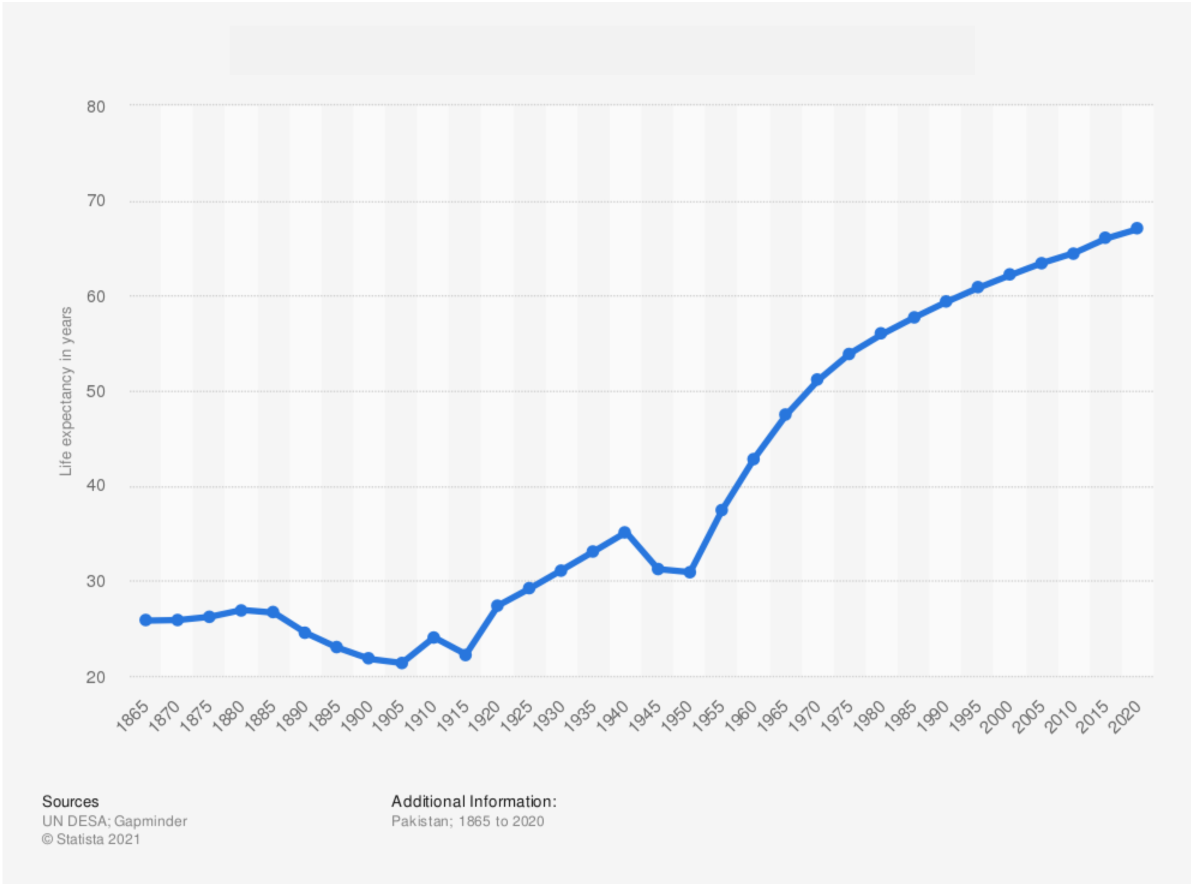


Figure 2.6: Life Expectancy in Pakistan over the Years

Above is an analytical evaluation of comparison between the trends that have undergone in the former years. From figure 2.2 to 2.4 it is ardently evident that the deaths of people indoor due to different types of disasters have remained constant or increased over time.

While in the same time period rather in a relatively broader time period as shown in figure 2.5 there can be seen a steep rise in average life expectancy.

These statistics pose a question at the falling credibility of safety standards and security, because the result of life expectancy compared to deaths from different parameters shows how although the life expectancy increased the deaths due to catastrophe has not improved likewise.

2.4 Research Gap

The gap in research that led to us to opt for this topic are as follows:

- Statistics in figures present a picture as of in what manner the life expectancy in Pakistan increases i.e. factors like safety, security and health improve, while the survival rate in case of said incidents topple.
- Wonju Lee., et al. worked to make people aware of a fire related emergency but did not work on a method to provide information regarding which path to opt and which to vehemently avoid.
- F O Okeke, G Chendo and C G Sam Amobi provided anti-terrorism architectural approach but they provided no approach as to how to tackle the issue in existing architectures.
- Although Qi Sun and Yelda Turkan worked on a way to provide the most preferred escape routes, but it lacked a real time solution i.e., the simulations could point out pathways but it wasn't going to be around when the catastrophe struck thus it required people to remember the paths to opt beforehand if catastrophe struck.
- Mingwu Ye et al. provided an in-depth study on recognizing the best paths to escape in case of an earthquake but did not comment on evacuation regarding on human inflicted incidents.
- There is requirement of a system that runs on integration of all the threat factors so that all buildings require installation of just a single system to virtually safeguard it.
- Record keeping of said incidents is next to zero for the purpose of learning trends for preventive measures.

- There might be measures of safety in case of catastrophe throughout the industry but there is no measure or project that provides safety in real-time, thus pre-determined formulas or guidance in most cases prove obsolete or irrelevant given the unpredictable nature of disasters. (See figure 2.7 and 2.8)

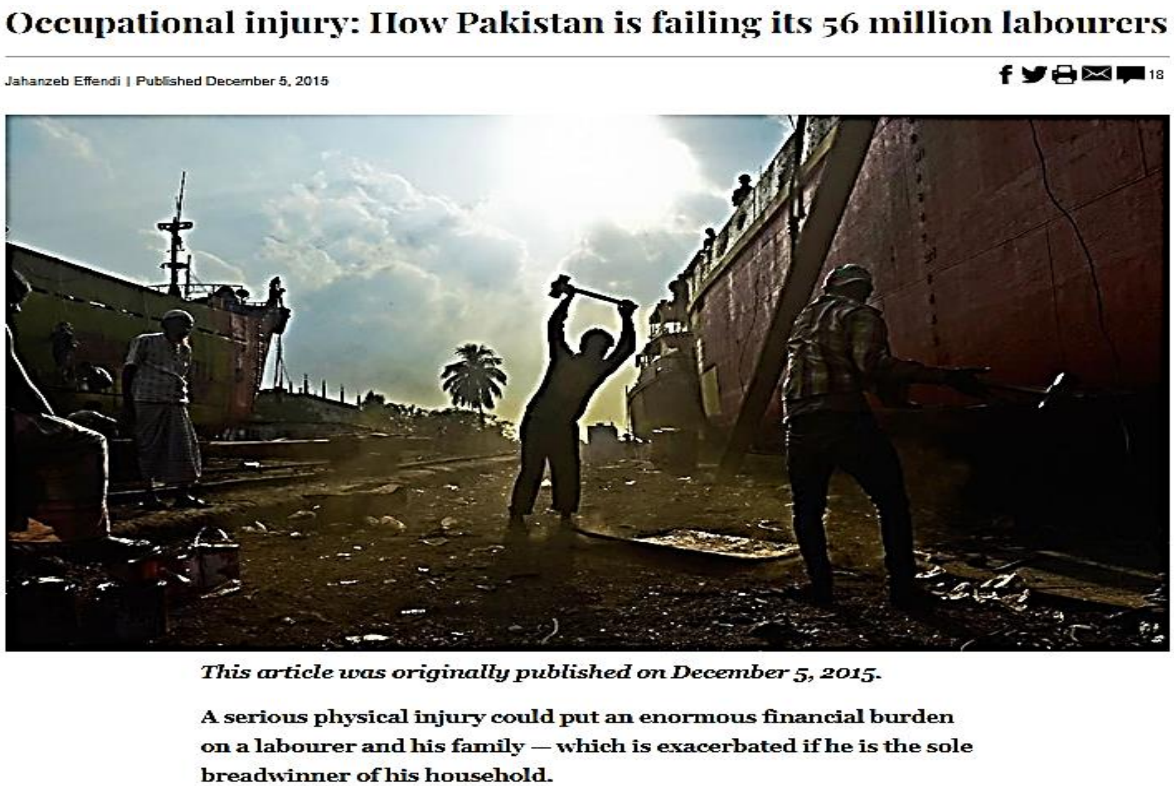

Factories of death

Editorial | Published November 6, 2015

How many other industrial accidents will we experience before we realise the gravity of the issue.—AFP/File

The collapse of a factory in Lahore's Sunder Industrial Estate, which buried at least 21 workers and wounded many others, has revealed an important reality about the dilapidated state of Pakistan's manufacturing economy.

Figure 2.7: Report on collapse of Sundar Estate



Occupational injury: How Pakistan is failing its 56 million labourers

Jahanzeb Effendi | Published December 5, 2015

This article was originally published on December 5, 2015.

A serious physical injury could put an enormous financial burden on a labourer and his family — which is exacerbated if he is the sole breadwinner of his household.

Figure 2.8: Negligence of safety; A Gamble putting 56 million at Risk

2.5 Equipment

The equipment involved in the formation of the circuit and its functioning is as underwritten.

2.5.1 Arduino Mini Pro 5V 16MHz

It is a microcontroller board based on the AT-mega328P function.. It consist of fourteen digital input/output pins (out of those 6 are used as PWM outputs), an onboard resonator, a reset button, and for pin headers holes are mounted. USB power and communication is provided by an FTDI cable and sparkfun enabled through a six-pin header. It is objected for semipermanent installation of objects and exhibitions. It does not have a pre-assembled header, so you can have variety of connectors and solder the wires directly. It is compatible for the pin layout.

