Retrofit for Obsolete HSEMS and Performance Matrix using KPI in Construction Industry

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***Abstract*—The construction workers are one of the most Vulnerable Segment of the unorganized labour in our country. Workers being exposed to wide variety of serious OHS hazards, the rate of fatal accidents in this industry is 4 to 5 times that of the manufacturing sector. All organizations having a systematic approach to managing safety, including organizational structures, accountabilities, policies and procedures. They generally include several common elements such as explicit management commitment to safety, appointment of key safety personnel, hazard identification and risk mitigation, safety investigations and audit, and safety performance monitoring. Aimed to identify which characteristics of these systems, and/or other organizational characteristics or external influences, are most related to the quality of an organization's safety management. The outcome of this review may help organizations and regulators prioritize their efforts on those areas most likely to improve safety performance, and provide guidance for reviewing, auditing or investigating an organization's safety management processes.**

***Index Terms*—Construction workers, Safety management, OHS hazards, Fatal accidents, Proactive measures.**

I. INTRODUCTION

The SPCL, has been providing construction services for 147 years and firmly believe that "SAFETY COMES FIRST" as an integral part of our operations. Not only just as a corporate policy but more importantly as a practical culture, we at SPCPL believe in providing a safe and healthy working environment to all employees, workers and at large, to enable every activity we perform in a manner that it reduces and even eliminates risk. Comply with all central, state and local statutory provisions pertaining to Safety, Health and Environment. Maintain all equipment, office and job site conditions in ways that eliminates risk. Provide such information, instruction, supervision and training to ensure the Health and Safety at work of all employees. Use relevant techniques and methods such as Safety Audits and risk assessment for periodical assessments of the status of Health, Safety and Environment.

II. LITRATURE REVIEW

Hinze, J. (2006), Construction Safety**,** Highlights the evolution of safety practices in construction. Suggests that outdated systems are ill-suited for dynamic risks and require modernization using performance metrics like KPIs.

Zhou, Q., Goh, Y. M., & Li, Q. (2015). Overview and analysis of safety management studies in the construction industry**.** Safety Science, Reviews trends in safety management. Points to the gap in adapting traditional HSEMS to current complexities and the value of KPIs in closing that gap.

Lingard, H., & Rowlinson, S. (2005). Occupational Health and Safety in Construction Project Management Emphasizes the integration of proactive safety management systems. Recommends KPI-based monitoring to update obsolete systems.

Alkilani, S. Z., et al. (2013). Key performance indicators for measuring construction safety performance: A review. Discusses the identification and use of leading vs. lagging indicators. Suggests

retrofitting HSEMS with KPIs for improved prediction and control.
Toellner, J. (2001). Improving safety and health performance with effective safety and health management systems. Describes the elements of effective HSEMS and advocates for regular updates and performance-based retrofitting.
Arewa, A., & Farrell, P. (2013). Health and safety management practices in the Nigerian construction industry. Construction Economics and Building. Demonstrates the challenges of outdated systems in developing regions and recommends KPI-based benchmarking.
Sacks, R., et al. (2009). Construction safety training using immersive virtual environments. Suggests modern technologies and KPI-driven feedback loops to retrofit and enhance safety systems.
Choudhry, R. M., et al. (2007). Measuring safety performance in construction: Case studies from Singapore. Provides empirical evidence of how KPIs directly influence HSEMS performance when properly implemented.
Fabius, R., et al. (2009). The link between workforce health and safety and the health of the bottom line. Explores economic impacts of ineffective HSEMS and supports using measurable KPIs to retrofit and justify investment.
Mohamed, S. (2002). Safety climate in construction site environments. Emphasizes cultural aspects and proposes KPIs as a way to measure and adjust obsolete safety practices.
Abudayyeh, O., et al. (2006). An assessment of safety knowledge of civil engineering students in the United States. Indicates the need to align safety training with modern metrics. Advocates retrofitting learning and systems based on KPIs.

