Study on Equipment Safety in Construction Management in & around Hyderabad

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***Abstract*— The construction industry continues to face a high incidence of equipment-related accidents, which result in considerable human, financial, and legal repercussions. Ensuring equipment safety is a critical component of effective construction management, as such incidents not only endanger lives but also contribute to costly delays, liability issues, and damage to a company's reputation.**

This research explores equipment safety within construction management by identifying major hazards, contributing risk factors, and effective safety measures. A mixed-methods approach was adopted, incorporating survey responses from construction professionals and in-depth case studies of equipment-related incidents. The findings emphasize the crucial role of regular equipment maintenance, comprehensive operator training, and adherence to safety protocols in mitigating accidents. Additionally, the study identifies areas that require further attention, such as the enforcement of stricter safety regulations, the cultivation of a strong safety culture, and the integration of innovative technologies.

The results offer practical recommendations for construction managers, regulatory bodies, and industry stakeholders aiming to improve equipment safety and foster safer job sites. A key takeaway is the importance of embedding a proactive safety culture within construction teams to ensure compliance with safety standards and raise awareness of safe practices. By tackling these essential aspects, this study contributes to the broader effort of enhancing safety management in construction, supporting both industry growth and the well-being of its workforce. Overall, the research consolidates insights from multiple sources to highlight persistent challenges and emerging solutions in equipment safety across the construction sector.

Keywords: Equipment safety, construction management, hazards, mixed-methods approach.

I. INTRODUCTION

The construction sector plays a pivotal role in urban development and economic growth, particularly in fast-growing cities such as Hyderabad. As construction activities increase, the use of heavy equipment has become essential for improving efficiency and meeting tight project deadlines. However, this reliance on machinery also introduces significant safety risks, making equipment-related accidents a major concern in construction management.

In the Hyderabad region, where infrastructure projects and urban expansion are accelerating, safety incidents involving equipment have become more frequent. These accidents often lead to serious injuries, fatalities, financial losses, and reputational damage for construction firms. Additionally, they contribute to project delays and potential legal disputes. While safety standards exist at national and regional levels, their enforcement and implementation on-site often remain inconsistent.

A major contributor to such accidents is the lack of adequate training for equipment operators, insufficient maintenance practices, and limited awareness of safety protocols among workers. Addressing these gaps is essential to improving workplace safety and ensuring the smooth execution of construction projects. Despite the importance of this issue, there is limited empirical research focusing on equipment safety in the specific context of Hyderabad's construction industry.

This study aims to explore the state of equipment safety practices in and around Hyderabad, identifying prevalent hazards, risk factors, and current mitigation efforts. By combining survey data with case study analysis, the research seeks to provide practical recommendations to enhance safety outcomes. The findings are expected to support construction managers, site supervisors, and policy makers in strengthening safety protocols and promoting a culture of safety across construction sites in the region.

II-OBJECTIVE

The objective of this study is to investigate the current state of equipment safety in construction management:

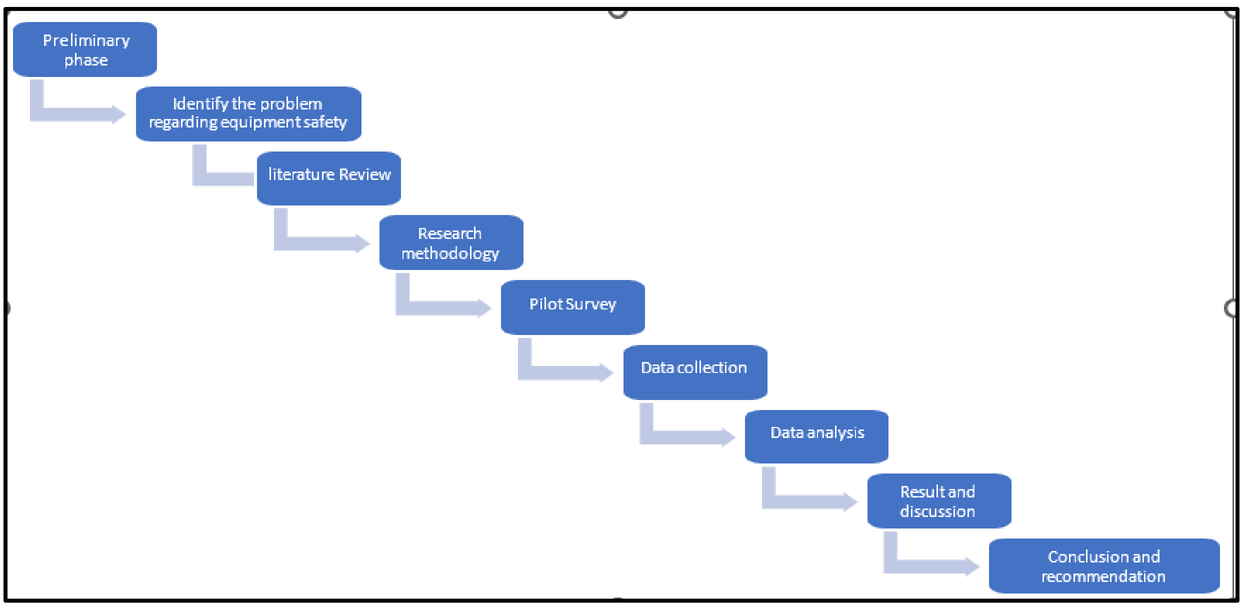
1.To Identify the most common equipment safety factors in various construction projects.

2.To find out the critical factors using relative important index (RII) in equipment safety factors.

3.To recognize most important factors by using spss (factor analysis method).

4. To suggest various ways to reduce the accidents in construction projects by equipment safety measures.

III. METHODOLOGY



3.1. Data Collection:

Data collection is a crucial phase in any study, particularly in the context of equipment safety in construction management. To gain a comprehensive understanding of the current safety practices, challenges, and outcomes, it is necessary to gather data from multiple sources using various methodologies. This section outlines the data collection process, including the types of data to be collected, the methods used, and the rationale behind these choices. A Questionnaire is a method of data collection through different means of interview such as telephone, email, personal interview, etc. for this study, a questionnaire is a list of questions prepared through which the respondent must respond.

A well design questionnaire will encourage responders to provide accurate and full information. A questionnaire is designed using google forms which is then distributed among different contractors, civil engineers site engineers, etc. for gathering information. For designing questionnaire, a five likert scale.

3.2.Factor Identification:

Analyze data and identify factors contributing to equipment safety issues, such as:
Human factors (physical limitations, training, decision making)
Equipment factors (maintenance, inspection, operator interface)
Environmental factors (lightening and visibility, site conditions, temperature and climate)
Organizational factors (safety culture, policies and procedures, training and development)

The top 10 factors affecting equipment safety in construction project are:

Table-1

S. No.	Top factors	RII	Rank
1	Operator training	0.845	1
2	Lack of routine inspection and maintenance	0.8441	2
3	Lightening and visibility	0.832	3
4	Improper training	0.8316	4
5	Overloading	0.83	5
6	Experience level	0.824	6
7	Lack of safety culture	0.82	7
8	Mechanical failure	0.794	8
9	Poor risk assessment	0.7683	9
10	Miss communication	0.731	10

3.3. Reliability Analysis:

Reliability is a factor when variables are constructed from the summed measures and utilized as predictor components in objective models. It is crucial to determine whether the same set of items would elicit the same responses if the queries were reworked and resubmitted to the same respondents. The researcher declares these test instrument-derived variables as reliable only when they consistently produce consistent and dependable responses during the test administration.

