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EFFECTIVENESS OF PERSONAL PROTECTIVE EQUIPMENT IN ENSURING CONSTRUCTION WORKER SAFETY: A STUDY OF GUJARAT'S CONSTRUCTION SECTOR

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Abstract

This Research focuses on the impact of Personal Protective Equipment (PPE) on improving occupational safety of the construction population in the small and medium-sized construction industries within the state of Gujarat. PPE observance is not constant despite the regulatory requirement and rising awareness because of discomfort, time limitation, and insufficiency of training. A questionnaire survey with face-to-face interview was administered on 398 construction workers of different job categories. The results demonstrate that, although the majority of the workers accept the protective worth of PPE, the real use of it depends on several aspects such as ergonomic restrictions, the lack of consistent employer encouragement, and the need to ensure productivity. As an extra, more than 70 percent of the employees are in favor of more strict enforcement and raise awareness, which means that workers are not afraid of instituted safety changes. In trying to create a more effective culture of safety within construction sites, the study is insistent on a three-pronged perceived solution combining the aspects of ergonomic design of PPEs, uniform training systems, frequent observation of workers, and encouraging safety awareness through campaigning.

Keywords: Personal Protective Equipment (PPE), Construction Safety, Worker Compliance, Gujarat, Occupational Health.

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1.INTRODUCTION

Construction industry has been accepted as one of the riskiest work places, and accompanied by high number of injuries, and fatalities. Safety of the workers is both a moral and legal issue in India especially in states such as Gujarat whose urban development is very rapid and therefore workers in construction sites are victims of constant activities in construction. The personal protective equipment (PPE) is the first line of the defense against numerous physical, chemical, mechanical hazards within the sites. PPE usage is also not consistent, despite the fact that its use is critical, probably due to a combination of practical, behavioral and organizational barriers.

This study examines the efficiency of PPE to protect the construction workers working in the small-and-medium scale construction sectors in Gujarat. It analyzes the real-life practices, perceived barriers and structural conditions that affect the adherence. It is by comprehending such dynamics that a safer culture can be created in construction to guard lives as well as increase productivity among the working population in that industry.

1.1 Importance of PPE in Construction Safety

Personal Protective Equipment should provide an effective shield between the workers and the hazards in the construction sites. Respiratory masks, goggles, safety boots, gloves, and helmets are designed to prohibit the most typical injuries, including (and not limited to) head damage, eye injuries, respiratory illnesses, and limb damage. Although engineering and administrative controls are designed to limit the risks, they are not that practical or adequate enough in high-paced and unpredictable construction environments. In this case, PPE is the last safeguard where it helps to mitigate the severity of injury and increase the resilience of the worker in the potentially risky activity when operating machinery, working at height, or in dust, chemical, or probably loud conditions.

Use of proper PPE besides individual protection is also very important in a legal sense. PPE is regulated through organs like the Occupational Safety and Health Administration (OSHA) and the Directorate General Factory Advice Service & Labour Institutes (DGFASLI) in India, and stipulates the requirements of employers to ensure mandatory use of PPEs. In addition to

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regulations, having visible PPE compliance promotes the safety culture, indicating that the organization is committed to worker welfare as well as establishing the norms of the behavior at the workplace.

1.2 Challenges to PPE Usage Among Construction Workers

There are various factors that limit its proper and regular use of PPE in spite of its demonstrated efficiency. At a personal scale, employees tend to state being uncomfortable, having reduced freedom of movement, experiencing heat stress, and being distracted to complete their work as the motives of not wearing PPE regularly. It is also possible that the equipment fails to encourage use due to a poor fit or design. Furthermore, PPE supply in the informal or subcontracted part of the industry might be uneven or in non-exhaustive at all, especially in smaller organizations working within the strict budget.

These problems are exacerbated by the problems in the organization. A large number of construction sites do not have any sort of well-organized safety training, follow ups or punitive measures in case of failure to comply. There is also poor or lax supervisory enforcement and safety is downgraded to speed and quantity production. Additionally, the existence of a diverse workforce nowadays that consists of a differentiated level of literacy, language barrier, cultural attitudes and so on, makes the communication process more complicated, and the unified adoption of safety norms more difficult. Such multidimensional challenges point out to the need of developing a holistic approach to realizing the effectiveness of PPE in the constructive environment of Gujarat.

1.3 Research Objectives

In an attempt to gauge the practicality of the Personal Protective Equipment (PPE) and determine elements that will determine its use among construction workers in Gujarat, the following objectives were put in place to provide direction to the research:

- To determine the use distribution as well as the perceived effectiveness of PPE by construction workers in Gujarat.
- To get valuable insights on crucial obstacles that influence the regular use of PPE including comfort, training, and employer support.

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Subject: Industrial Safety Engineering

- To suggest practical recommendations on the ways to improve adherence to PPEs and reinforce the safety culture in the construction sector.

