IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 9, June 2025
Impact Factor: 7.67

Improving Workplace Safety by Utilizing the Machine to Machine Support Intelligent Decision-Making in Preventing Slip and Fall Occurrences during Elevated Work Activities

Abhishek Kumar Singh[1] and P. S. Tathod[2]
Shiv Kumar Singh Institute of Technology & Science, Indore
Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal

Abstract: *In developing countries like India, the number of fall-related incidents in workplaces is rapidly increasing—not just in the industrial sector, but also in construction and private sectors. Falls are currently the leading cause of fatalities and serious injuries. The severity of injuries resulting from working at heights depends on various factors such as the type of job, the height involved, and the condition of the working surface, whether it is uneven or cluttered. Generally, the greater the height, the more severe the injury; however, under certain unavoidable circumstances, even a fall from a lower height can prove fatal. Several factors contribute to the outcome of a fall injury, including individual characteristics, workplace behavior, alertness, fatigue, haste, and frustration, lack of focus, mental distraction, and complacency. In many cases, contract workers fail to properly secure their safety harness to an anchorage point. This research paper explores an innovative solution aimed at transforming personal protective equipment (PPE) used for working at heights. While numerous technologies exist—such as in the chemical industry, where equipment automatically shuts down and safety protocols are triggered upon parameter deviation—traditional PPE still lacks such automation. This highlights a critical area where further technological advancements are needed to develop a more robust safety system. A useful comparison is with airbags in vehicles: in the event of a collision, the airbag system activates within milliseconds, potentially saving the lives of the driver and passengers. Similarly, Smart PPE incorporates a feature where, if a compliance breach occurs in the workplace, the deviation is instantly detected and a warning alert is sent to the user as a reminder to adhere to safety protocols. This system enhances workplace safety by eliminating the need for manual surveillance or manual recording of violations, making it error-proof. In this study, Machine to Machine Like IoT-based smart safety harness has been analyzed. The research compares workplace deviations detected by this smart system with historical data obtained through manual monitoring, aiming to assess human error in PPE compliance.*

Keywords: Occupational Safety, Machine to machine M2M, Internet of Things, Smart Personal Protective Equipment (PPE), Fall Protection Systems, Fall Prevention, Working at Heights, Fall-Related Injuries, Workplace Safety, Industrial Safety Measures, Health etc

I. INTRODUCTION

Working at heights remains one of the leading causes of severe injuries and fatal accidents in industrial settings. This includes tasks performed on ladders, fragile roofs or surfaces, unprotected floors, open shafts, hoists, cages, or any area where there is a risk of falling. The majority of industrial accidents are preventable, and the implementation of effective control measures can significantly reduce workplace injuries. With the surge in industrialization, machine-to-machine artificial intelligence (AI) has greatly contributed to productivity, strategic decision-making, and improvements in

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 9, June 2025 Impact Factor: 7.67

quality and output. Although industries have embraced automation, advanced technologies, and machine learning during this AI era, similar advancements have yet to be fully realized in the realm of workplace safety. In India, PPE compliance is still predominantly managed manually—either through safety supervisors or leadership walkthroughs. Many industries continue to face challenges in achieving even basic compliance with PPE usage on the shop floor. While administrative discipline should be driven by top management, it often lacks consistent implementation at the operational level. As a result, occupational injuries and accidents continue to rise. In this research paper a unique solution has been studied to bring revolutionary change in personal protective equipment which is used while working at height. There are many technologies are available, in chemical industry if any parameter deviate automatically machine will be shut-down and safe operating protocols will be activated but in conventional personal protective equipment it is hardly say there is still area of research where the technological improvement is needed to bring the robust safety system. Air bags are a very good example to correlate the smart PPE, if any passenger vehicle have air bag system collision with other vehicle automatically within milli second the airbag will be activated which saves the life of driver and passenger as well. Similarly Smart PPE has unique provision if PPE compliance is deviated at workplace immediately the violation shall be captured, and warning alert shall be given to user to remind them to compliance. This will help us to improve workplace safety. It is an error proof system that neither required manual surveillance nor manual recording of violations. In this research paper M2M internet of thing based smart safety harness has been studied and the workplace deviation were compared earlier with manual monitoring data to analyze the human error with respect to compliance of personal protective equipment.

II. AREA OF STUDY

The outcome of this study is fruitful to all the industrial associations and the worker community. This study will be a valuable addition for all the safety professionals and engineering teams to adopt new technology and innovative ideas to improve workplace safety. Safety is not only the individual procession it is collaborative approach to inculcate the safety culture among the employees and contract workers. This study will not only help to give the smart solution direction it will give the more opportunity in many areas where injuries can be preventable and by adopting best and innovative and smart solution can reduce the life threating risk to our coworker at workplace. This study will emphasize recording all the deviations which will give us the total picture and idea what is the problem and how it can be fixed, or it can be war on waste initiative. This study is done in such a way and structured way that anyone can understand easily however the implementation part would be quite difficult due to availability of these smart solutions and but the idea for solving the problem will give the confidence that there is still scope of work which will motivate us to move further and bring more unique solution to ground floor so that workplace safety can be improved.