2.5.1.1 Version

It has two types of ProMini. One operates at 3.3V and 8MHz and the respective one operates at 5V and 16MHz.

For our particular project, 3.3V can be used for small projects, but 16MHz is used when multiple paths are involved. FTDI cable and breakout board is used to charge the software, or a regular 3.3V and 5V power supply with Vcc pins (based on the given model). A voltage regulator is placed on the board to control the voltage up to 12VDC. The advantage of this circuit is that it can be utilized in unregulated power supply as well.

2.5.1.2 Extensions

The extensions used with the mini kit are as mentioned.

- RAW For offering an ‘uncooked’ voltage .
- 3.3 or 5 volt supply regulated by VCC.
- GND Ground pins.

2.5.1.3 Inputs and Outputs

14 virtual pins at the Pro Mini can function as an input or output. They function at 3.3 or 5 volts (relying at the model). These pins consists of specialized functions:

- Serial: zero (RX) and 1 (TX): Its function is to receive (RX) and transmit (TX) TTL serial statistics. The pins are linked to the TX-zero, RX-1 pins of the six pin header.

- External Interrupts 2 and 3: The pins may function to cause an interruption on a lower value, a growing and falling edge, or a extrude in value. The connect Interrupt characteristic for details is given below.
- PWM 3, 5, 6, 9, 10, and 11: Provide eight-bit PWM output with the analog Write characteristic.
- SPI 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK): These pins aid SPI communication, which, despite given the fact that furnished through the underlying hardware, isn't presently protected withinside the Arduino language.
- LED (13): It is a integrated LED linked for virtual pin 13. When the LED is on, the pin value is high and when its low it is off.

It consists of eight analog inputs, each of which give 10 bits of resolution (1024 specific values). On the edge of board four headers are used; two (inputs 4 and 5) on holes withinside the indoors of the board. The analog inputs degree from floor to VCC. Additionally, a few pins have specialized functionality:

- Reset. The microcontroller can be reset by lowering the line. Typically, A reset button is featured which shields and block the one at the board.

2.5.1.4 Communication

The Arduino Pro Mini has some of centers for speaking with a computer, every other Arduino, or different microcontrollers. The ATmega328P presents UART TTL serial communication, that is to be had on virtual pins zero (RX) and 1 (TX). The Arduino software program consists of a serial display which lets in easy textual statistics to be dispatched to and from the Arduino board through a USB connection. The ATmega328P additionally helps I2C (TWI) and SPI communication.

2.5.1.5 Programming

The Arduino Pro Mini may be programmed with the Arduino software program. The ATmega328P at the Arduino Pro Mini comes pre-burned with a bootloader that lets in you to add new code to it without the usage of an outside hardware programmer. It communicates the usage of the authentic STK500 protocol reference.

You also can skip the bootloader and software the ATmega328P with an outside programmer.

2.5.1.6 Automatic Software Reset

Rather than requiring a bodily press of the reset button earlier than an add, the Arduino Pro Mini is designed in a manner that permits it to be reset with the aid of using software program jogging on a related laptop. One of the pins at the six-pin header is attached to the reset line of the ATmega328P through a 100nF capacitor. This pin connects to one of the hardware go with the drift manage traces of the USB-to-serial converter related to the header: RTS whilst the usage of an FTDI cable, DTR whilst the usage of the Sparkfun breakout board. When this line is asserted (taken low), the reset line drops lengthy sufficient to reset the chip. The Arduino software program makes use of this functionality to assist you to add code with the aid of using without a doubt urgent the add button withinside the Arduino environment. This method that the bootloader could have a shorter timeout, because the decreasing of the reset line may be well-coordinated with the addition.

This setup has different implications. When it is attached to both a laptop jogging Mac OS X or Linux, when a connection made from software program (through USB) it resets every time. For the subsequent half-2d or so, the bootloader is jogging at the Pro. While its miles programmed to disregard malformed statistics (i.e. whatever except an addition of latest code), it's going to intercept the primary few bytes of statistics dispatched to the board after a connection is opened. If a caricature jogging at the board gets one-time configuration or different statistics whilst it first starts, ensure that the software program with which it communicates waits a 2d after establishing the relationship and earlier than sending these statistics.

2.5.1.7 Physical Characteristics

The dimensions of the Pro Mini PCB are approximately 0.7" x 1.3".

2.5.1.8 Technical Specifications

Table 2.1 shows the technical features of the CPU of our project.

Table 2.3: Technical Specifications of Arduino Pro Mini

Microcontroller	ATmega328P
Board Power Supply	3.35V
Circuit Operating Voltage	5V
Digital I/O Pins	14
PWM Pins	6
UART	1

SPI	1
I2C	1
Analog Input Pins	6
External Interrupts	2
DC Current per I/O Pin	40 mA
Flash Memory	32KB of which 2 KB used by bootloader
SRAM	2 KB
EEPROM	1 KB
Clock Speed	8 MHz

2.5.2 Female Headers x-40

Female header strips are often used as low-cost connectors for custom cables and perforated prototyping circuit boards. The standard spacing is the same as most unsoldered breadboards, with a 0.1-inch pin header. The most commonly used pin headers are single-row or double-row 0.1 "(2.54mm) connectors. This is a standard pitch compatible with breadboards. These are available in male and female versions. Used to connect the Arduino board to the Vero Board Prototype. The female header strips on an Arduino board are shown in figure 2.9.

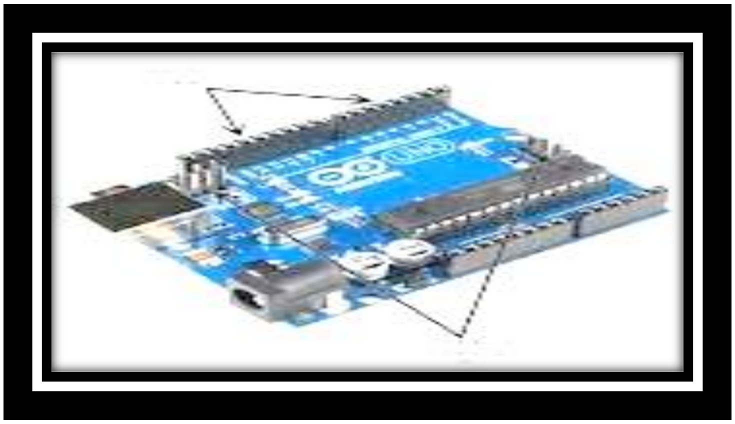


Figure 2.9: Label of Female Headers on an Arduino Circuit

2.5.3 Vero Board Prototype

Veroboard is a brand of stripboard, a preformed circuit board material made of copper strips on insulated cardboard as shown in figure 2.10. When using the Veroboard, the components are properly placed and soldered to the conductors to form the required circuit. To divide the strip into multiple electrical nodes, you can usually cut the traces around the holes to increase the complexity of the circuit.

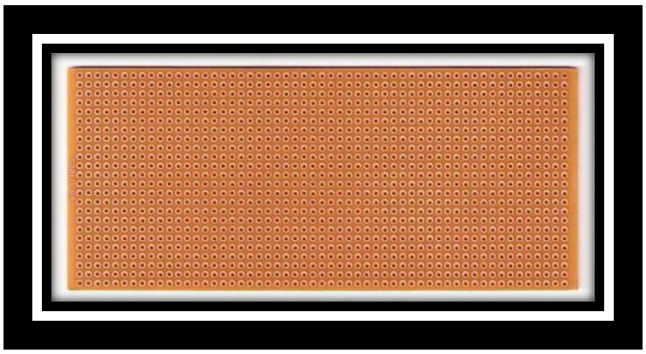


Figure 2.10: A Generic Vero Board

2.5.3.1 Function

- High quality prototyping board using traditional stripboard pattern. The rail runs the length of the board.

- StripBoard1 uses high quality FR4 glass epoxy board. It has better stability and moisture resistance than phenol or SRBP (resin adhesive paper) boards to prevent warping.
- 0.1-inch pitch for integrated DIP circuits and headers.
- Bus Board size is 1/4 the size of a standard 3UVME board.
- 4 mounting holes available.

2.5.4 Fixed voltage regulator

The voltage sources in the circuit are variable and may not provide a fixed voltage output. The voltage regulator IC keeps the output voltage constant. The LM7805 voltage regulator, which is a member of the 78xx series of fixed linear voltage regulators used to maintain such swings, is a common voltage regulator integrated circuit (IC). The xx in 78xx indicates the output voltage it provides. The 7805 IC provides a stabilized +5-volt power supply with equipment for adding heat sinks. A fixed voltage regulator is as shown in figure 2.11.

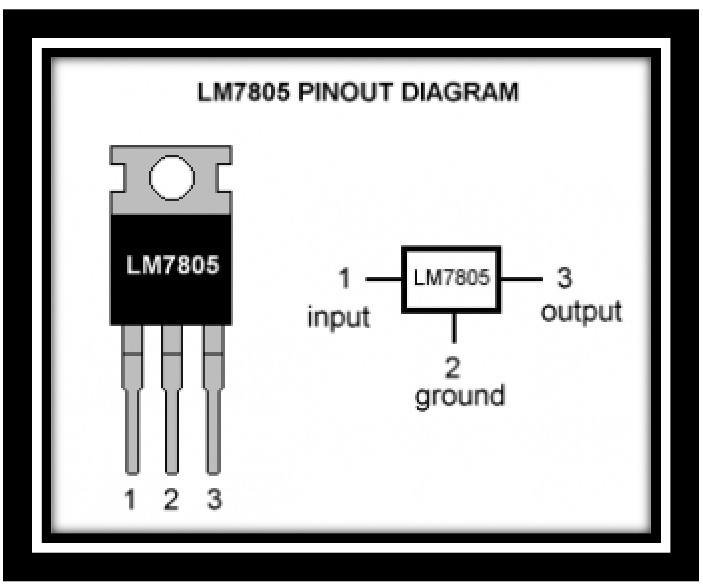


Figure 2.11: Outputs of LM7805

Table 4.2: Details of Pins and their Functions of 7805 IC

Pin No.	Pin	Function	Description
1	INPUT	Input voltage (7V-35V)	In this pin of the IC positive unregulated voltage is given in regulation.
2	GROUND	Ground (0V)	In this pin where the ground is given. This pin is neutral for equally the input and output.
3	OUTPUT	Regulated output; 5V (4.8V-5.2V)	The output of the regulated 5V volt is taken out at this pin of the IC regulator.

