# CHAPTER 148

## Using IoT for Health & Safety Management in Construction Site

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**ABSTRACT**

The use of IoT technology for construction site health and safety management is examined in this paper. The study highlights the main issues with traditional safety monitoring, including the inability to manage manual safety records, the absence of real-time monitoring, and the restricted ability to track worker compliance. The efficiency of current safety training was evaluated by a survey that identified workers' knowledge gaps as well as their strengths. These observations led to the proposal of an Internet of Things (IoT)-based safety monitoring system that uses sensors, RFID readers, and a central data gateway to improve real-time safety compliance tracking. The suggested system has several benefits such as Real-Time Monitoring; Data-Driven Decision-Making; Cost-Effectiveness; and Smooth Integration. Even though the system is still in the design stage, preliminary cost comparisons show considerable savings, and work is being done to find funds for deployment. This research aims to provide evidence to justify that Adoption of IoT in construction safety improves emergency response, real-time monitoring, and hazard detection, guaranteeing a safer working environment. Productivity, sustainability, and industry transformation are further enhanced by efficient human resource management and digital integration.

**Keywords:** IoT in construction safety; Real-time data monitoring; Hazard detection; Safety compliance; RFID sensors; Data-driven decision-making; Human resource management.

### 1.0 Introduction

### 1.1 Background

Despite being a major driver of economic growth, the construction industry confronts several obstacles, including low efficiency, a slow adoption of digital technology, and a reliance on reactive safety measures, which frequently results in accidents. With real-time monitoring, hazard detection, and enhanced compliance tracking, IoT integration provides a proactive solution. An IoT-enabled flexible safety solution improves risk reduction, certification verification, and employee training.

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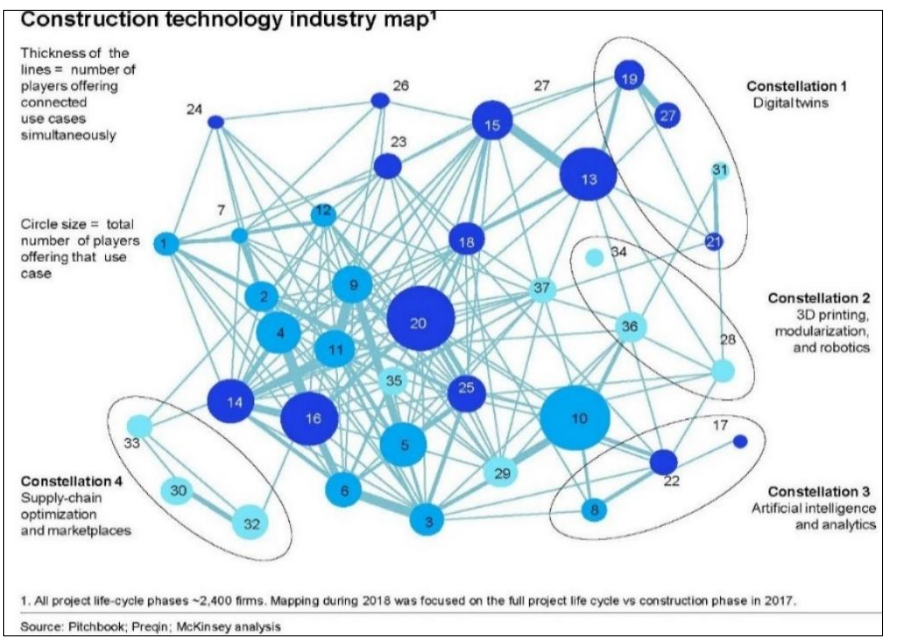
Post-transition, efficient HR administration guarantees improved scheduling, communication, and employee retention. Adoption of IoT promotes sustainability, cost-effectiveness, and data-driven decision-making in addition to safety, which helps to revolutionise the sector over the long run.

### 1.2 Scope

This study examines how IoT affects construction health and safety, focussing on antiquated manual processes that raise the risk of accidents. Real-time monitoring, hazard detection, and proactive risk management are made possible by IoT technologies. IoT's promise to lower accidents, boost productivity, and fortify safety culture is analysed alongside obstacles like infrastructure, data privacy, and budgetary limitations. The study creates an interface that combines computer vision, automated safety training, real-time monitoring, and predictive analytics. Proactive, data-driven safety management may revolutionise construction by utilising AI, machine learning, and cloud computing, which will meet the digitalisation requirements of Industry 4.0.