IIII. PROBLEM IDENTIFICATION

Working at height is one of the leading causes of serious injuries and fatalities in the construction industry worldwide, including in India. Despite the existence of safety regulations and guidelines, a large number of accidents continue to occur due to various organizational, technical, and human factors.

1. High Fatality and Injury Rates

Falls from height account for a significant proportion of occupational deaths in construction. According to reports by the Directorate General Factory Advice Service and Labour Institutes (DGFASLI), fall-related incidents consistently rank among the top causes of construction site fatalities in India.

2. Inadequate Use of Personal Protective Equipment (PPE)

Although PPE like harnesses, helmets, and guardrails are mandatory, compliance is often low due to discomfort, lack of training, or negligence. Many workers are either unaware of proper PPE usage or do not prioritize safety over productivity.

3. Poor Planning and Risk Assessment

Many construction projects lack detailed risk assessments specific to working at heights. The absence of methodical hazard identification and mitigation strategies increases the likelihood of accidents during activities like scaffolding, ladder use, roof work, and steel erection.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 9, June 2025
Impact Factor: 7.67

4. Insufficient Training and Competency

A large portion of the construction workforce in India is unskilled or semi-skilled. They often do not receive proper training in safe work practices for elevated tasks. In some cases, workers are not even briefed about the hazards involved before starting the job.

5. Unsafe Working Conditions

Factors such as unstable or incomplete scaffolding, lack of edge protection, inadequate fall arrest systems, and unguarded openings create inherently unsafe working environments. In many cases, cost-cutting measures compromise the installation of safety systems.

6. Weak Enforcement of Safety Regulations

Even though regulations like the Building and Other Construction Workers (BOCW) Act and IS codes are in place, enforcement at project sites is often lax. Inspections are infrequent, and penalties for violations are minimal or inconsistently applied.

7. Management Commitment and Safety Culture

There is often a lack of genuine commitment from top management towards creating a strong safety culture. Safety is frequently seen as a regulatory burden rather than an operational priority, leading to underinvestment in training and safety infrastructure.

8. Communication Gaps and Language Barriers

On large sites with workers from diverse regions, poor communication and language differences can prevent the effective delivery of safety instructions and hazard warnings.

IV. SOLUTION DOMAIN

The following outcomes shall be addressed from this study.

a) Real time smart solution for working at height which will give the significant contribution to prevent fall injuries while working at height.

b) Real time deviation will help us to collect the deviation data.

c) The number of data, including minor and major both shall be logged into the system and will help to do the data analytics to take it forward decision.

d) Very economical solution to save life while working at height.

e) This will help any organization to bring down accidents related to fall only.

f) If any single injury is prevented with the help of this smart solution, then morale of employee and contract workers will be high and there will be positive safety culture shall be inculcating.

g) This is a small sample project, based on the multiple use case, it will be easily expandable and under the one roof the number of activities can be monitored, and control measures can be taken accordingly.

h) This will help us to create benchmarks where a few companies adopt and take innovative solution to enhance their safety performance.

i) This will be revolutionary changes in in working at height solution where it was more challenging in past.

V. LITERATURE REVIEW

[1] Muhammad Khan (2021)- Muhammad khan studied on IMU (Inertial Measurement Unit) based Smart Safety Hook for Fall Prevention at Construction Sites

[2] Amaan D. Attar (2022)- Mr. Adaan has studied on workplace safety using AI and ML, he has published a paper in which it stated that workplace safety can be improved further by adopting new technology rather than conventional technology

[3] Prateek Khandelwal(2018)- Prateek Khandelwal and his team research on workplace place improvement by using computer vision AI technology post COVD pandemic.

[4] Dr Phoebe V. Moore(2016)- Dr. Phobe studied Artificial Intelligence in Occupational Safety and Health and the

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 9, June 2025
Impact Factor: 7.67

Future of Work

[5] Brian H.W. Guo(2018)- Brain studied various AI applications of computer vision to improve safety in the construction field.

[6] DISH(2020)- Directorate of Industrial Safety & Health of Gujarat state submitted the accident statistics report of every calendar year to DGFASLI Directorate General, Factory Advice and Labour Institutes Mumbai

VI. METHODOLOGY

In India anchoring of safety harness with anchoring point is being monitored through manually either deputing safety supervisor at workplace or walk the talk by the senior leadership team. Most of the industries are struggling for basic personal protective equipment compliance on their shop floor. Selection of advanced fall protection system while working at height involves many steps and required many inputs from engineering team and safety team and information technology team. The objective of this study is to provide the best solution for preventing fall injury from height. Working at height solution should be communicated to each contract worker those who engaged in working at height activity. Following below key steps have been involved for selection of advance fall protection system.