2.5.5 Heat Sink For 7805

A heat sink is a piece of metal designed to dissipate heat energy to the surrounding environment. It helps the device fall below the maximum junction temperature by dissipating excess energy and preventing damage from high temperatures. All electronic components dissipate heat, and usually their package (body) is sufficient to dissipate a small amount into the surroundings, however voltage regulators such as a 7805, 7812, LM317T, require assistance if they are to operate to their extreme limits.

2.5.6 Relay 12V DC

12V DC Relay switches as shown in figure 2.12 are the best solution for full voltage applications because low current circuits can control high current circuits such as, vehicle horns, headlights, auxiliary lights, fan motors, blower motors, and the myriad of existing devices found in today's vehicles.

Figure 2.12: A 12V DC Relay Switch

2.5.7 Resistors

A resistor is a multi-terminal passive electrical component that attaches a resistor as an element of an electrical circuit. Resistors of different sizes are shown in figure 2.13. Electronic circuits use resistors to reduce current, adjust signal levels, divide voltages, bias active elements, and terminate transmissions.

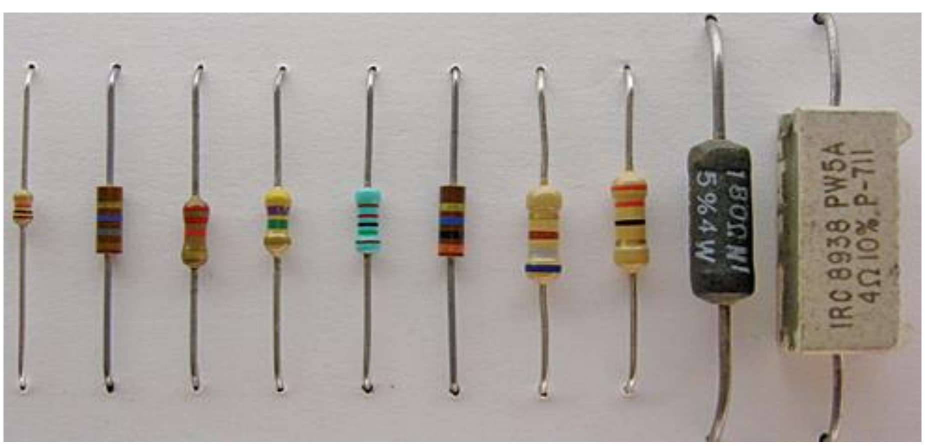


Figure 2.13: Typical Resistors

2.5.8 NPN Transistor

The C945 transistor is a type of negative-positive-negative (NPN) bipolar transistor. Circuits that require high speed, low current transistors typically use transistors such as the C945 transistor. Circuits such as small signal amplifiers and high-speed switching circuits can use one or more C945 transistors. C945 transistors can be used in different types of electronics, but are ideal for low power application use.

2.5.9 Piezo Buzzer 5VPTH

Passive speaker buzzers are used in electronic circuits for alarm and security. There is no oscillation source, and a square wave (frequency 2K5K) is required to drive it. Generates tones from approximately 2kHz to 5kHz that can be controlled via the Arduino PWM pin. Figure 2.14 shows a Piezo Buzzer.

Figure 2.14: A Typical 5V Piezo Buzzer

Table 2.3: Peizo Buzzer Values

Rated voltage	**5V DC**
Rated current at rated voltage	1mA
Capacitance	13000 ±30%pF
Sound output at rated voltage	>80dB
Resonant frequency at rated voltage	4000 ±500Hz

2.5.10 KY026 Flame Sensor

The KY026; Flame Sensor module (figure 2.15) is considered as an exceptional device for detecting infrared radiation emitted by any kind of flame. It involves a potentiometer that adjusts the digital output, analog output and sensitivity.

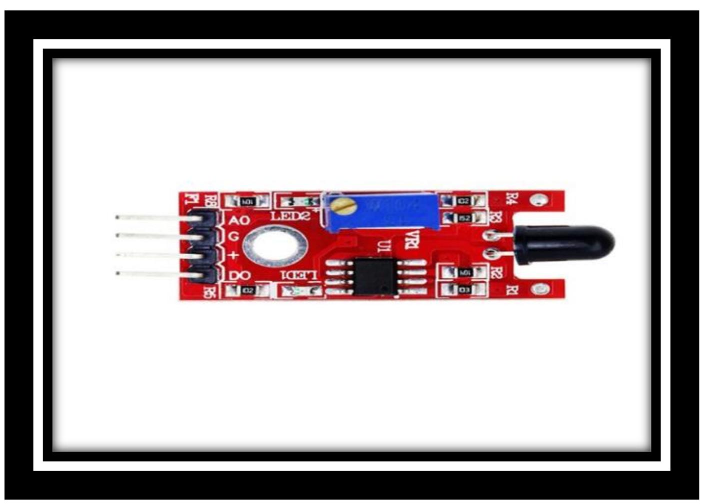


Figure 2.15: Flame Sensor KY-026

2.5.10.1 Function

The following are its functions.

- Sensor for flame wavelengths from 760nm to 1100nm Infrared is the most sensitive.
- 60^{o} degree Celsius sensor detection
- Dual output mode.
- AO: Analog output, real-time output voltage signal of thermal resistor.
- DO: When the temperature reaches a certain threshold, the upper and lower signal thresholds of the output can be adjusted with a potentiometer.
- Operating voltage: DC 3V – 5.5V.

2.5.11 Shrink tube

Shrink tube as shown in figure 2.16 is a thermoplastic tube that shrinks when exposed to heat. When the is placed around the cable assembly and electrical components, the heat shrink tubing folds radially to match the contours of the device and create a protective layer.

Figure 2.16: Shrink Tubes for Electric Wires

Table 2.4: Tube Sizes against Wire Gauges

Tubing Size	**Starting Size (in)**	**Recommended Insulated Wire gauges**
1/16	.0625	22-30
3/32	.0938	16-26
3mm	.118	16-22
5mm	.197	10-14

2.5.12 Female DC Jack With Connectors

DC Jack is widely used in the electronics industry to connect adapters to circuit boards. The most commonly used DC jack is the 2.1mm x 5.5mm (as the one shown in figure 2.17) DC jack. Here, 5.5 mm is the outer diameter and 2.1 mm is the inner pin size. The DC plug (male) must match this dimension for a proper fit. Most non-exclusive coaxial power connectors comply with 2.1x5.5 dimensions. For most DC plugs, the outer body is the negative power supply and the inner body is the positive power supply.

Figure 2.17: Typical DC Connectors

2.5.12.1 Basic type DC jack

It has the following salient features.

- PCB mount socket.
- Control cabinet or panel mounting socket.

2.5.12.1.1 DC Socket for Circuit Board Mounting

Commonly used in many DIY projects, the PCB mount DC jack is also used on the Arduino UNO, Arduino Mega, and Arduino Due boards. The PCB mount socket has three pins.

2.5.12.1.2 DC Socket for Cabinet Mounting

Panel-mounted or panel-mounted DC jacks are commonly used when you need to provide DC power to the circuits mounted on the panel. The panel mount DC jack is designed with metal nuts and can be easily screwed into the cabinet.

2.6 Softwares

The following is a brief descript about softwares that our study involves.

2.6.1 Arduino UNO

It is a software used to program Arduino chips. It is used to write different codes for Arduino, it can compile the code and run analysis to check for any errors. It also has the function to upload that code to the hardware and check if its compatible with it or not. It can write to multiple platforms such as Arduino R2 and R3, Arduino mini, Arduino mini pro etc. it also has a number of compilers and it can switch between 3V, 5V and 12V programing.

2.6.2 Tera Term

It is a software or terminal emulator to read the results from different programed hardware (DEC VT100 to DEC VT 382). It has a scripting language called Oniguruma and it also has a number of plugins. It can store data in many forms but the most preferred is .CSV form.

2.6.3 Dynamo

It is a programing software which uses visual interface rather than typing or coding interface. Its script is in the form of connecting elements of an algorithm and it is basically used to perform different coding operation in Autodesk REVIT by using visual interface. It gives the same results as that of coding but with ease.

2.6.4 Modelical

It is a plugin package for “Dynamo”. It is a python-based toolset which can provide you with multiple decision-making processes such as deciding between multiple the colors based on the RGB code.

2.6.5 Autodesk REVIT

It is building modeling software widely used by architects and structural, mechanical, electrical and safety engineers. It allows us to design architecture of a building also integrating the structural component. It is capable of extending to 4^{th} and 5^{th}. It can be used for maintenance purpose and for any rehabilitation purpose. It has multiple plugins. It can generate rendered photos and visual.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The methodology for research adopted in a pursuit to achieve the considered objectives are discussed and presented in the following section. The research strategy shows how researchers carry out their studies to achieve and answer research objectives. Multiple techniques were used to carry out this research as per the requirements of certain objectives. These techniques include review of previous studies and accident occurring's. It was followed by prototype development, testing and then evaluation of proposed system from industry experts. The identification to testing phase can be depicted in figure 3.1.