Table2

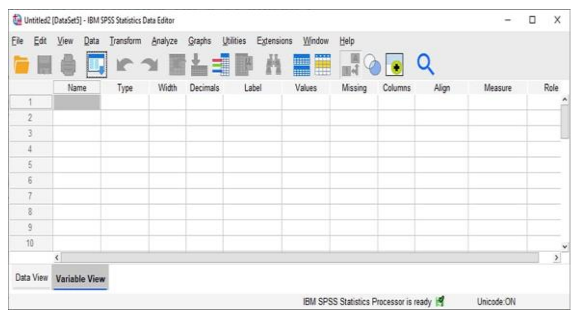
Reliability Statistics (All factors)	
Cronbach's Alpha	N of Items
0.842	32

Table No. 3 represent Cornbach's Alpha internal consistency

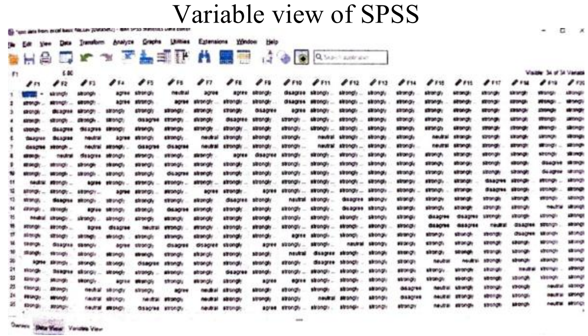
Cronbach's alpha	Internal consistency
0.8> a >0.7	Acceptable
0.7> a>0.6	Questionable
0.6> a>0.5	Poor
0.5 > a	Unacceptable
a>0.9	Excellent
0.9 > a>0.8	Good

3.4. SPSS

SPSS (Statistical Package for the Social Sciences) is one of the most widely used statistical software packages in the world. Originally developed by IBM, SPSS is designed for data management, statistical analysis, and reporting. It has become an essential tool in various fields such as social sciences, health research, market research, education, and government, where data analysis is crucial for decision-making. SPSS offers a user-friendly interface combined with powerful analytical tools, making it accessible to both beginners and advanced users. Its versatility in handling large datasets, performing complex statistical tests, and generating detailed reports makes it a preferred choice for researchers and analysts. SPSS supports a wide range of statistical procedures, from basic descriptive statistics to complex multivariate analyses, which helps users extract meaningful insights from their data.



Variable view of SPSS



Interface of SPSS

3.5-Factor Analysis

Factor analysis is a statistical technique that uses statistics to investigate the relationships between observed variables and condense them into a more manageable set of unobserved factors. It is frequently implemented in a variety of domains, including economics, social sciences, psychology, and market research. Factor analysis aims to identify latent patterns or dimensions that explain the associations or variations among a collection of observed variables. Factor analysis initiates with the collection of data on a set of variables. These factors can be interconnected, for instance, through a series of survey inquiries that are designed to evaluate fundamental concepts such as IQ, personality traits, or customer satisfaction.

KMO and Bartlett's Test

The selected variables are tested and the outcome of the given variable is shown in (table 4) the result of KMO and Bartlett's Test with a value of 0.824. This says that data is correct for Factor Analysis

Table-4

KMO and Bartlett's Test		
Kaiser- Meyer-Olkin Measure of sampling Adequacy.		0.824
Bartlett's test of Sphericity	Approx. chi-Square	4196.624
	Df	0.485
	Sig.	.000

3.6 Interpretation of Communalities

The table of communalities provides insight into how much of the variance in each item can be explained by the extracted factors. Here's a detailed interpretation:

Initial Communalities:

Initial communalities are all 1.000 because this represents the total variance for each item before any extraction. Each item has its total variance set to 1, indicating that initially, we assume each item accounts for 100% of its variance.

Extraction Communalities:

Extraction communalities represent the proportion of variance in each item that is accounted for by the extracted factors after the analysis. Higher values indicate that a larger portion of the item's variance is captured by the factor solution.