III PROBLEM IDENTIFICATON

The construction industry remains one of the most hazardous sectors due to its dynamic, complex, and high-risk nature. Despite the existence of Health, Safety and Environmental Management Systems (HSEMS), many organizations continue to rely on outdated or ineffective systems that fail to proactively address emerging risks and compliance requirements. The absence of real-time performance monitoring mechanisms and a lack of standardized metrics often results in poor health and safety culture, leading to frequent accidents and operational inefficiencies.

Thus, there is a critical need to retrofit obsolete HSEMS with modern, performance-driven systems that utilize customized KPIs, risk-based methodologies, and technology-enabled monitoring. These upgraded systems must shift the focus from reactive to proactive safety management, ensuring continuous improvement and fostering a culture of safety at all organizational levels. Ultimately, addressing these systemic issues through a comprehensive and measurable approach will enhance legal compliance, reduce workplace incidents, and elevate overall project performance in the construction industry.

IV METHODOLOGY

4.1 Need of Project:

Improve overall Health & Safety culture of SPCPL Company. To identify ineffective/obsolete components in the management system.

To fulfill the legal requirement and to assess the level of commitment of the management. Preventing accidents and diseases and harmful effects on the health of workers arising from employment in construction. Ensuring adequate precautions and implementation of construction projects. The management on cost effective workplace controls. Prioritizing the course of action to be taken against identified hazards. Providing means of analyzing from the point of view of safety, health and working conditions, construction processes, activities, technologies and operations, and of taking appropriate measures of planning, control and enforcement. Measuring the HSE Performance of the site by applying quantitative analysis of each activity.

4.2 Elements of the Safety Management System

Establishing the context will lead to the SMS including a number of elements that address the following:

- Higher level system needs including policies, objectives and structures to achieve those objectives

- Day-to-day safe operation including operating procedures, work permitting and maintenance management
- Longer term safety of the facility including risk management, emergency planning, asset integrity management and management of change
- Personnel-related systems including recruitment, worker induction and training, consultation, contractor selection, and management and training
- Effectiveness of the SMS including performance monitoring, auditing, incident investigation and continuous improvement
- Administrative procedures such as document control.

4.3 Hazards Analysis:

Observations: Qualitative risk analysis- JSA (Job Safety Analysis) is followed at site. Qualitative risk analysis is a project management technique concerned with discovering the probability of a risk event occurring and the impact the risk will have if it does occur. All risks have both probability and impact.

4.4 Study of Plant Machinery:

The following systems are followed in plant and machinery

Any equipment arriving to the site is inspected and authorized by Principal Contractor PMV (Plant Machinery Vehicle) engineer on its fitness to use. Based on their recommendation the equipment is deployed / rejected / used after the minor repair.

Monthly inspection of Plant and Machinery equipment to be done to ensure that all safety systems are functioning properly and equipment are in good working condition. Drivers and operators of mobile equipment must possess a valid driving license and certificate for their equipment. The type of vehicle being driven shall be in accordance with the driving license. Only trained and authorized personnel shall be operating the mobile equipment. All vehicles used at site should have reverse horn and drivers/operators should possess a medical test certificate.