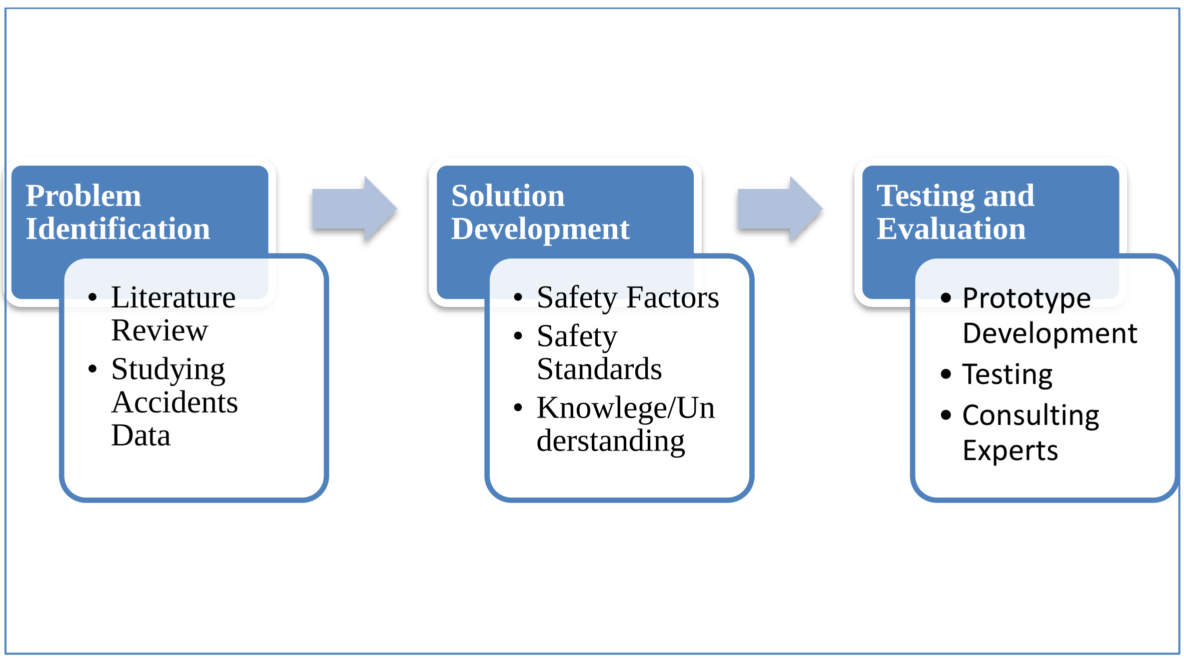


Figure 3.1: Research Design

3.2 Research Methodology

Azhar et al. (2009) proposed a framework for research related to construction management. The proposed framework is transformed by the need of this research as shown in Figure 3.2. This research is conducted in 3 phases.

The phases include problem identification, solution development and testing & evaluation. These particular events are further divided into multiple maneuvers that develop the salient features of a project leading from the literature review that deals with the literary purpose of the project to the technological review, that refers to innovative maneuvers undergone to achieve the goal of the project.

Moreover, the process of testing and evaluation is iterative and it takes years repetitive process to solidify the prowess of your project.

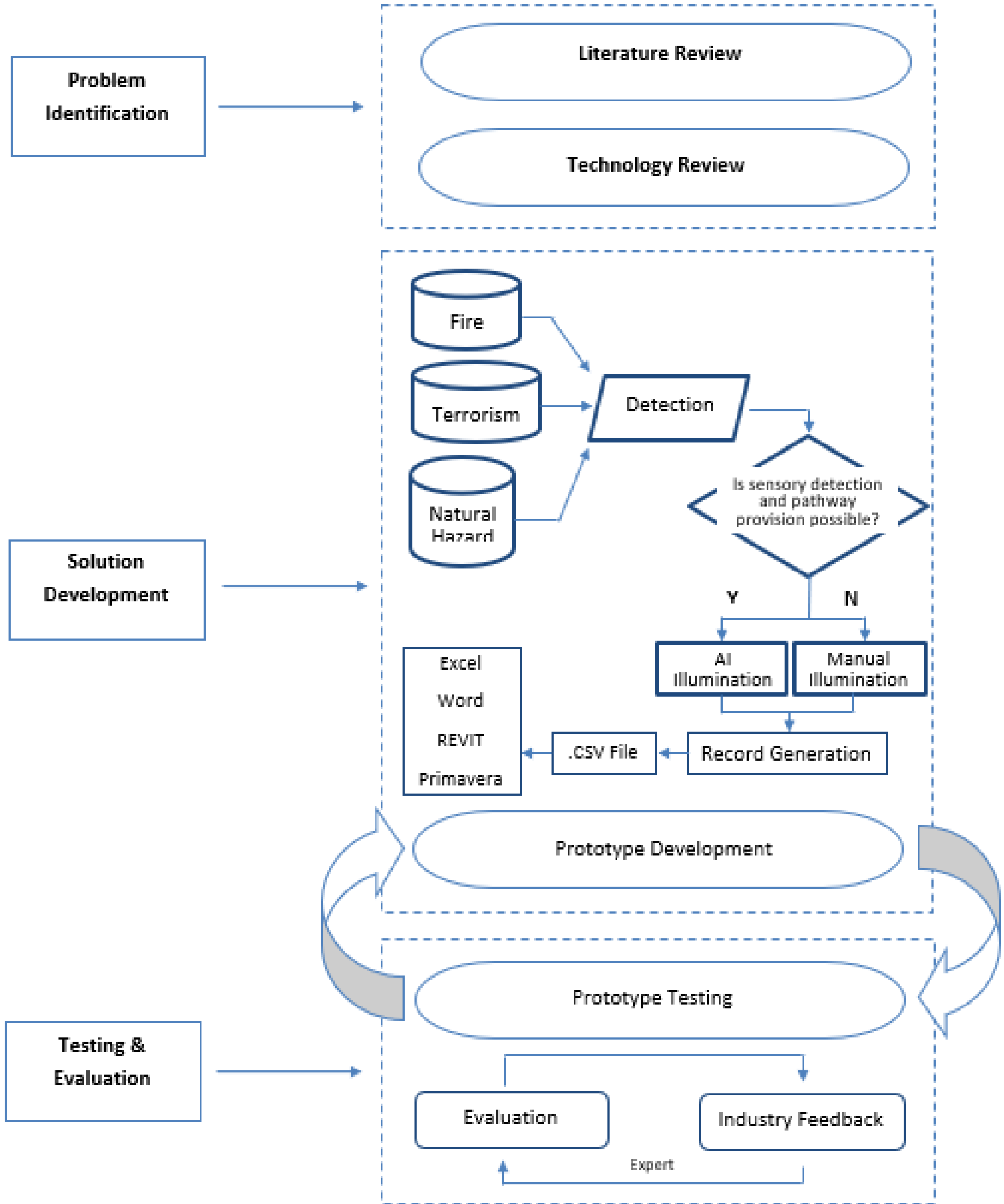


Figure 3.2: Research Methodology Framework

3.5 Procedure

The detailed description of the procedure along with figures is depicted underway.

3.5.1 Identification Process

In first place we studied all the problems that people faced in time of a fire or any emergency in building during construction as well as after construction. Going through all the issues and short-listing issues which will have been discussed in chapter 1 and 2. To address these issues and to find a solution to it analysis was done. Papers and survey suggested a number of solution but the best was that a path identification system should be a basic part of the fire/hazard alarming system.

3.5.2 Prototype Development

A prototype was constructed using Arduino hardware and was codded with UNO software to address the issue. A number of experiments were carried out with the apparatus and changes were made in the protype relating to sensors and the lighting. A universally acceptable notations demarcations were used, so that it is understandable to everyone, because the recipients of the services are majorly individuals of lagging knowledge and intellect.

3.5.3 Procedural Sequence

The basic chain of events involving softwares, their inputs and outputs, their links with each other and their individual roles in the project can be roughly depicted as shown below in figure 3.2. Further elaboration of these softwares is the part of this document and will be featured later.

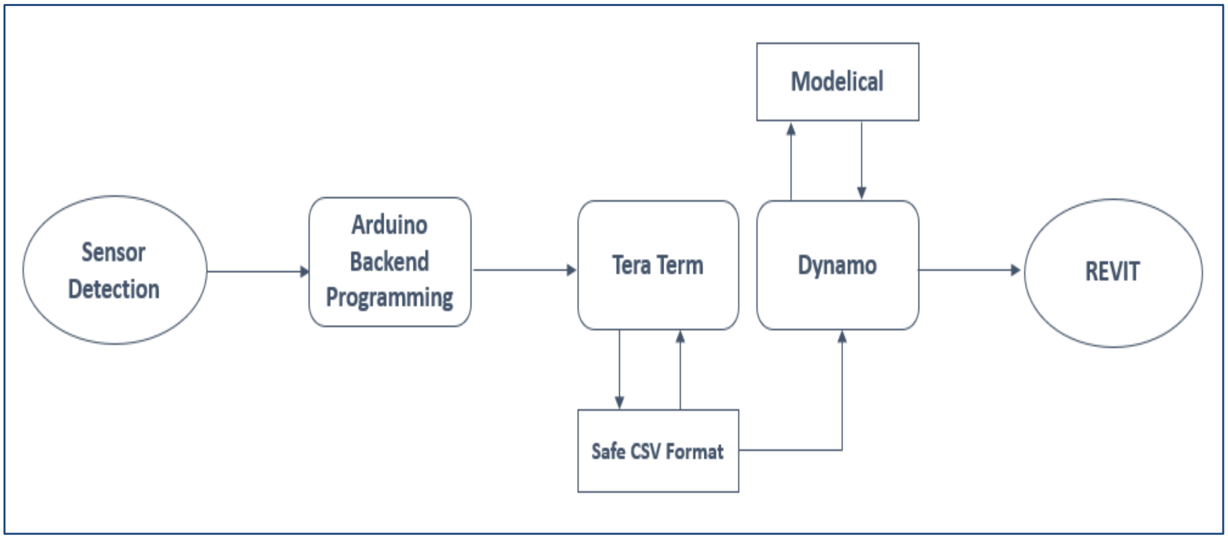


Figure 3.3: Procedural Sequence of Software Work

3.5.4 Procedure Adopted

The overall activity can be broken down into the following sub activities, from the point of sensor interaction to the point of LED output display

3.5.4.1 Sensor Activity

This can be broken down into the following steps:

1. The sensor detects the fire in form of the radiation coming from it. The range of detection is around 18-20m in any direction.
2. The sensor converts this data in the form of binary and sends it to the Arduino UNO for processing. Arduino UNO is the software we opted to use as the main processing unit of our prototype.
3. The Arduino then store this data and it acts on it according to the code given in Annexure 1 which are snaps taken from the computer.