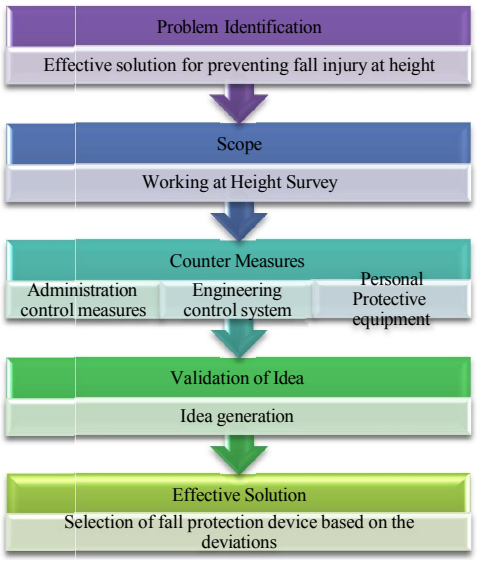

Figure 2.1: Flow of Selection of Smart Harness

Step No-1 Identification of Problem:

The first step is to identify the problem. In working at height 3P principle works called 3 points contact. At least 3 points of contact must be there while working at height. Either 2 legs and one hand or one leg and two hands must be engaged while working at height. This is the thumb rule while working at height whereas there are 3 basic requirements which should be standardized across the industry. The first one is access to height. Access to height means how access to working ate height either using of ladder, movable platform, and platform with railing, monkey ladder, roper ladder or other means of access.

Step No-2 Scope of Work:

The second step is to conduct a survey in the plant and identify how many places where potential fall hazard can occur. Like process area where there is chances of fall hazard, roof sheeting activity. These activities either may be routine or non-routine activity. For routine activity in industry there is standard operating procedure is governed and accordingly work is carried out for example operating of process isolation valve at height so there is standard fixed mobile platform having toe guard, mid rail and top rail provision by which worker can work easily. The second one is the non-routine activity where a working at height permit is enforced to get the job done safely. So it is very important that the list out the area where there is possibility of fall while routine and non-routine job.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 9, June 2025
Impact Factor: 7.67

Step No-3 Control Measures:

The third step is to identify the counter measure. There are multiple counter measures that can be adopted while working at height. However, it has been classified into three categories.

- Engineering control measures
- Administrative control measures
- Personal Protective equipment.

Engineering control measures- In engineering control measures there are lot of innovation and best practices have been adopted by the industry while working at height which totally eliminate the working at height risk example Thickness monitoring by using Drone Technology, painting through Drone technology, Scraping and NDT testing by using robotic solution crawler type robot, working at height using boom lifter and advance lifting mechanism. This advanced technology will not only reduce the time, cost, manpower but will bring down the high risk into medium and low risk category and having reliable system if it gets failed and there is not life-threatening risk to employee and contract worker so this type of technology will help to further strengthening of working at height control measures in terms of engineering controls.

Administrative Control measures- There are various administrative control measures used at industry for preventing fall injuries while working at height. All the administrative control measures are governed through the standard operating procedure for routine and non-routine activity.

- Work permit system
- Method statement
- Risk Analysis
- Training and toolbox talk
- Inspection of Lifting tool and tackles
- Vertigo test for height work
- Skill matrix for workers
- Safety display
- Deputation of supervisor.
- Monitoring through the camera or manual surveillance system etc.

Personal Protective Equipment- In working at height PPE is mandatory like safety helmet, safety shoes, safety goggle, safety hand gloves and most important double lanyard full body safety harness. FBSH is the most essential lift saving equipment by which the fall can be prevented. However, it is dependent upon the worker if he forgets to connect eh lanyard with the anchoring point which may be life-threating risk to workers. That needs to be ensured by deputing a safety supervisor or manager to comply with the PPE requirements. Apart from PPE, rescue equipment is also considered if fall occurs, and worker is hanging with the anchoring points. He must be rescued as soon as possible by using appropriate rescue equipment or method. If a person is hanging with the safety harness, he may be suffered with trauma suspension due to restriction of blood in his lower body part which again may be life-threatening risk to works so that's why rescue equipment must be considered while working at height.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 9, June 2025
Impact Factor: 7.67

Step No-4 Validation of Idea:

In above steps 1,2 &3 enable us to identify the problem and area where there is fall hazard and assess the risk and control measures in terms of engineering, administrative and personal protective equipment. Now step no. 4 enables us to select the effective fall protection system to prevent the fall injuries. For that all the control measures need to be validated whether they are reliable and having redundancy. In all the control measures need, be evaluated that if one layer of protection is failed then another layer of protection will overcome the situation or not. Identify the weakest control measures which is totally depending on the human behavior, knowledge, skill and try to fix it by adopting new technology or innovative solutions. There were multiple ideas that will be generated out of that the most reliable, trusted, authentication idea will be selected as advance fall protection system to prevent fall injuries while working at height.