Table No. 5 Components Analysis

Total Variance Explained

sr.no	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of squa Loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	13.235	37.835	47.835	13.235	37.835	47.875	7.670	22.632	38.63
2	6.664	18.294	66.245	6.765	29.478	67.240	8.224	23.198	48.69
3	3.606	9.545	56.597	3.655	10.654	65.883	6.304	17.680	55.13
4	2.68	8.834	73.875	2.958	9.256	75.873	5.176	12.489	75.83
5	.764	2.245							
6	.872	.865							
7	.686	.782							
8	.455	.567							
9	.492	.353							
10	.462	.255							
11	.376	.793							
12	.313	.441							
13	.367	.079							
14	.379	.974							
15	.356	.891							
16	.271	.894							
17	.257	.736							
18	.235	.689							
19	.231	.653							
20	.187	.653							
21	.156	.538							
22	.152	.482							
23	.174	.465							
24	.144	.401							
25	.176	.308							
26	.125	.310							
27	.079	.384							
28	.070	.267							
29	.054	.287							
30	.053	.175							
31	.050	.161.							
32	.046	.135	100.00						

3.7.Component Matrix

The component matrix shows the loadings of each item on the extracted components. This matrix helps to understand how each item contributes to the different components. Here's a detailed interpretation

Table No. 6

Component matrix				
	Component			
	1	2	3	4
O1-inadequate supervision and site management	.156	.548	.476	342
O2-poor planning and coordination	.152	.351	308	.381
O3-lack of safety culture	.174	.239	.448	.079
O4-improper work scheduling	.144	.545	.653	.163
O5-insufficient budget allocation	.176	.534	382	.248
O6-poor risk assessment	.125	.464	.425	.027
O7-lack of emergency	.119	.501	306	.089
O8- Improper training	.107	.451	.541	.047
E1- high wing speed	.379	-.008	-.408	-.022
E2- Lightening and visibility	.356	.135	-.221	.507
E3-ground stability	.271	.0281	-.324	.541
E4- dust or pullation	.257	.103	.451	.398
E5-limited site space	.235	.128	-.389	.369

E6- noise pollution	.231	.189	-.390	.366
E7-temperature extreme	.187	- .0214	-.387	.302
H1- Operator Training	.764	.786	.374	.356
H2- Experience level	.872	.799	.463	.083
H3- Fatigue	.686	.684	.382	.000
H4- Stress and Pressure	.455	.672	.422	.068
H5- Decision making	.492	.664	.361	-.046
H6-miss communication	.462	.680	.389	.028
H7-negligence	.376	.715	.368	.026
H8-Physical limitations	.313	.781	.114	.064
H9-compliance	.367	.154	.558	-.029
Eq2- lack of routine inspection And maintenance	.100	.032	-.536	.178
Eq3- use of improper equipment	.090	-.054	-.289	-.344
Eq4- poor lubrication and cleaning	.085	-.030	-.167	.-436
Eq5- Minor failure	0.80	0.10	-152	-.446
Eq6- Overloading	0.72	-.067	.-.178	-.413
Eq7-Outdated technologies	0.69	-.088	-.259	-.477
Eq8- Rope or hook were	0.66	-.079	-.121	-.499

The Principal Component Analysis (PCA) conducted in this study extracted four key components that represent distinct categories of factors influencing safety performance in construction projects. The interpretation of the component matrix provides valuable insights into the underlying structure of the collected data and helps group related variables for effective safety management strategies.

The factor analysis successfully identifies four principal domains affecting safety in construction: human behaviour, organizational management, environmental conditions, and equipment reliability. These insights:

a) Highlight the multi-dimensional nature of safety challenges.

b) Support the need for integrated safety strategies that combine training, planning, site design, and technology upgrades.

c) Serve as a basis for developing targeted interventions and improving safety performance indicators in future projects.

By focusing on these key components, project managers and safety officers can make informed decisions to reduce risks and enhance overall construction site safety.

IV. RESULTS

Using the Relative Importance Index (RII), critical factors affecting equipment safety were identified and ranked within four major categories: Human, Environmental, Organizational, and Equipment Factors.