4. The Arduino code basically process the data and decides on which side the fire is and then turns on the red lights on the following side and green on the safe side. It also sends this data to the computer through a wired or wireless connection
5. The data is received by the computer. It sends this data to ‘Tera Term’ for processing and displaying the results in form of RGB codes.
6. Tera Term also stores this data in any format, but we have chosen to store it in the form of .CSV (comma separated variable) form. It is shown in figure 3.3.

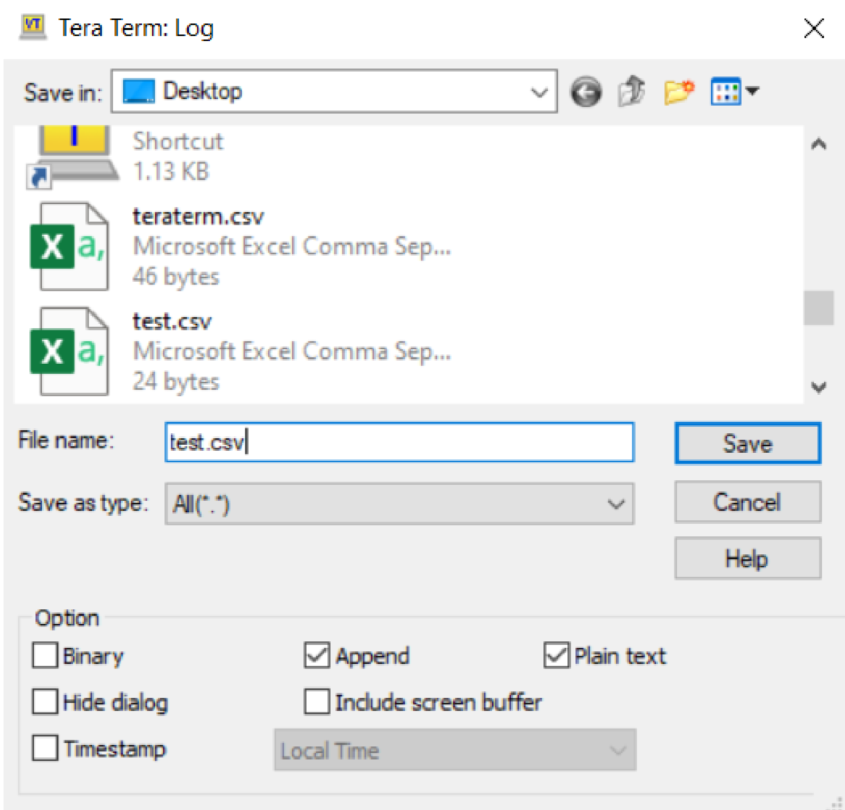


Figure 3.4: Tera Term File Saving Window

7. The data is then read by the Dynamo which is a programing and algorithm processing plugin for REVIT. It helps us to change the material properties and parameters of a elements as depicted in figure 3.4.

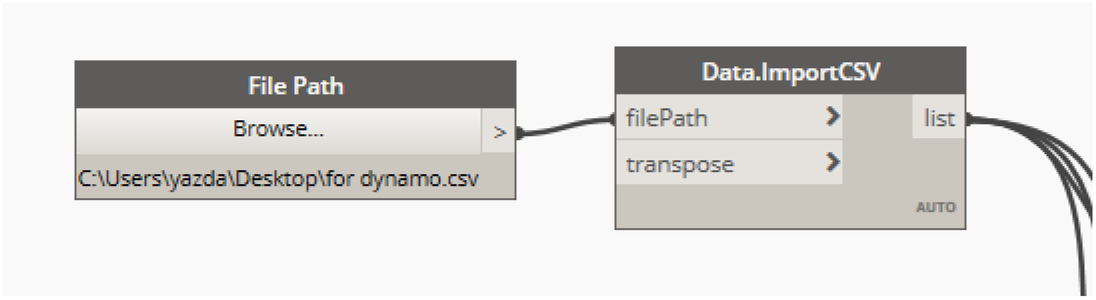


Figure 3.5: Algorithm section of Dynamo

8. Modelical is a plugin for the Dynamo which helps in deciding the color and in indicating the fire in the form of colors. Through programming and formation of a logical path it is programmed and run as shown in figure 3.5.

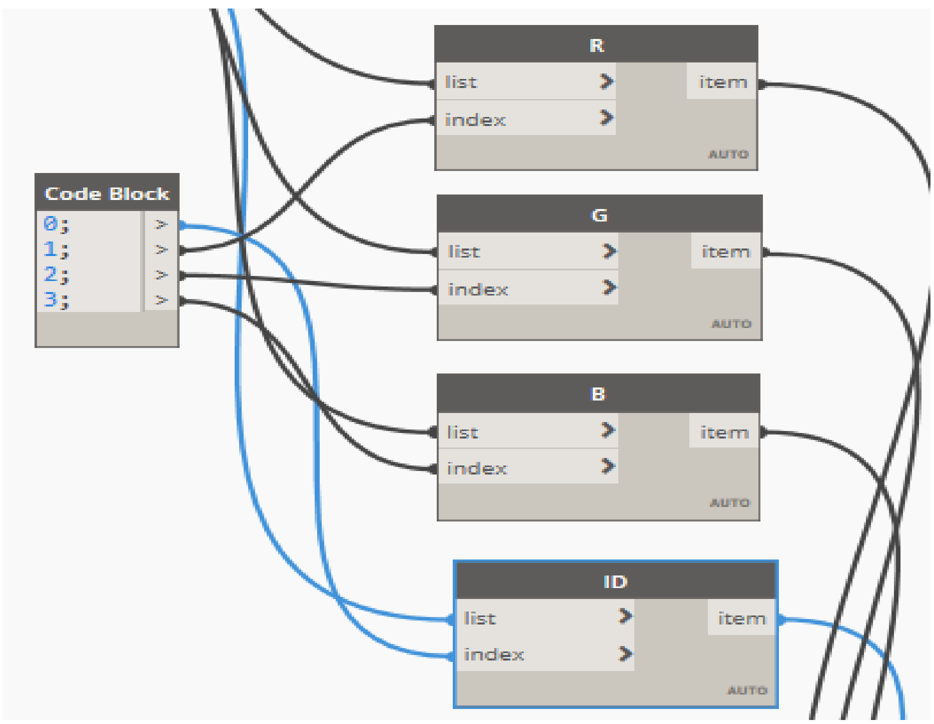


Figure 3.6: Modelical's Program made Algorithms

9. The data is sent back to dynamo and the dynamo performs the decision making based on the following algorithm shown in annexure 2, this algorithm varies in case more factors or sensors are to be added.
10. Dynamo sends the results to REVIT and the output in REVIT is shown in form of colors that it switches between red and green depending upon the pathways open and deemed ‘safe’ to pass through.

CHAPTER 4

RESULT AND DISCUSSIONS

4.1 Introduction

The preparation of a prototype only yields solid results in terms of statistics once it is put through the dense process of testing and practical experimentation multiple times. This of course takes years of record keeping and a thorough cost to output analysis.

However, the results in case of our brief study and application of the project will be discussed in this chapter.

4.2 Results of all Hardware

The following are the obtained results from all the hardware involved in the making of this project.

4.2.1 Various Sensors

The basic sensors attached to the project give the sensory data a binary form and send it to Arduino mini pro. The binary language of a typical input is as shown in figure 4.1.

4.2.2 Arduino Mini Pro

Arduino Mini Pro sends the data through rendering to the LED lights as discussed in chapter 3.

4.2.3 LED Lights

LED lights are used to flash colors as indicators, green depicting ‘safe’ and red depicting ‘unsafe’ as shown in figure 4.2.

4.3 Results of Softwares

The following are the obtained results from all the softwares involved in the making of this project.

4.3.1 Arduino Backend

All the data from sensors that goes as an input into Arduino Mini Pro kit is actually sent over to Tera Term for translation for a convertible output.

4.3.2 Tera Term

Tera Term is a software plugin that basically receives the Arduino binary data and converts into a usable file type for instance .csv file.

4.3.3 Dynamo

Dynamo is used to make logical chains that basically lead to indication of which lights to turn on or off on REVIT. The output chart is depicted in annexure 1. It also sends output to a plugin called modelical that is shown in annexure 2.

4.3.4 Modelical

Modelical receives data and gives result in form of decision making of what to render and change, annexure 2 depicts the output.

4.3.5 Autodesk REVIT

Display of the mainstream output of the front end is carried out on REVIT.

4.4 Outcomes from the Project

The following can be depicted as the outcomes of the project that proved as a service for the people that were helped from it.