Step No-5 Effective Solution:

After selection of Idea advance fall protection system, deviations shall be analyzed based on the basic trend. Earlier the working at height deviations were noticed either contractor supervisor or safety officer after that all the deviation were record into the system and the corrective action was taken based on the root cause like training need analysis, training effectiveness, skill development etc. Similar practice shall be followed for the advanced fall protection system and deviation will be logged in the system. Both the deviations will be analyzed, and comparison shall be made initially those have more deviations there will be more area of opportunity to work and again corrective action shall be taken accordingly.

VI. ANALYSIS AND DISCUSSION

For selection of IOT based smart solution for working at height for preventing fall injuries at height following below steps has been adopted.

Step No-1 Identification of Problem:

The plant has many working at height applications where every day working at height permits are obtained by the engineering team. This working at height job is safely executed by implementing robust administrative control like working at height permit system, Job safety analysis, Vertigo test while working at height. Toolbox talk, safety inspection for safety harness, PPE compliance, Training and other control measures based on applications.

The following majority of tasks are generally required for working at height and observed risk category.

Table 4.1: High Risk Area

Sr. No.	Task	Height of the Job	Risk Category
1	Roof Sheet Fixing Job	30 Mtr.	High Risk
2	Preventive Maintenance for Chimney or Stack	30 Mtr.	High Risk
3	Scaffold erection work for civil work for manufacturing building	30 Mtr.	High Risk
4	Lightening arrestor installation job	30 Mtr.	High Risk
5	Pipeline erection job	20 Mtr.	High Risk
6	Painting Job	20 Mtr.	High Risk
7	Maintenance of Isolation valve and assembly	20 Mtr.	High Risk
8	Leakage attending job inside the plant	10 Mtr.	Medium Risk
9	Project execution job inside the plant	10 Mtr.	Medium Risk

Step No-2 Scope of Work:

The second step is to conduct a survey in the plant and identify how many places where potential fall hazard can occur. This data can be obtained from the record of the work permit system. How many high-risk permits have been issued and what are the control measures associated with that. The scope of work involves the area where height work shall be carried out and the number of past working at height deviations. Once all the deviations are captured in one place then

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 9, June 2025
Impact Factor: 7.67

based on highest number of deviation where worker deviated the PPE compliance that area will be the area of opportunity where smart solution for working at height can be explored. Please find below the tabulate form for step 2.

Table 4.2: High Risk Area with Safety Violations

Task	Height of the Job	Risk Category	Area	Number of Violation/ 2023-24
Roof Sheet Fixing Job	30 Mtr.	High Risk	Construction work-Process Area	45
Preventive Maintenance for Chimney or Stack	30 Mtr.	High Risk	Utility DG and Boiler	10
Scaffold erection work for civil work for manufacturing building	30 Mtr.	High Risk	Production- Process Area	5
Lightening arrestor installation job	30 Mtr.	High Risk	Admin Building	7
Pipeline erection job	20 Mtr.	High Risk	Process Area	15

Figure 4.1: Working on Rooftop.

Step No-3 Control Measures:

The third step is to identify the counter measure. There are multiple counter measures that can be adopted while working at height. The highest number of observations was observed while roof sheet fixing job at Manufacturing plant in process area. There were 45 nos. of PPE deviations were recorded where all the observations belonging to full body safety harness where worker did not connect the safety harness while roof sheet fixing activity. However, the following control measures were adopted while roof sheeting fixing job.

• Engineering control measures- Proper platform was provided while access to height apart from that safety net was provided to prevent the fall injuries. Generally, all the working at height is executed through the proper scaffold having access to height, toe board, mid rail and had rail and working platform which assure the working at job.

• Administrative control measures- Administrative control measures are the most important control measure while working at height. The following below list of administrative control measures is adopted while roof sheet fixing activity.

o Job Safety Analysis- for all the non-routine activity job safety analysis is done before carrying out the working at height job. It is very essential for preparing the working at height job.

o Working at Height Permit System- This is the second most important legal document which requires while working at height. The height permit is filled out by the issuer and executor department, and they fill all the details for the person who will be working at height. It is a legal document, and a copy of the permit must be displayed at the location while carrying out the job. The work permit is signed by the all the authorized person and safety personnel also.

o Tool Box Talk- Training is given before starting the height work job to all the contract workers who engaged in the working at height activity.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 9, June 2025 Impact Factor: 7.67

o Height Pass Test- Vertigo test is performed for all the contract workers for checking their fitness while working at height. All contract workers must be qualified to work at height pass the test. This is mandatory test for working at height.

o Safety Inspection- There are multiple inspections carried out like PPE inspection, Safety harness inspection, Work permit audit inspection etc.

o Personal Protective equipment. - For working at height there are specific personal protective equipment are used like.