**Figure 1: Construction Industry Map**




### 1.3 Research objectives

- To identify ways to improve health and safety management on the construction site using IoT.

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- To explore the comparative advantage of IoT over the traditional method in improving health and safety management.
- To recommend best strategies for implementing IoT in health and safety management in construction projects.

## 2.0 Research Methodology

This research probes into the feasibility study on implementation of IOT application in construction site for health and safety management of workers through a survey-based approach and analyse the response using statistical tools.

### 2.1 Identification of IoT practices in construction

A literature review analysed academic research on IoT applications for safety and health management in construction. Relevant digitalization practices were extracted and documented.

### 2.2 Questionnaire survey

The survey was conducted among 84 construction professionals and students, ensuring diverse perspectives. Responses were collected and analysed.

### 2.3 Pilot interview

Five Interviews were conducted at different construction sites for better understanding in digital safety management.

### 2.4 IBM SPSS analysis

Data was statistically analysed using IBM SPSS, applying:

- Relative Importance Index
- Reliability analysis (Cronbach's alpha)
- Descriptive statistics (Mean, Standard Deviation, Range)
- One sample T Test

**Table 1: Respondent Details**

| Sr. No. | Description Experience (in years) | Number of Respondents |
|---|---|---|
| 1 | 1-5 | 60 |
| 2 | 6-10 | 14 |
| 3 | Above 10 | 10 |

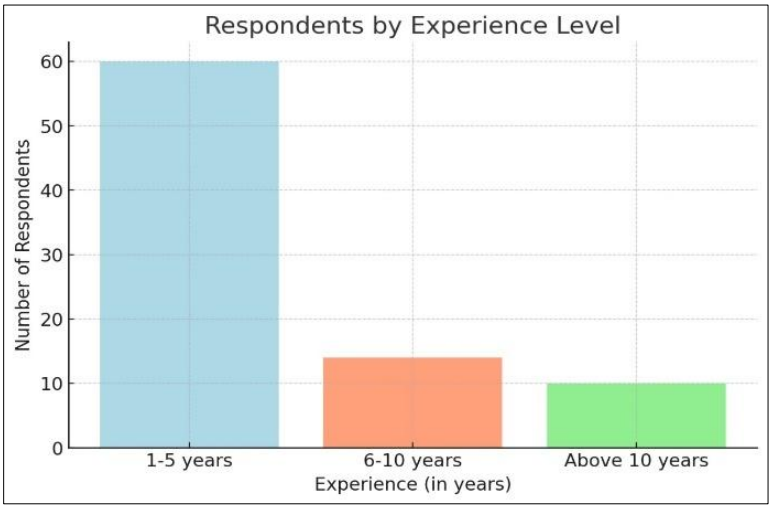
### 2.5 Descriptive statistical analysis

Responses were screened for completeness. Frequency distributions, factor averages, and graphical representations of agreement percentages were generated.

**3.0 Data Analysis**

Following figures show the respondents as per their current designations and years of experience in their respective fields. The respondents chosen are with different portfolios and responsibility in the construction sector.

**Figure 2: Respondent Details: Distribution of Respondents by Experience Level**




*Section 1: Safety Management - Traditional method*

Very less frequency of safety training sessions is conducted on site leading to an increase in risk of accidents. Poor safety audits are conducted on sites. Reporting safety incidents is quite often ignored by the organization management. Manual records are hard to handle and maintain on site. This shows that there needs to be an improvement on safety monitoring on site by technology implemented solution.

*Section 2: Using IoT in Safety Management*

Majority of respondents agreed safety monitoring and management is efficient when it is digitalized compared to manual work of safety engineers or supervisors on site. Wearable safety IoT devices have good agreeableness to monitor workers safety, health and movement on site. IoT based warning systems can reduce the rate of accidents on site. IoT based decision making has a faster way of making decisions compared to manual making. The results show there is strong support towards implication of IoT on construction site.