4.4.1 Path Shortened

It was estimated through virtual case analysis that while escaping any kind of catastrophe an escaping person takes 170% of the total distance he travels to leave a building. Assisted by this prototype this could be brought down to 100-130% depending upon the route open and opted.

This significantly shortened distance travelled greatly reduces the time taken to escape a catastrophe thus potentially saving many important lives.

4.4.2 People Saved

Through another virtual case analysis, it was determined that a guided AI system would help in guiding and saving almost every one of the avoidable injuries or fatalities. The prototype is a life saver for a lot of individuals considering the fact that almost 7% of high-risk incident victims face avoidable deaths as per an estimate.

4.4.3 Guidance to Safety Workers

It is considerably common that rescue workers lack the knowledge as of what are the paths to adopt to reach the source of catastrophe or reach the individuals in distress. For this purpose, the prototype is essential as it clearly defines the paths to opt and the ones to not.

4.4.4 Avoiding a Stampede

Tight spaces, limited exits and multiple entry routes cause stampedes in case of havocs. It is analyzed through site visits and survey that almost all the buildings that facilitate a dedicated fire escape do not have enough room for the number of expected occupants in the whole complex to vacate the premises swiftly.

Considering the fact that incase of havoc people could be running in all directions and thus those critical junctions could become choked and result in stampedes and unwanted delays in the process of vacating the building premises. Thus, our project through automated and real time guidance would help pave smooth paths avoiding the process of choking.

4.4.5 Smooth Traffic Flow

It is known through various case studies that due to multi-directional maneuver of the crowd in case of disaster, the overall pace of the safety attaining process lags down and thus multiple lives fall on stake.

In case of uni-directional movement in case of an installed Arduino circuit with equipment a lot of time will be saved and resultantly a lot of lives

4.4.6 Data Recording

Through data collection via internet surfing a lot of cases of similar nature were found leading to multiple deaths from similar causes.

Through record keeping and comparing these kinds of issues can be addressed by observing their repetitive nature and thus taking preventive measures in similar scenarios.

4.5 Discussion

We asked a panel of experts from an Engineering firm in Peshawar ‘Green Builders and co.’ about the different aspects of our project after explaining to them the functionality of it and the following results were acquired from the questionnaire. Our questionnaire was placed in front of a sample total of 50 individuals.

We first questioned regarding the need, usability and implementation of the safety feature.

The opinions were as shown in figure 4.1, 4.2 and 4.3.

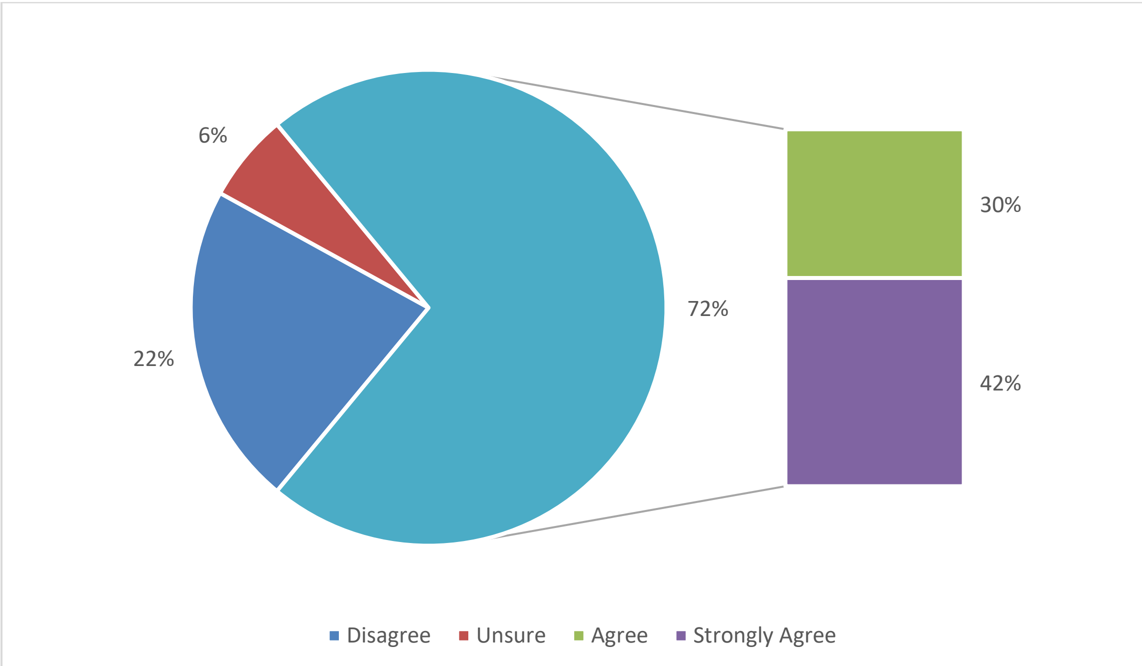


Figure 4.1: Expert Response on Project Need

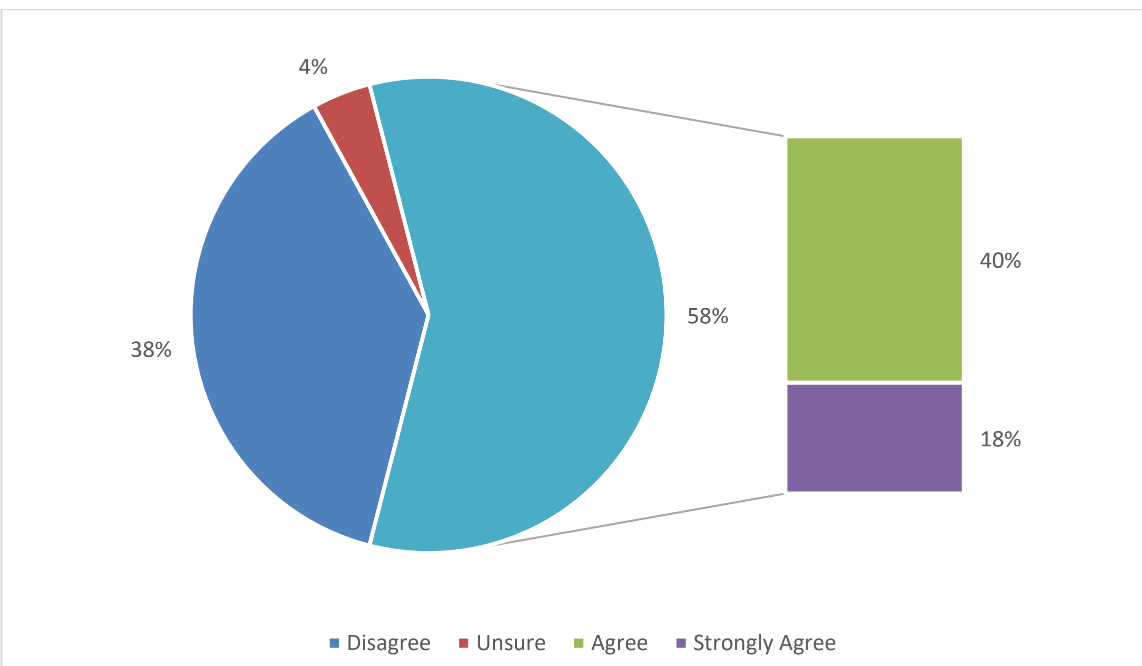


Figure 4.2: Expert Response on Project Implementation

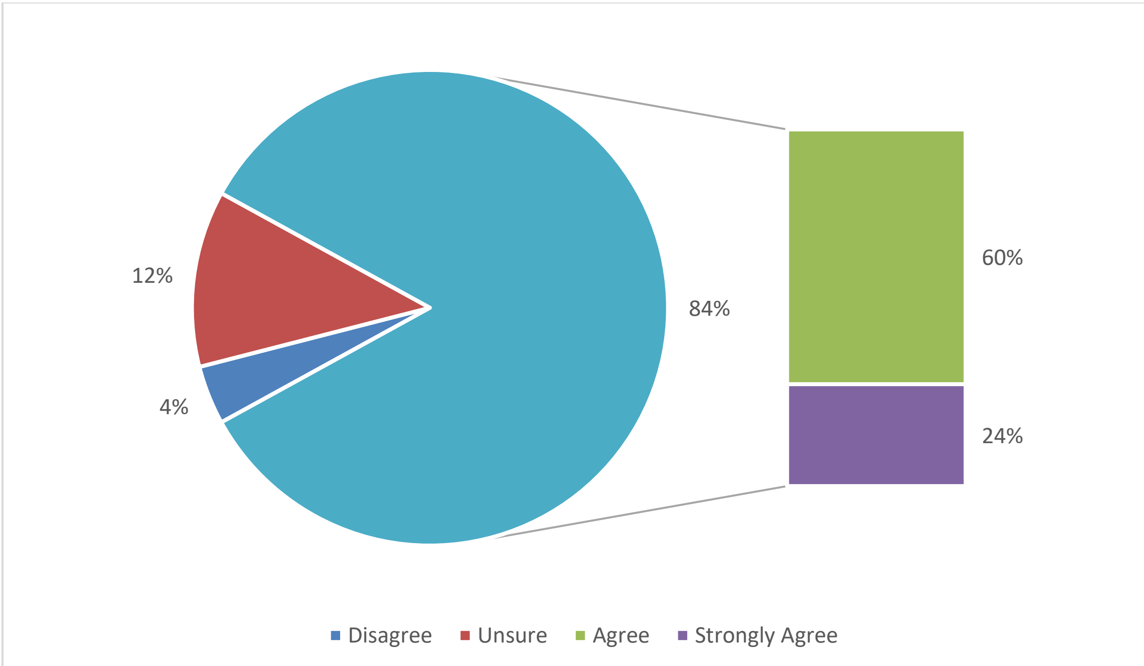


Figure 4.3: Expert Response on Project Effectivity

Overall, there was overwhelmingly positive opinion of experts on the need, implementation and the efficiency of the project. It can be best summarized by consulting table 4.1.