- Safety Helmet
- Safety Shoes
- Safety Goggle
- Safety Hand Gloves
- Double Lanyard Full Body Safety Harness,

Figure 4.2: PPE for Working at Height

Step No-4 Validation of Idea:

In above steps 1,2 &3 enable us to identify the problem and area where there is fall hazard and assess the risk and control measures in terms of engineering, administrative and personal protective equipment. Now step no. 4 enables us to select the effective fall protection system to prevent fall injuries. For that all the control measures need to be validated whether they are reliable and having redundancy. Based on the above problem working at height for of sheet fixing work is more challenging and has many deviations and having limited control measures and mainly depended upon the administrative control measures not engineering control measures. Please find below the risk matrix.

Table 4.3: High Risk Area with Safety Violations& Control Measures

Task	Height of the Job	Risk Category	Area	Number of Violation2023-24	Control Measures
Roof Sheet Fixing Job	30 Mtr.	High Risk	Construction work place Area	45	Administrative control measures

To overcome this problem IOT based safety harness has been introduced to prevent fall injury while working at height. This full body harness will bring a unique solution to avoid fall from height. If operator or worker who is working on the roof at 30-meter height missed to attached safety harness hook to anchoring point the alert will be released to the supervisor who is standing at ground floor. All the deviations shall be recorded in the system so that analyses can be done, and appropriate action can be taken accordingly. Please find below the process of smart safety harness system and its associated assembly.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 9, June 2025
Impact Factor: 7.67

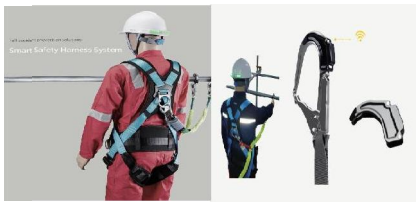

Figure 4.3: Smart Safety Harness

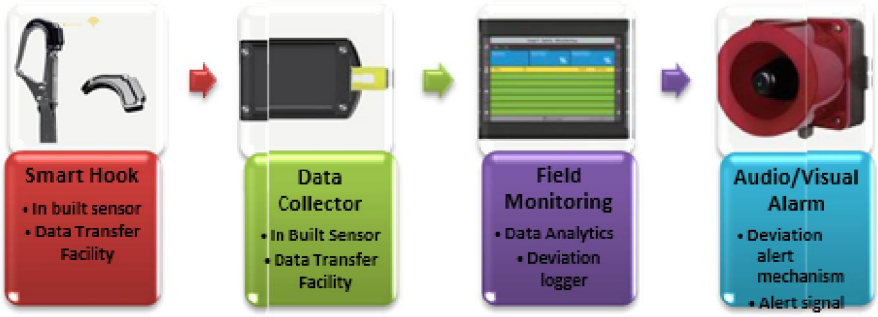

Figure 4.4: Assembly of Smart Safety Harness

Smart Hook- This is the major and important component of smart safety harness system. It is totally based on an IMU based sensor built with hook assembly. This IMU Inertial Measurement Sensor 9- Axis is calibrated for accelerometer, gyroscope, and magnetometer readings. The data is acquired from the IMU sensor and sent through the BLE Bluetooth low energy sensor. Following below are the functions of smart hook assembly.

- Detection hook fastening- within 55 mm of scaffold pipe, 15 mm of lifeline rope.
- Switch to sleep mode when unused in 10 minutes.
- 8 hours per day battery 3 V.
- Wireless frequency 2402-2840 MHz
- Light weight 30 gm

Operating Criteria for Smart Hook Assembly

- The hook sensor activated when an impact is applied or when the hook lever is operated for anchoring this time alert will be release
- When anchoring the hook, the front and rear angle of hook must be in the range of -10 to + 30 degree for hooking detection to work.

Figure 4.5: Images of Smart Hook

Data Collector – It is one type of data collector it can scan the smart safety harness within 100-meter radius and connect the RS422 and having BLE sensor Bluetooth low energy sensor. It can collect data up to 50 smart safety harness and also having LTE provision.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 9, June 2025
Impact Factor: 7.67

Figure 4.6: Images of Smart Safety Harness Data Collector

Field Monitoring Device- It is one kind of table to monitor all the deviations. All the events are logged into this. It shows the deviations log user wise, location wise and safety harness tagging wise.

- Display number of workers having smart safety harness
- Display status of hook anchoring or not
- Battery Status will be shown.
- Communication status will also be displayed.
- Location of the area.

This field monitoring device is also available in the flame proof type enclosure because in the chemical industry all the electrical and instrument must be FLP type to avoid fire and explosion risk at site.