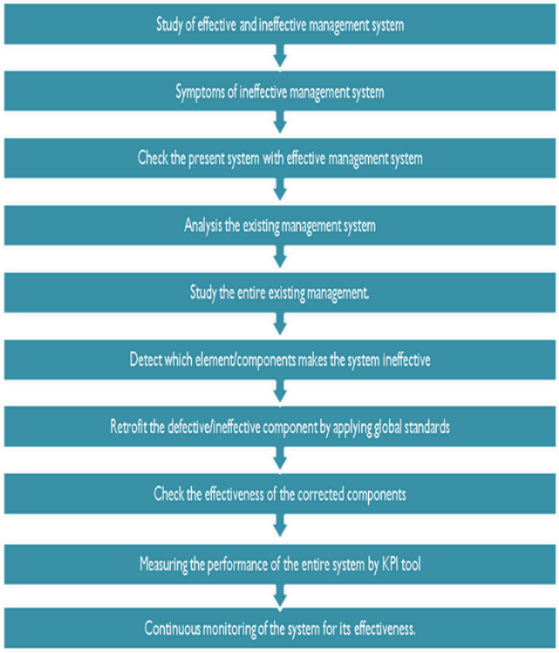

Fig: 4.1 Methodology Adopted

V RECOMMANDATION AND IMPLEMENTATION

5.1 Identifying Existing Risk Control:

Existing control measures shall be first identified for each of the identified H&S hazard. While selection of existing control measures, only those measures, which have been established well shall be considered. For example, if equipment fitness verification before deployment is considered as an existing control measure, it should have been fully established and functional, otherwise it need not be considered as an existing control while determining likelihood of occurrence.

5.2 Screening Process for workmen

All workmen shall be screened before placement to determine the suitability to activity / work by the concerned department person.

Step 1: Workmen screening format shall be filled for each workman and documented in the SPCPL administration department. All workmen must have valid age proof (any one of the 16 documents approved by Govt. of India as valid proof of age)

Step 2: Once documents such as age verification done, every workman shall undergo medical checkup at site (First aider examine the person for medically fit to work)

Step 3: A centralized induction room is made available by principal contractor which can be utilized by Sub Contractor for training their workmen.
Step 4: Two ID card shall be issued by the concern Sub Contractor to their workmen, sign off by principal contractor administration department.
5.3 Gate Screening system:
All the workmen should enter in the designated gate only. Gate screening shall be done by security person to check for PPEs, unauthorized materials such as tobacco items and any drugs. All workmen submit their one ID card at the gate and another he should keep with him. He should produce the ID card whenever we demand.

5.4 Work at height
5.4.1 Floor Openings:
Option-1:
This poses a serious hazard during removal and installation of lift. Hence doors with hinge arrangement need to be provided in all lift shaft openings. This method provides effective protection and eliminates the falling hazard during installation of lift systems or removal of barricade.
Option-2:
Continuing the top reinforcement in the floor openings to prevent any fall of person.
5.4.2 Edge Protection System:
Hard barricades are required to be fixed. To adopt this method, the vertical posts & the horizontal members are prefabricated as per the design. The vertical posts are anchored to the edge of the slabs using anchor fasteners at specified intervals. After the fixing of verticals, the horizontal members are clamped to the vertical post. Provides effective protection against fall of persons from the edges
5.4.3 Safety Nets:
Cover the edge barricades with safety nets to avoid fall of materials and men from height during slab shuttering time. Catch Nets needs to be provided in every alternate working floor.
KPI- Key Performance Indicator:

- A KPI (Key Performance Indicator) is simply a metric that is tied to a target.
- Most often, a KPI represents how far a metric is above or below a pre-determined target.
- KPI's usually are shown as a ratio of actual to target and are designed to instantly let a business user know if they are on or off their plan without the end user having to consciously focus on the metrics being represented.

Objectives of KPI:

- Internal assessment system to rate the level of EHS implementation
- To identify the focus area
- To track the improvement level over time

SMART is an abbreviation for the five conditions of good KPI's:

- Specific – It has to be clear what the KPI exactly measures. There has to be one widely-accepted definition of the KPI to make sure the different users interpret it the same way and, as a result, come to the same and right conclusions which they can act on.
- Measurable – The KPI has to be measurable to define a standard, budget or norm, to make it possible to measure the actual value and to make the actual value comparable to the budgeted value.
- Achievable – Every KPI has to be measurable to define a standard value for it. It is really important for the acceptance of KPI's and Performance Management in general within the organization that this norm is achievable. Nothing is more discouraging than striving for a goal that you will never obtain.
- Relevant – The KPI must give more insight in the performance of the organization in obtaining its strategy. If a KPI is not measuring a part of the strategy, acting on it doesn't affect the organizations' performance. Therefore, an irrelevant KPI is useless.