*Section 3: Challenges & Recommendations of using IoT in Construction Safety*

High initial costs. Required government funding and subsidiary schemes. Resistance from workers to adapt. Require efficient training. Technological knowledge drawback with regards to labourers

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**Figure 3: Respondent Details: Count of Industry Type by Designation**

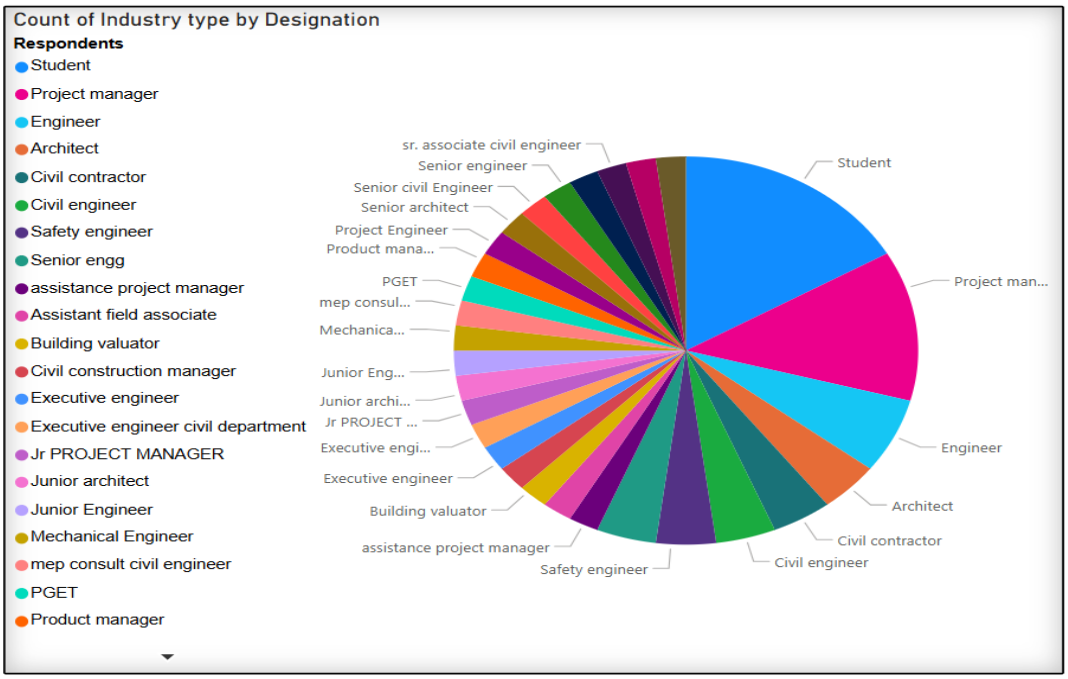


**Table 2: Construction Project Details**

| | Location | Type of project | Scale of project | Designation of the personnel | Experience |
|---|---|---|---|---|---|
| Site 1 | Thane, Mumbai | Residential | Large | Senior Engineer | 5 years |
| Site 2 | Baner, Pune | Residential | Medium | Senior Engineer | 7 years |
| Site 3 | Baner, Pune | Residential & Commercial | Medium | Safety Engineer | 5 Years |
| Site 4 | Mahalunge Phase 2, Pune | Residential & Commercial | Large | Safety engineer | 7 years |
| Site 5 | Moshi, Pune | Residential | Medium | General Manager | 12 years |

### 3.1 Details of pilot interview participants

*Summary of responses from construction site:*

- Due to high initial cost with respect to project cost.
- In small and medium-sized private projects, there is no special personnel regarding safety, i.e. a Safety engineer.
- Lack of technical knowledge about usage of IoT devices.
- The Traditional practices itself are not being taken seriously i.e. there is no SOP regarding Safety.

- The shoes, helmets and other safety utilities are being misplaced every day, using expensive IoT devices will be a headache for the client and contractor.
- The safety engineer itself is not trained in using the IoT devices, which makes it difficult to handle and maintain the IoT devices on site.
- Labors are hesitant to use the devices because there is no direct Benefit to them.