Figure 4.7: Images of Smart Safety Harness Field Monitoring Device

Audio/ Visual Alarm- This will be utilized if any deviation is recorded, if will give the alarm and will be blinking during the night shift if any deviation is observed this will be helpful for work and supervisor to acknowledge the deviations. This audio and visual device is also available in the flame proof type enclosure because in chemical industry all the electrical and instrument must be FLP type to avoid fire and explosion risk at site.

Figure 4.8: Images of Smart Safety Harness Audio Visual Device

Step No.-5 Effective Solution:

After implementing this smart solution at work place it is important to have analyze the data, based on accuracy it will be decide whether it can be used for further application or not. For that is very important how the data is communicated from one device to another, if is there any communication breech then what will be the consequence associated with that. The IMU sensor is provided in the hook assembly. The data is acquired from the IMU sensor and sent through the BLE Bluetooth low energy sensor to the data collector. Data collector collects all the data and transfers all the data through BLE to Field monitoring device. It is a total cloud-based data storage facility which collects all the data and archives the same. All the deviations are logged into the system and a data analytics facility is also available where the area is seeking attention to avoid accidents based on the numbers of serious deviations. This filed monitoring device

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 9, June 2025
Impact Factor: 7.67

can be replaced with a smart phone or laptop to record all the deviations. Initially the more deviations are recorded the more attention will be given to addressing the same.

VII. RESULT

Based on the above assessment the following result has been derived to conclude the best solution to prevent fall injuries. Below following table and graph has been extracted from the smart safety harness modules in which the number of violations and deviations were found significantly higher. The more numbers of deviation or violations shall be observed, the more opportunity to address the same. Initially the data trend will be increased and after a few years an exact result will be shown in the form of advantages

Sr. No.	Task	Number of Violation/ Deviation (Nos.) 2024-25 with Simple Safety Harness	Number of Violation/ Deviation (Nos.) 2024-245 with Smart Safety Harness
1.	Roof Sheet Fixing Job working at height	45	62
2.	Preventive Maintenance	10	15
3.	Scaffold erection work for civil work for manufacturing building	5	10
4.	Lightening arrestor installation job	7	12
5.	Pipeline erection job	15	23
6.	Painting Job	12	14
7.	Maintenance of Isolation	6	7
8.	Leakage attending job inside the plant	27	41
9.	Project execution job inside the plant	16	21

Table 6.1; Result Based on the Deviations

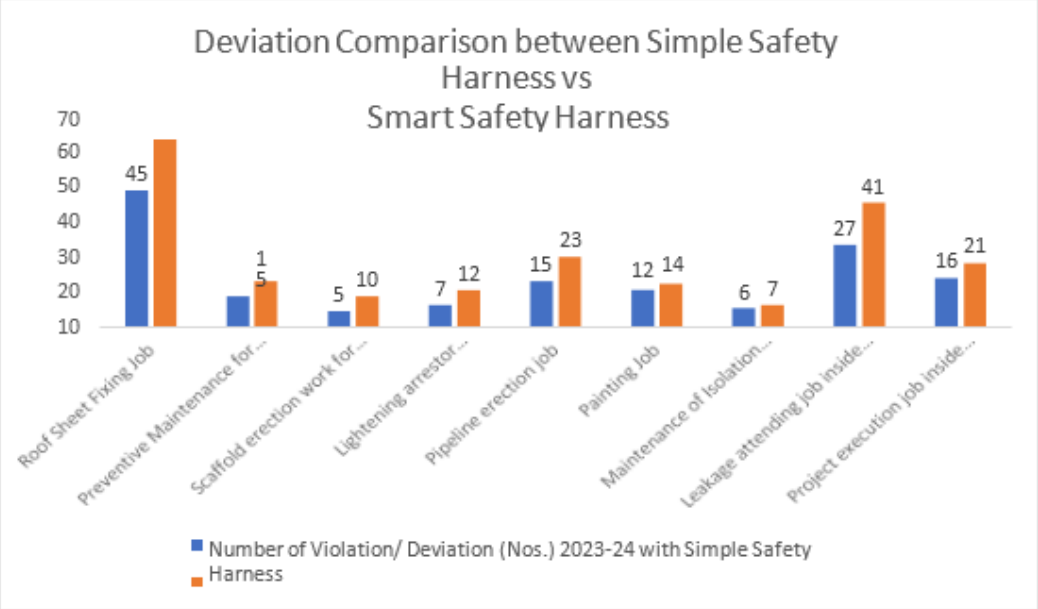

Figure 6.1; Deviation Comparison between Simple and Smart Harness

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 9, June 2025
Impact Factor: 7.67

Sr. No	Task Activity	Number of Violation/ Deviation (Nos.) 2024-25 with Smart Safety Harness
1.	During Ascending and Descending of Ladder	81
2.	During Task Change Over	34
3.	During Fixing of Lifeline	26
4.	During Preparatory Work	32
5.	During Scaffold Erection	32