Organizational Factors:

•Improper Training (RII: 0.8316) – *Rank 1*: Most critical factor, indicating a direct link between lack of training and increased equipment-related incidents.

•Lack of Safety Culture (RII: 0.82) – *Rank 2*: Demonstrates a systemic issue where safety is not prioritized across organizational levels.

•Poor Planning & Coordination (RII: 0.80) – *Rank 3*: Reflects challenges in execution due to lack of foresight and logistical preparedness.

•Other Notable Factors: Inadequate site supervision (RII: 0.7816), poor risk assessment (0.76833), and improper scheduling (0.752) also pose considerable threats to operational safety.

Environmental Factors*:*

•Lightning and Visibility (E2: RII 0.832) and High Wind Speed (E1: RII 0.8033) were among the top-ranked, showing how unpredictable environmental conditions contribute to unsafe work environments.

Equipment Factors*:*

•Lack of Routine Inspection (Eq2: RII 0.8441) and Overloading (Eq6: RII 0.83) were highlighted as major technical issues leading to mechanical failures and safety breaches.

Human Factors*:*

- Operator Training (H1: RII 0.845) ranked highest among all categories, underscoring the need for competence in handling machinery.
- Negligence (H7) and Miscommunication (H6) also emerged as prevalent causes for equipment-related safety incidents.

Discussion

The results from the RII analysis and supporting case studies demonstrate that:

- Training Deficiency is Systemic**:** Improper training, ranked the highest, suggests that workers are often assigned tasks beyond their competency. This not only risks their lives but also affects machinery, delays timelines, and increases project costs.

- Organizational Culture Impacts Safety Directly: A weak safety culture indicates a lack of management commitment to safety practices. It creates a trickle-down effect, where even the best safety plans fail in execution due to neglect or complacency.
- Technical and Procedural Shortcomings Coexist: While faulty equipment and lack of maintenance contribute to accidents, these often stem from organizational oversights such as failure to plan inspections or enforce protocols.
- Environmental Controls are Underestimated: High RII values for environmental factors suggest that adaptive measures (like suspending crane work during high winds) are either missing or inconsistently enforced.
- Factor Interdependence: The factor analysis via SPSS shows that most incidents are rarely due to a single cause. For example, a crane accident may be due to poor planning, untrained operators, bad weather, and outdated equipment—all interacting simultaneously.
- Stakeholder Involvement is Inadequate: Data suggests that workers and site supervisors are not adequately involved in safety planning, and most safety policies remain on paper without on-ground implementation.

V. CONCLUSION

This study aimed to evaluate the critical factors affecting equipment safety in construction management and to propose effective measures for improving safety standards. Through a comprehensive analysis involving literature review, field surveys, site observations, and statistical analysis using SPSS and the Relative Importance Index (RII), the research has successfully identified and prioritized key safety concerns.

The findings highlight that improper training, lack of a safety culture, poor planning, and inadequate supervision are the most pressing organizational issues that contribute to equipment-related accidents. Additionally, human factors such as operator error, negligence, and communication gaps, along with environmental challenges and equipment-related failures, further aggravate the risks on construction sites.

The study successfully identified 32 critical factors affecting equipment safety, categorized into four major groups: Organizational, Environmental, Human, and Equipment-related factors. Through surveys and site observations, it was found that improper training, lack of safety culture, and mechanical failure are among the most frequently cited and impactful factors in equipment-related safety issues.

The RII analysis revealed that:

- Improper training (RII = 0.8316)
- Lack of safety culture (RII = 0.82)
- Poor planning and coordination (RII=0.80)
- were the top-ranked factors. These findings demonstrate that organizational deficiencies play a major role in equipment-related accidents and should be a key focus for safety interventions.

Factor analysis using SPSS validated the RII findings and grouped the 32 factors into four significant components. This analysis confirmed the construct validity of the categorization and reinforced the prominence of organizational and human factors as primary influencers on safety outcomes. The KMO test and Bartlett's test confirmed the data set's suitability for factor analysis.

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