**Table 3: RII Table**

| No. | Questions | Mean |
|---|---|---|
| 1 | Using IOT tools like Wearable Safety Devices, Smart Barrier Systems, etc. can help to track each labourer's activity on site | 4.62 |
| 2 | A safety induction program is mandated for labourers. | 4.60 |
| 3 | Cameras and IOT sensors can be placed around construction sites to detect unsafe conditions. | 4.57 |
| 4 | Warning and alarm systems for any hazardous and unsafe conditions can be implemented on-site using IoT. | 4.57 |
| 5 | More training programs should be conducted to educate management employees and workers about IoT integrated safety systems. | 4.54 |
| 6 | IoT safety devices could be designed more user-friendly for construction workers. | 4.52 |
| 7 | Government and industry stakeholders support is required for IoT implementation. | 4.49 |
| 8 | Lack of technical knowledge among workers is a major barrier to implementing IoT. | 4.45 |
| 9 | IOT can become a modern construction safety strategy 4.40 | 4.40 |
| 10 | The work of a safety assistant or safety manager on site will become easier by using IOT applications to automate the manual tasks. | 4.39 |
| 11 | Decision-making on any unsafe/ hazardous conditions will become easier using IOT. | 4.37 |
| 12 | IOT can be used in optimizing labour efficiency. | 4.25 |
| 13 | High initial costs make IoT adoption in construction safety difficult. | 4.25 |
| 14 | Small and medium-sized construction firms find IoT implementation financially unfeasible. | 4.21 |
| 15 | Manual safety audit records are not easy to handle and store on site. | 4.19 |
| 16 | Tracking all the labourers will make it easier to ensure the safety of each labourer on site. | 4.18 |
| 17 | Training sessions on safety procedures are infrequent on the construction site. | 3.87 |
| 18 | Integrating IoT with existing construction safety processes is complex | 3.70 |
| 19 | There is resistance from workers and management in adopting IoT-based safety solutions. | 3.69 |
| 20 | . Safety training does not reflect current best practices and regulations. | 3.65 |
| 21 | Management often ignores reported safety incidents. | 3.36 |
| 22 | Safety Audits do not happen regularly on the construction site. | 3.30 |
| 23 | The death of labourers can be reduced using traditional safety management methods. | 2.54 |
| 24 | . Traditional methods of safety management are the best ways to decrease unsafe conditions on construction sites. | 2.37 |

### 3.3 Relative importance index

A statistical tool called the Relative Importance Index Table is used to rank various elements according to their significance. It is frequently used in research projects, particularly in project prioritizing, safety evaluation, and construction management.

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- *High Important factors:* RII close to 5.0: According to the responders, structured safety programs and Internet of Things solutions are essential for improving building site safety.
- *Moderate Important factors:* RII between 3.5 – 4.5: Despite its perceived benefits, IoT adoption is slowed by obstacles like cost, complexity, and stakeholder reluctance.
- *Less important factors:* RII below 3.5: According to the respondents, IoT-based solutions are more effective than conventional safety management techniques.
- Uses of RII:
  - Setting priorities aids in determining the most crucial elements influencing a particular field (e.g., safety, project hazards).
  - Decision-making by prioritizing factors.
  - Assists in identifying areas that require immediate attention.
  - The RII chart emphasizes how important IoT technology is for enhancing construction safety.
  - Cost, reluctance to adapt, and complexity are major obstacles.
  - Relying solely on conventional safety management techniques is the last strategy.

### 3.4 Reliability analysis

From the software of IBM – SPSS, a reliability analysis test was conducted for the questionnaire survey done and the alpha value found is 0.76 which is considered good.

**Table 4: Case Processing Summary**

| | | N | % |
|---|---|---|---|
| Cases | Valid | 84 | 100.0 |
| | Excluded | 0 | .0 |
| | Total | 84 | 100.0 |

**Table 5: Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .760 | 19 |

From the software of IBM – SPSS, a reliability analysis test was conducted for the questionnaire survey done and the alpha value found is 0.76 which is considered good. The supposed alpha value range should be between 0.7-1 to be considered. As the test conducted and the result obtained is consistent as the range of 0.7-0.8 is minimum acceptable value.

*The formula to calculate Cronbach's Alpha:*

where, N = number of items

$\overline{c}$ = mean covariance between items.

$\overline{v}$ = mean item variance.

**Table 6: Reliability Analysis**

| Case Processing | Values |
|---|---|
| Total cases | 84 |
| Valid cases | 84 |
| Excluded cases | 0 |
| Alpha Value | 0.760 |
| Number of items in case | 19 |

- Due to inadequate training, auditing, and record-keeping, traditional safety techniques are regarded as ineffectual.
- IoT is viewed as a useful substitute for decision-making, hazard detection, and safety tracking.
- Two of the biggest obstacles to IoT adoption are high costs and a lack of technical expertise.
- For implementation to be successful, additional training and government backing are required.