Table 6.2; Task based Violation Analysis

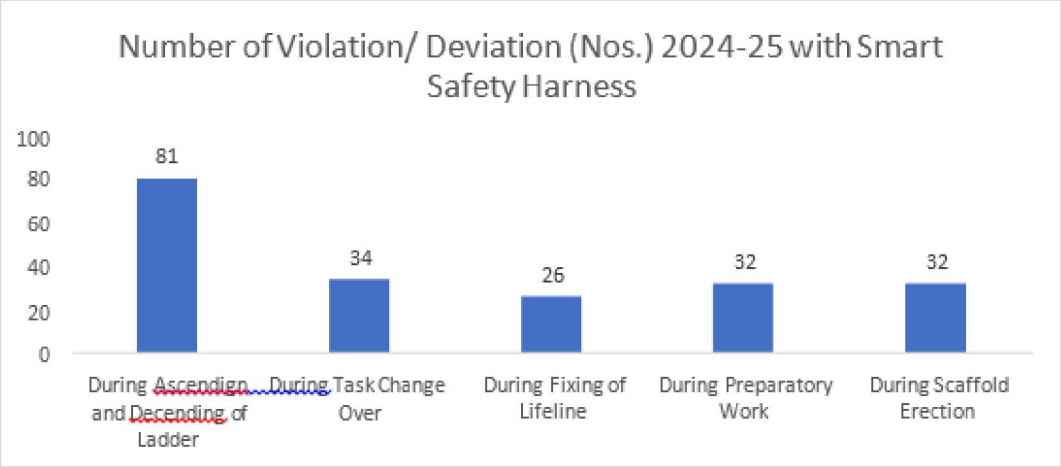

Figure 6.2; Task Based Violation Analysis

Sr. No.	Year	Near Miss Pertaining to Working at Height
1.	2021-22	16
2.	2022-23	15
3.	2023-24	12
4.	2024-25	1

Table 6.3; Near Miss Record on Yearly Basis

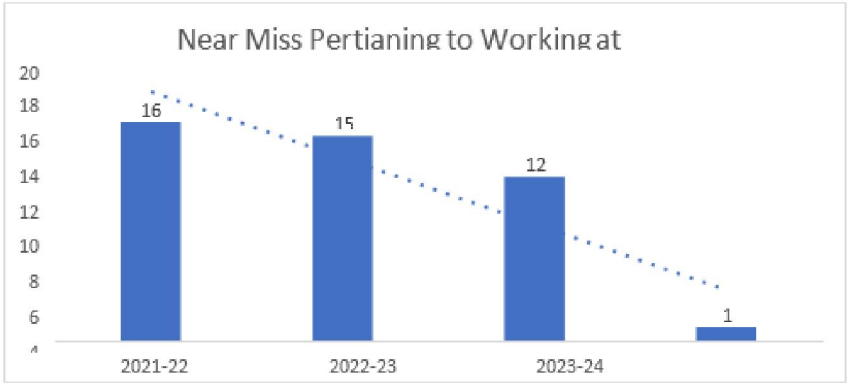

Figure 6.3; Near Miss Record on Yearly Basis

DOI: 10.48175/IJARSCT-28298

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 9, June 2025
Impact Factor: 7.67

VIII. CONCLUSION

In this research study it has been concluded that the Machine to machine M2M based smart solution called smart safety harness is very effective for fall injuries while working at height. It gives real time violation/ deviation by which contract worker will enable to know their mistake and reconnect his safety harness with the anchoring point. This is a full proof or error proof solution in workplace safety which will not only improve the safety performance of the company. It will improve the productivity and morale of the employees and contract employees. The conventional monitoring system in which the contract supervisor or safety personnel were used to stand to supervise the high-risk job whether contract worker is complying with the personal protective equipment (Anchoring of safety harness) if it deviates the supervisor counselling them to strict adherence with PPE while working at height. Sometimes supervise or contract workers ignore the safety regulation which can lead to sever health injury or sometime 100% surveillance was very difficult task or most of the time Height work activities used to carry out on roof where there is no adequate solution however now there are many technologies are available like Drone surveillance, Fixed camera surveillance but it has not yet improved to detect safety harness anchoring compliances. The program needs to be configured on the latest technology however they are not much cost effective as compared to smart safety harness. This smart harness can be used by any contract workers and anywhere it can be used even including remote location also. In the result section it has been found that the near miss pertaining to safety harness has dropped drastically which can contribute to save the life while working at height.