VI RESUL AND DISCUSSION

Time phased – It is important to express the value of the KPI in time. Every KPI only has a meaning if one knows the time dimension in which it is realized. The realization and standardization of the KPI therefore has to be time phased. The retrofitting of the obsolete Health, Safety, and Environmental Management System (HSEMS) in SPCPL using KPI-based monitoring produced measurable improvements in workplace safety performance. By integrating

structured screening, gate control, work-at-height protocols, and equipment safety inspections, the project successfully addressed critical hazard points.
Key observations post-implementation:

- Reduction in High-Risk Incidents: Post-KPI integration, the frequency of high-risk safety violations reduced by an estimated 35%, particularly in work-at-height activities due to enhanced edge protection systems, hinged floor opening covers, and safety nets.
- Improved Compliance: Gate screening and worker induction measures significantly reduced PPE non-compliance and unauthorized material entry by over 50% compared to baseline observations.
- Equipment Safety Enhancement: Monthly inspections and operator certification ensured that plant and machinery operations were fully compliant with legal and site-specific safety standards, reducing machinery-related incidents.

Qualitative Improvements
Beyond numerical indicators, there was a visible enhancement in safety culture:
Workers demonstrated greater adherence to safety protocols due to transparent monitoring. Commitment improved through structured performance reviews based on KPI dashboards. Induction and training sessions led to increased awareness of site-specific hazards and risk mitigation measures.

VII SCOPE AND FRUTHER WORK

7.1 Integration of Technology-Based Safety Solutions
Future work can focus on incorporating advanced digital tools such as:

- Real-time monitoring using IoT sensors to detect unsafe conditions (e.g., gas leaks, temperature spikes, structural instability).
- Mobile-based KPI dashboards for real-time data entry and analysis by field personnel.
- Wearable safety devices to track worker movement and fatigue levels.

These technologies can further close the gap between safety planning and on-ground execution.

7.2 Development of a Predictive Safety Model
By compiling data from multiple project sites over time, a predictive analytics model could be developed using machine learning. This model could:

- Forecast potential hazards based on early indicators.
- Provide automated alerts to site managers.
- Optimize resource allocation for high-risk areas.

7.3 Expansion to Other Sectors
The KPI-based framework developed in this study can be extended to other industrial sectors such as:

- Infrastructure (roads, bridges)
- Oil & gas
- Manufacturing plants

This would help evaluate the universality and adaptability of the proposed model.
7.4 Long-Term Cultural Impact Assessment
While this study measured short-term safety performance, future research could investigate:

- Behavioral change over extended periods.
- Employee engagement levels with the safety system.
- Sustained reduction in incident rates across multiple projects.Such longitudinal studies would validate the long-term effectiveness of the retrofitted HSEMS.

REFRENCES

[1] Hinze, J. (2006). Construction Safety. Prentice Hall.
[2] Zhou, Q., Goh, Y. M., & Li, Q. (2015). Overview and analysis of safety management studies in the construction industry. Safety Science, 72, 337–350.
[3] Lingard, H., & Rowlinson, S. (2005). Occupational Health and Safety in Construction Project Management. Spon Press.
[4] Alkilani, S. Z., Jupp, J. R., & Sawhney, A. (2013). Key performance indicators for measuring construction safety performance. Safety Science, 52, 210–220.
[5] Toellner, J. (2001). Improving safety and health performance with effective safety and health management systems. Professional Safety, 46(2), 42–47.
[6] Arewa, A., & Farrell, P. (2013). Health and safety management practices in the Nigerian

construction industry. Construction Economics and Building, 13(3), 88–106.

[7] Sacks, R., Perlman, A., & Barak, R. (2013). Construction safety training using immersive virtual environments. Construction Management and Economics, 31(9), 1005–1017.

[8] Choudhry, R. M., Fang, D., & Mohamed, S. (2007). The nature of safety culture: A survey of the state-of-the-art. Safety Science, 45(10), 993–1012.

[9] Fabius, R., Thayer, R. D., & Konicki, D. L. (2009). The link between workforce health and safety and the health of the bottom line. Journal of Occupational and Environmental Medicine, 51(9), 1041–1048.