**Table 7: One-sample t Test**

| | Test Value = 84 | | | | | | |
|---|---|---|---|---|---|---|---|
| | T | df | Significance | | Mean Difference | 95% Confidence Interval of the Difference | |
| | | | One-Sided p | Two-Sided p | | Lower | Upper |
| Training sessions on safety procedures are infrequent on the construction site. | -715.035 | 83 | <.001 | <.001 | -80.131 | -80.35 | -79.91 |
| Safety Audits do not happen regularly on the construction site. | -796.584 | 83 | <.001 | <.001 | -80.702 | -80.90 | -80.50 |
| Traditional methods of safety management are the best ways to decrease unsafe conditions on construction sites. | -553.658 | 83 | <.001 | <.001 | -81.631 | -81.92 | -81.34 |
| Safety training does not reflect current best practices and regulations. | -648.591 | 83 | <.001 | <.001 | -80.345 | -80.59 | -80.10 |
| Management often ignores reported safety incidents. | -765.940 | 83 | <.001 | <.001 | -80.643 | -80.85 | -80.43 |
| The death of labourers can be reduced using traditional safety management methods. | -505.749 | 83 | <.001 | <.001 | -81.464 | -81.78 | -81.14 |
| A safety induction program is mandated for labourers. | -1101.394 | 83 | <.001 | <.001 | -79.405 | -79.55 | -79.26 |
| Manual safety audit records are not easy to handle and store on site. | -714.649 | 83 | <.001 | <.001 | -79.810 | -80.03 | -79.59 |
| IOT can become a modern construction safety strategy | -1170.526 | 83 | <.001 | <.001 | -79.595 | -79.73 | -79.46 |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Using IOT tools like Wearable Safety Devices, Smart Barrier Systems, etc. can help to track each labourer's activity on site | -1256.893 | 83 | <.001 | <.001 | -79.381 | -79.51 | -79.26 |
| Tracking all the labourers will make it easier to ensure the safety of each labourer on site. | -888.099 | 83 | <.001 | <.001 | -79.821 | -80.00 | -79.64 |
| Warning and alarm systems for any hazardous and unsafe conditions can be implemented on-site using IoT. | -1096.692 | 83 | <.001 | <.001 | -79.429 | -79.57 | -79.28 |
| The work of a safety assistant or safety manager on site will become easier by using IOT applications to automate the manual tasks. | -1077.792 | 83 | <.001 | <.001 | -79.607 | -79.75 | -79.46 |
| IOT can be used in optimizing labour efficiency. | -908.281 | 83 | <.001 | <.001 | -79.750 | -79.92 | -79.58 |
| Decision-making on any unsafe/ hazardous conditions will become easier using IOT. | -1057.146 | 83 | <.001 | <.001 | -79.631 | -79.78 | -79.48 |
| Cameras and IOT sensors can be placed around construction sites to detect unsafe conditions. | -1162.083 | 83 | <.001 | <.001 | -79.429 | -79.56 | -79.29 |
| There is resistance from workers and management in adopting IoT-based safety solutions. | -880.867 | 83 | <.001 | <.001 | -80.310 | -80.49 | -80.13 |
| High initial costs make IoT adoption in construction safety difficult. | -1056.187 | 83 | <.001 | <.001 | -79.750 | -79.90 | -79.60 |
| Integrating IoT with existing construction safety processes is complex. | -815.714 | 83 | <.001 | <.001 | -80.298 | -80.49 | -80.10 |
| Small and medium-sized construction firms find IoT implementation financially unfeasible. | -922.585 | 83 | <.001 | <.001 | -79.786 | -79.96 | -79.61 |
| Government and industry stakeholders support is required for IoT implementation. | -1122.408 | 83 | <.001 | <.001 | -79.512 | -79.65 | -79.37 |
| More training programs should be conducted to educate management employees and workers about IoT integrated safety systems. | -1234.399 | 83 | <.001 | <.001 | -79.464 | -79.59 | -79.34 |
| IoT safety devices could be designed more user-friendly for construction workers. | -1233.314 | 83 | <.001 | <.001 | -79.476 | -79.60 | -79.35 |
| Lack of technical knowledge among workers is a major barrier to implementing IoT. | -1094.777 | 83 | <.001 | <.001 | -79.548 | -79.69 | -79.40 |

### 3.5 Descriptive statistical analysis of data

The survey results assessing traditional safety methods in construction are included in this sheet. A Likert scale (1–5) is used in the responses to gauge respondents' agreement with various claims including safety measures, audits, and training. Each question received ratings

from 85 respondents. Areas where respondents agree or strongly agree with statements are shown by higher mean ratings. Areas where conventional approaches can be viewed as ineffectual are highlighted by lower mean scores.