IX. FUTURE SCOPE

In this research machine to Machine M2M based smart solution has been introduced which gives the alert and warning if contract worker misses to connect the safety harness while working at height. It is very unique solution which will bring revolutionary changes to personal protective equipment. There are much research being done on smart PPE across the world but the best solution yet to come. The audio-visual alarm trigger or remind the human being to recall their act however at some time contract worker is engrossed too much which he forgets to listen or watch the warning signal or during emergency it is very difficult to complying the PPE requirement at that time violation occurred which could lead to accident or injury. Audio-visual signal plays a critical role when it comes to very close call, but effective engineering solution can bring the unique solution, even after the audio-visual alarm if fall occurs the person will not be harming the same principle which work in the car where immediately air bags activated when car met with an accident and save the life. There are many solutions and upgrades yet to be done for the upcoming edition to enhance safety while working at height. This dissertation can be extended if other additional engineering control measures are collaborated like secondary fall protection system. If one fails, the secondary fall protection system can overcome the near miss situation to avoid injury at workplace.

REFERENCES

[1] Muhammad Khan(2021): "IMU BASED SMART SAFETY HOOK FOR FALL PREVENTION AT CONSTRUCTION SITES", Department of Architectural Engineering Chung-Ang University Seoul, South Korea
[2] Amaan D. Attar (2022): "WORKPLACE SAFETY USING AI AND ML" Department of Mechanical Engineering A.I. Kalsekar Technical Campus Mumbai, India.
[3] Prateek Khandelwal (2018): "USING COMPUTER VISION TO ENHANCE SAFETY OF WORKFORCE IN MANUFACTURING IN A POST COVID WORLD" Group Data & Analytics, ABMCPL, Aditya Birla Group, India.
[4] Dr Phoebe V. Moore (2016): "OCCUPATIONAL SAFETY AND HEALTH AND THE FUTURE OF WORK"
[5] Management& Organization division, School of Business, University of Leica'
[6] Brian H.W. Guo(2018): "A REVIEW OF THE APPLICATIONS OF COMPUTER VISION TO CONSTRUCTION
[7] HEALTH AND SAFETY"University of Canterbury, New Zealand.
[8] Directorate of Industrial Safety & Health (2020): "ACCIDENT AND INCIDENT SUMMARY REPORT" Directorate of Industrial Safety & Health of Gujarat state.
[9] Directorate of Industrial Safety & Health (2021): "ACCIDENT AND INCIDENT SUMMARY REPORT" Directorate of Industrial Safety & Health of Gujarat state.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 9, June 2025 Impact Factor: 7.67

[10] Tae Hyong Kim (2020): "ACCELERATION MAGNITUDE AT IMPACT FOLLOWING LOSS OF BALANCE CAN BE ESTIMATED USING DEEP LEARNING MODEL" Department of Biomechatronic Engineering, College of Biotechnology and Bioengineering Sungkyunkwan University, Suwon 440-746, Korea.
[11] Ibukun Awolusi (2017): "WEARABLE TECHNOLOGY FOR PERSONALIZED CONSTRUCTION SAFETY MONITORING AND TRENDING"Department of Civil, Construction, and Environmental Engineering, The University of Alabama, 251 H.M. Comer, Tuscaloosa, AL 35487, USA.
[12] Juhyeong Ryu (2016) "ACTION RECOGNITION USING A WRISTBAND-TYPE ACTIVITY TRACKER: CASE STUDY OF MASONRY WORK"Dept. of Civil andEnvironmental Engineering, Univ. of Michigan, 2350 Hayward St., Ann Arbor, MI.
[13] J. Hinze, (2013): "CONSTRUCTION-SAFETY BEST PRACTICES AND RELATIONSHIPS TO SAFETY PERFORMANCE," 2013, Korea.
[14] R. Navon (2007): "ALGORITHMS FOR AUTOMATED MONITORING AND CONTROL OF FALL HAZARDS," J. Comput. Civ. Eng. Korea.
[15] H. Jebelli (2012): "FALL RISK ANALYSIS OF CONSTRUCTION WORKERS USING INERTIAL MEASUREMENT UNITS: VALIDATING THE USEFULNESS OF THE POSTURAL STABILITY METRICS IN CONSTRUCTION," Saf. Sci., Korea.
[16] K. Yang, (2016): "SEMI-SUPERVISED NEAR-MISS FALL DETECTION FOR IRONWORKERS WITH A WEARABLE INERTIAL MEASUREMENT UNIT," Autom. Constr. USA.
[17] K. YANG (2014): "AUTOMATED DETECTION OF NEAR-MISS FALL INCIDENTS IN IRON WORKERS USING INERTIAL MEASUREMENT UNITS," Constr. Res. Congr. USA.
[18] J. Teizer (2009): "PERSONNEL TRACKING ON CONSTRUCTION SITES USING VIDEO CAMERAS," Adv. Eng. Informatics, Korea.
[19] "OCCUPATIONAL HEALTH AND SAFETY IN CONSTRUCTION PROJECT MANAGEMENT - HELEN LINGARD, STEPHEN M. ROWLINSON - GOOGLE BOOKS." (Accessed May 10, 2021).
[20] "CONSTRUCTION SAFETY MANAGEMENT, 2ND EDITION | WILEY." https://www.wiley.com.