Table 4.1: Expert Feedback on Project

%	Project Need	Project Implementation	Project Effectivity
Strongly Agree	43	19	25
Agree	30	39	60
Unsure	6	4	12
Disagree	21	38	3

4.6 Comparison

A comparison between our project and the previous conventional systems on the basis of five vital factors was made on the basis of an attained score out of 10. The factors chosen were:

- Cost: The cost of our system was obviously significantly more than the previous conventional systems due to automation and BIM integration in our case.
- Understandability: Out system was deemed more understandable because it only took two colors to convey a message not phrases or sentences.
- Prominence: Obviously, the system we built was more prominent in moments of catastrophe.
- Durability: Because of multiple parts and circuitry our system was less durable than the conventional one.
- Flexibility/Mobility: Both are easily maneuverable.

The points given through evaluation are shown in table 4.2

Table 4.2: Points out of 10 for Selected Factors of both Systems

Out of 10	Conventional System	Automated System
Cost	9	5.5
Understandability	6.5	9.5
Prominence	5	8.5
Durability	8	7.5
Flexibility	8	8

The comparison radar was plotted for these systems is shown in figure 4.4. For computation to find which system is better we sum the points. The points for Automated System are 38.5 out of 50, while for conventional one is 36.5 out of 50 thus, the winner and preferred is obviously the automated system.

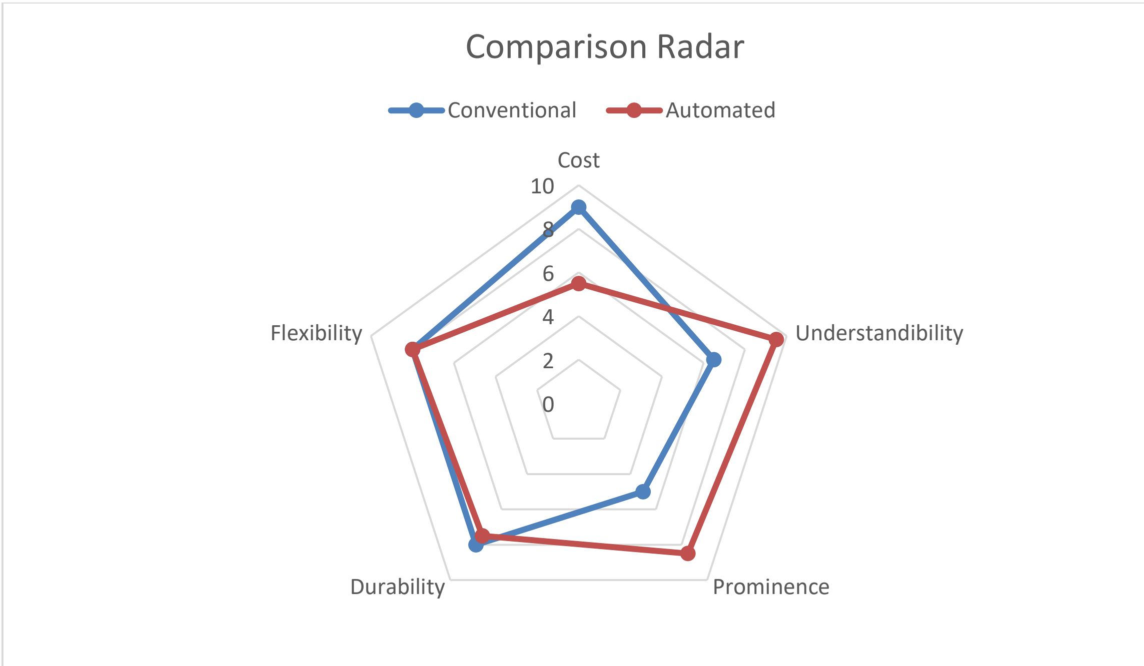


Figure 4.4: Comparison Radar for both Systems

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter includes the conclusion of this research and the recommendations to offer regarding this project.

5.2 Conclusions

Modernization is the key to ease in daily life and a leap towards a safer more ideal world. This world took off from the invention of fire, to a wheel, to agriculture, to steam engine, to the most sophisticated supercomputers. From proletarian times mankind has thrived for betterment, for comfort and for remorse. Life expectancy and safety procedures have been on a steep improvement. In these times, to improve procedures for provision of safety of construction workers is a dire need of time and an utmost compulsion.

This project is a seed to a giant tree in the forest of technological revolutions. The former claim is statistics based and if this project is patented and runs throughout the world for the sake of safety of workers or any kind of individuals involved, the reduction in deaths might come plummeting down to the levels parallel to the range of life expectancy. Mathematically this means the reduction in deaths in the factors of thousands per year worldwide.

5.3 Recommendations

The project prepared by this syndicate does not have applications limited to safety in fire hazards and it is not just exclusive for construction workers, the following are recommendations as to what are the other ways in which this project can be utilized and used.

5.3.1 Poisonous Gases Detection

The MQ135 is an air quality sensor designed to detect gases (NH_3, NO, NO_2, CH_3, smoke, and CO_2). Usually used for mining, office, or factory. MQ135 is an ammonia sensitive sensor, also senses sulfides, benzene vapors, smoke & other harmful gases. It is inexpensive and especially suitable for air quality monitoring applications. The module sensor Q135 is less conductive in fresh air. The conductivity of the sensor increases with increase in concentration of flammable gas. It converts the conductivity change into output signals.

This sensor can be remotely connected to our prototype and integration with this could make it able for evacuation of workers in places like mines which are susceptible to gas leakage.

5.3.1.1 Working Mechanism

The working mechanism of MQ135 smoke detecting sensor consist of a tube, which houses tubes of aluminum oxide used as measurement electrodes and a heating element, the floor is usually made of tin dioxides. The back of the housing consists of connection wires and the front houses the stainless-steel mesh. Burning something releases smoke which in turn releases gases. The thin layer of tin dioxide (SnO_2) reduces resistance. The resistance is then compared to an external resistance applied and the difference/change is the transmitted as signals.

5.3.2 Concrete and Column Failure Detection using Arduino

In most of the cases buildings are occupied with individuals at all times, it is never known when a disaster would strike, and a recently stable structure could pose as a collapsing structure. Earthquakes and ground destruction can cause internal cracks and deviations from neutral structures and beams. In most cases, we are unaware of the condition of the structure surrounding us. Perhaps the places that we enter every day maybe a breaking concrete beam structure and can collapse at any time. But being unaware we enter the building with satisfaction. Therefore, we are required to have a good monitor for concrete, wood and supports made from metal for unreachable structures. Fortunately, there is sufficient work done in that region and thus devices capable of such tasks are available. “Structure Analyzer” which is an electronic device is attachable to structure of metal concrete, wood etc. It analyses the angles and bending, measure the bend in the place where it is installed, and sends the data to the internet of things and then the user can access it from anywhere. This could be integrated with our prototype to assist safe exit right before catastrophe occur.

To enable the possibility of practibility of such an idea the following is required.

- Arduino 101 board
- 2x flex sensor
- 2x10k resistor

We can also use a BLE or Arduino module, which in turn can reduce the number of components that we require. Flexion or flexure stress are measured by the Flex sensors because the resistance changes as it bends. The circuit is very small because all you have to do is connect two resistors and two flex sensors.

We have to connect one resistor to receiving pin of an Arduino. Connect the pin of flex sensor in the same way. Connect the resistor using the A1 pin. We can connect the buzzer to output pin and one pin to ground.