*Most Agreed Statement:*

- "Safety induction program is mandated for laborers."
- According to this, safety induction programs are a tried-and-true method in conventional safety management.
- Most Disagreed Statement (Mean = 2.36, Mode = 1):
- "Traditional methods of safety management are the best ways to decrease unsafe conditions on construction sites."
- This implies that many respondents do not entirely trust conventional approaches to enhancing safety. According to the research, standard safety measures are not thought to be very successful in averting dangerous situations or fatalities, although having certain advantages (such as induction programs). Improvements are required in the areas of management accountability, training updates, and improved record-keeping

*Section 2: Using IoT application for safety and health monitoring*

Survey results on IoT-based safety techniques in construction are included in this sheet. A Likert scale (1–5) is used in the responses to gauge respondents' agreement with various claims on the efficacy of IoT.

- High mean scores → Show a high level of agreement with the advantages of IoT.
- Low Mean Scores → Indicate scepticism or reluctance to IoT adoption.
- Standard Deviation → Indicates the consistency or division of ideas.
- Most Agreed Statement (Highest Mean & Mode = 5):
  - "IoT can improve construction safety."
  - It shows a strong belief in the potential of IoT to improve safety protocols.
- Most Disagreed Statement (Lowest Mean & Mode = 2-3):
  - "IoT can optimize labor efficiency."
  - Raises doubts about the direct effect of IoT on employee productivity.

Consistently high ratings for the use of cameras and wearable safety devices for monitoring showed broad acceptance. Ratings for safety assistant job assistance and labour efficiency optimisation with IoT were more inconsistent, indicating ambiguity in practical implementation.

## 4.0 Conclusion

This study examines how IoT technology can enhance health and safety management on construction sites. Findings indicate that IoT-based solutions enable automatic safety compliance tracking, real-time monitoring, and data-driven decision-making. By integrating sensors, RFID, and IoT gateways, construction firms can improve worker safety, reduce

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accidents, and streamline safety procedures. Cost analysis reveals that IoT deployment offers significant long-term savings compared to manual safety management. Despite these benefits, widespread adoption faces challenges such as high initial costs, integration difficulties, and worker resistance. Cybersecurity risks and data privacy concerns must be addressed to prevent unauthorized access. The study highlights the need for industry-wide standards and regulations for seamless IoT implementation.

While IoT can transform construction safety, further research is required to address scalability, enhance security, and develop user-friendly systems. Future studies should focus on pilot testing and real-world applications to evaluate long-term effectiveness. Overcoming these challenges will enable IoT to reduce fatalities, improve safety, and enhance industry productivity. IoT-based safety management in construction offers many benefits, but several challenges hinder its adoption. High upfront costs for sensors, RFID tags, and cloud infrastructure pose financial barriers. Resistance from workers and management, limited internet access at remote sites, and the need for ongoing technical expertise further slow implementation. Concerns over surveillance and lack of familiarity also impact worker acceptance. Effective training programs are essential to ensure proper use. Additionally, IoT solutions must be user-friendly to encourage adoption. Overcoming these organizational, financial, technical, and regulatory challenges is crucial to maximizing IoT's potential in construction safety.

### 4.1 Recommendation

The investigation suggests that the following steps could enhance conventional safety procedures:

- A rise in Frequent Safety Audits: The modest level of agreement (Mean = 3.30) with the audits indicates that their frequency or enforcement needs to be improved.
- Revise Programs for Safety Training:
  - According to respondents (Mean = 3.65), safety training is out of date.
  - Effectiveness can be increased by utilizing IoT-based training, digital learning resources, and real-time case studies.
  - 3. Enhance Management Accountability & Incident Reporting:
  - There is room for improvement in the way management handles reported events (Mean = 3.36).
  - Putting in place automated reporting methods could improve openness and stop safety issues from being ignored.
  - 4. Improve Safety Audit Data Management.
  - It is believed that keeping audit records by hand is inefficient (Mean = 4.19).
  - Safety record digitization may improve usefulness and accessibility.
  - To boost IoT-based safety solutions' uptake and acceptance.
- Increase Awareness & Training: Since tracking and monitoring are generally accepted, training employees more about AI-based decision-making helps increase acceptance.

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