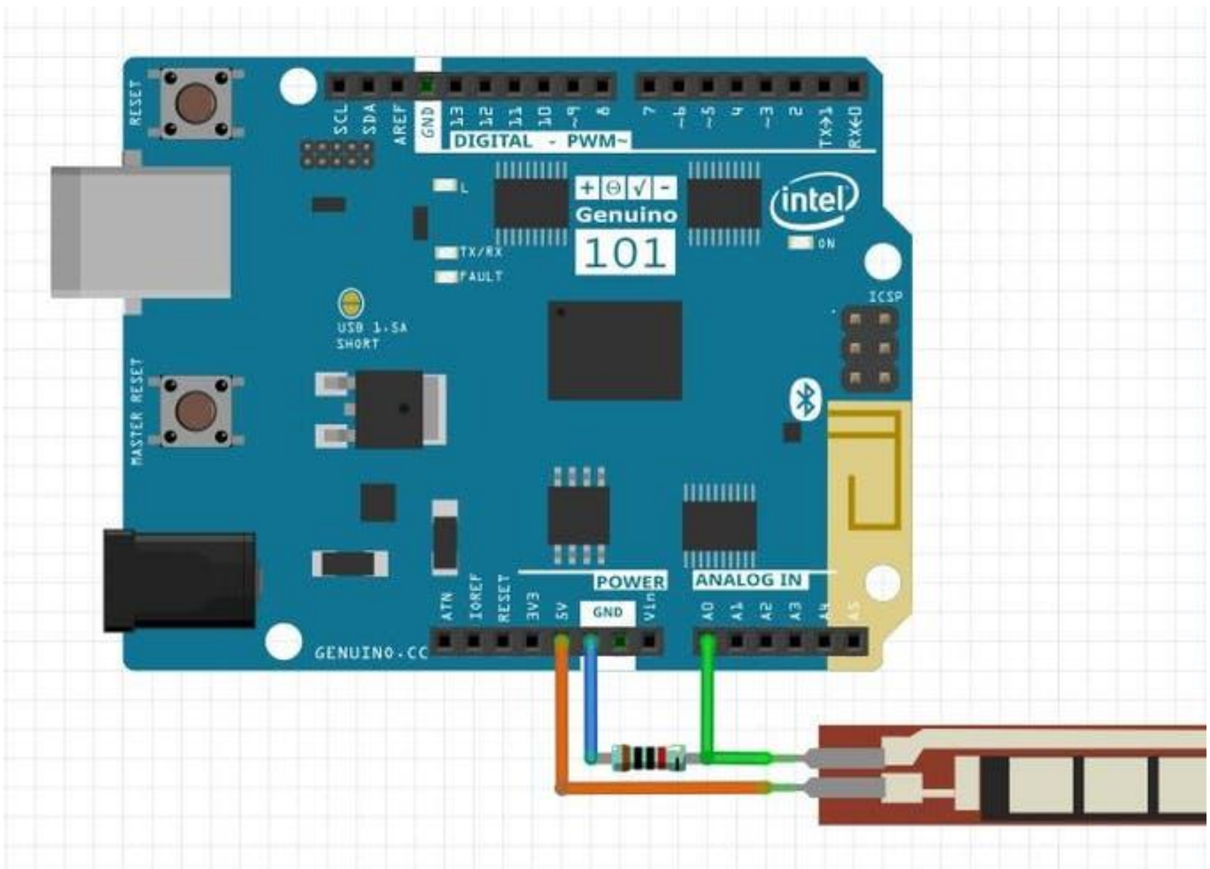


Figure 5.1: AO General Connectivity

5.3.2.1 Working

Paste the device into the structure you want to monitor. Also glue the two flex sensors together. Power the board using a USB cable. Now whenever the structure will have any crack, or the deviation will increase from the defined deviation it will ring the buzzer. This device can allow you to check the deviation values or change in angles of the structure. This is a tiny device which can be very effective. During a busy schedule, it can help us to detect and analyze the change in deviation in deflection and angle. This device can save hundreds of lives by notifying you about small but dangerous structural issues.

5.3.3 Terrorist Attack Detection in Schools/Colleges/Universities Manually

Schools, Colleges and Universities are the places that are under terrorist threat since Dec, 2014 APS Peshawar attack. Security of these education institutions is very important federal issue. A lot of work is done in this regard but there is a need of constant improvement. When a place is under terrorist attack, people there get frightened, and rush towards all emergency Exits. So, the scope of our project is to provide information about safety exits and giving a clear indication about which, all emergency exits are also under attack, to the people there to help reduce losses in critical situations like terrorism.

5.3.3.1 Working

When Security manager in the security room, sees an attack, he will manually operate using BIM structure of the building, and will give an indication about safety exists. It will help people to leave that place without any hesitation. Millions of lives can be saved by using this simple BIM circuit.

5.3.4 Environmental Parameters Determination Based on Low-Cost Sensors

Structure monitoring is an important task for engineers, given that the age of structures is closely related to energy consumption. This article is about Arduino applications Base low-cost sensor for building environmental monitoring. Humidity and temperature fluctuations were measured using the open-source Arduino platform and four DHT22 environmental sensors. To verify the accuracy of the data acquisition system used, we used a statistical approach to check the reproducibility and discrepancies of the recorded data. According to statistical calculations, the discrepancy in temperature parameters is less than humidity, so the sensor is more accurate in measuring temperature than humidity. The maximum range of derived standard deviations for temperature and humidity parameters is less than 0.13 and 1.33 respectively.

5.4 Limitations

The limitations of this project are discussed as follows

- The prototype developed by the syndicate aims to make the project as pocket friendly as possible but that came at the cost of accuracy and responsive efficiency of the sensor.
- In case the project is of a smaller scale the cost of this system might be ratio wise too much. This might have a profound effect on the overall price of the project.
- In case of using it in under construction projects or mines, it is known clearly that the paths (entry/exit) will change regularly thus the removal and rewiring of the system could be tedious and might require a dedicated person to operate it.
- In case of large-scale projects where a lot of paths are involved and a lot of LED lights are installed, the power source could be shifted from batteries to the main powerline which could fear cutouts or power outs. Additional batteries could be installed but the cost would be increased considerably from it.
- The equipment is breaking and damage prone in case of direct impact with falling objects or collapsing infrastructures, although the system in a parallel run system and one line being disabled without effecting the rest.

- To link the project to BIM or operate in digitally (which is a requirement), requires REVIT or any other model making which is not common in countries like Pakistan.

5.5 Future Research Directions

The project aims to provide this kind of system to every under-construction or constructed project there is, but buying it separately for purpose building might not be a viable idea in most cases thus, a safety manager should be made must to have a ‘safety kit’ consisting of this prototype. He should be responsible for the installment and management of this system. This could revolutionize the system of construction safety in Pakistan and maybe around the world.

It is a suggestion to further pair this project up with other smart equipment to further maximize its scope and assist in safety of projects in more aspects than before.

There is a dire need to develop this project and mature up the agenda to create automation and BIM based projects like this that were before this point in time not perceived.

References

Azhar, S. and A. Behringer (2013). A BIM-based approach for communicating and implementing a construction site safety plan. Proc., 49th ASC Annual International Conference Proceedings.

Gangolells, M., et al. (2010). "Mitigating construction safety risks using prevention through design." **41**(2): 107-122.

Karunasena, G., et al. (2013). "Construction Safety Management Assessment Framework for Developing Countries."

Koehn, E. E., et al. (1995). "Safety in developing countries: professional and bureaucratic problems." **121**(3): 261-265.

Oloufa, A. A., et al. (2003). "Situational awareness of construction equipment using GPS, wireless and web technologies." **12**(6): 737-748.

Perttula, P., et al. (2006). "Improving the safety and efficiency of materials transfer at a construction site by using an elevator." **132**(8): 836-843.

Reese, C. D. and J. V. Eidson (2006). Handbook of OSHA construction safety and health, crc press.

Sun, Q. and Y. Turkan (2019). A BIM Based simulation framework for fire evacuation planning. Advances in Informatics and Computing in Civil and Construction Engineering, Springer**:** 431-438.

Sunindijo, R. Y., et al. (2011). "CHPT construct: essential skills for construction project managers." **3**(2): 139-163.

Ye, M., et al. (2012). "Methodology and its application for community-scale evacuation planning against earthquake disaster." **61**(3): 881-892.

Zahoor, H., et al. (2015). Construction safety research in Pakistan: A review and future research direction. 7th International Civil Engineering Congress (ICEC-2015)“Sustainable Development through Advancements in Civil Engineering” June 12.

Huang, X., et al. (2003). "Analysis of construction worker fall accidents." **129**(3): 262-271.

Sun, Q. and Y. Turkan (2019). A BIM Based simulation framework for fire evacuation planning. Advances in Informatics and Computing in Civil and Construction Engineering, Springer**:** 431-438.

Ye, M., et al. (2012). "Methodology and its application for community-scale evacuation planning against earthquake disaster." **61**(3): 881-892.

Bureau, U. S. (n.d.). *Construction Spending*. Retrieved from United States Census Bureau: https://www.census.gov/construction/c30/c30index.html

Government, U. (2019). *Bureau of Labor Statistics*. Retrieved from bls: https://www.bls.gov/

Labor, U. S. (2020). *Occupational Safety and Health Administration*. Retrieved from OSHA: https://www.osha.gov/

OSHA. (2022). *United States Department of Labour* .

Annexure

1. Programming in Arduino UNO

Fire_Safe_Exit_Indicator_Circuit_Yazdan_Risalpur §

```
int flameleftpin = A0;
int flamerightpin = A2;
int leftsafelight = 10;
int rightsafelight = 11;
int buzzer = 2;

int flr, frr = 0;

void setup() {

    Serial.begin(9600);
    pinMode(flameleftpin, INPUT);
    pinMode(flamerightpin, INPUT);
    pinMode(leftsafelight, OUTPUT);
    pinMode(rightsafelight, OUTPUT);
    pinMode(buzzer, OUTPUT);

    digitalWrite(leftsafelight, 0);
    digitalWrite(rightsafelight, 0);

    initialize();
    delay(500);
}

void loop() {

    flr = digitalRead(flameleftpin);
    frr = digitalRead(flamerightpin);
```

```
if(flr == 0){

    Serial.print(20);
    Serial.print(",");
    Serial.print(226);
    Serial.print(",");
    Serial.print(0);
    Serial.print(",");
    Serial.println(0);
    Serial.print(10);
    Serial.print(",");
    Serial.print(10);
    Serial.print(",");
    Serial.print(255);
    Serial.print(",");
    Serial.print(44);
    digitalWrite(rightsafelight, 1);
    digitalWrite(buzzer, 1);
    delay(1000);
    digitalWrite(buzzer, 0);
    delay(4000);
    digitalWrite(rightsafelight, 0);
}
```

```
    else if(frr == 0){

        Serial.print(10);
        Serial.print(",");
        Serial.print(226);
        Serial.print(",");
        Serial.print(0);
        Serial.print(",");
        Serial.println(0);
        Serial.print(20);
        Serial.print(",");
        Serial.print(10);
        Serial.print(",");
        Serial.print(255);
        Serial.print(",");
        Serial.print(44);
        digitalWrite(leftsafelight, 1);
        digitalWrite(buzzer, 1);
        delay(1000);
        digitalWrite(buzzer, 0);
        delay(4000);
        digitalWrite(leftsafelight, 0);
    }
}

void initialize(){

    for(int a = 0; a < 3; a++){

        digitalWrite(buzzer, 1);
        delay(200);
        digitalWrite(buzzer, 0);
        delay(200);
    }
}
```

2. Flowchart of the Fire Hazard Programming via Modelical