2. REVIEW OF LITREATURE

The effective use of Personal Protective Equipment (PPE) in the construction sector has been a critical area of concern in occupational safety research, particularly in developing economies where construction activities are rapidly expanding, yet safety compliance remains inconsistent.

Acharya and Shrestha (2021) interviewed building construction workers in Nepal to learn about the use of PPE in the laboratory. They discovered that most of the workers were aware of the relevance of the PPE, but very few workers are using it as hardly required because of discomfort, unavailability, and also inadequate monitoring. They also highlighted that awareness in itself was not enough to enhance compliance; instead, effective training programs in an orderly manner, effective enforcement and regular provision were required to enhance the uptake of PPE in the workforce.

Albert, Shakantu, and Ibrahim (2021) examined the general issues that have agitated the construction performance in Nigeria through material management practices. In as much as they did not directly address the issue of the mismanagement of critical safety resources, such as PPE, the study also indirectly showed the consequences of mismanagement as well as generation of unsafe working conditions due to mismanagement of safety materials. They noted that poor planning, inaccurate inventory management, and uneconomical use of resources would most of the time create shortages of PPEs that would consequently predispose individuals to site hazards.

Ammad et al. (2021) followed a scientometric method of studying the world research topic on the use of PPE in the construction of projects. By their analysis, there was increasing interest in the subject matter within the past 2 decades, especially with regard to occupational health, avoidance of accidents and safety engineering. Although the number of published work and safety consciousness is on the increase, the study indicated that the translation of the same to site commitments is a big challenge, particularly in areas where there are poor safety cultures and less institutional reinforcement of the same.

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Ashtekar et al. (2019) explored how the Indian construction worker coped with the heat and whether specialized cooling garments help with health risks. Their research showed that when the ambient temperatures were high, there was a significant decrease in PPE compliance because the workers tended to wear fewer protective materials in order to cut the effects of heat stress. However, when the cooling garments were introduced, it had a positive effect on the thermal comfort and ensured further willingness to keep PPE on. This study emphasized the environmental issues that affect the uptake of PPEs especially in areas that are hot and humid such as India.

Elavarasan, Kamal, and Sivagamasundari (2021) reviewed in detail such factors which had an impact on PPE use in construction project. Some of the major determinants that they came up with are the workers knowledge, quality of training, enforcing by the employer, and socio-economic limitations. According to the authors, the main reasons that led to poor compliance were lack of supervision, discomfort caused by poor PPE design and inadequate legal punishment. Their results highlighted the necessity to work with an integrated framework that facilitates the behavioral, managerial, and regulatory factors to enhance the use of PPE.

3. RESEARCH METHODOLOGY

The systematic planning followed to explore the efficacy of Personal Protective Equipment (PPE) amongst the construction workers in Gujarat is presented in this Section. The quantitative and qualitative approach was combined to obtain pertinent data and to apply some significant conclusions regarding the usage pattern, difficulties, and compliance patterns under assessment concerning PPE.

3.1 Research Design

This was a descriptive research study and structured questionnaire was used as an instrument of primary data collection. This survey comprised closed and open questions in the questionnaires to obtain quantitative and qualitative data. At the forefront of the investigators were the frequencies of PPEs use, comfort, and employer support, worker attitudes and training called exposures.

Airo International Journal
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3.2 Sampling and Participants

The sample size of 398 construction employees has been drawn through stratified random sampling technique of various small and medium-sized construction companies in Gujarat in the survey. The participants of the sample were workers of different occupational titles like masons, carpenters, welders and general laborers, which covered various site conditions and different levels of exposures to risk.

3.3 Data Collection Procedure

The information was gathered using face-to-face interview in different construction sites. Such a technique made it possible to clarify the answers in real time and contributed to making data capture more accurate. There was also the possibility to watch the use of PPE in the actual place of work as the optional in-person activity offered context to the written answers.

3.4 Data Analysis Tools

Data collected was analyzed in Microsoft excel and IBM SPSS statistics. Frequencies and percentages were then obtained to describe the data using descriptive statistics. There was also the generation of visual charts and tables to present a better overview of the patterns in the use of PPE training and safety-implementation practices.

3.5 Ethical Considerations

During the research, high standards of ethics were upheld. The participants were also told about the aims of the study and their replies were promised not to be disclosed. The respondents were interviewed on a voluntary basis and a signed informed consent was taken before the interview.

5. RESULTS AND DATA ANALYSIS

In this section, a survey of 398 construction workers all over Gujarat is reported in the analysis of the study. The aim of the study was to learn their demographic characteristics, Personal Protective Equipment (PPE) use habits, feelings of comfort and efficiency and employer, as well as training and enforced act mechanisms.

Airo International Journal
Peer-Reviewed
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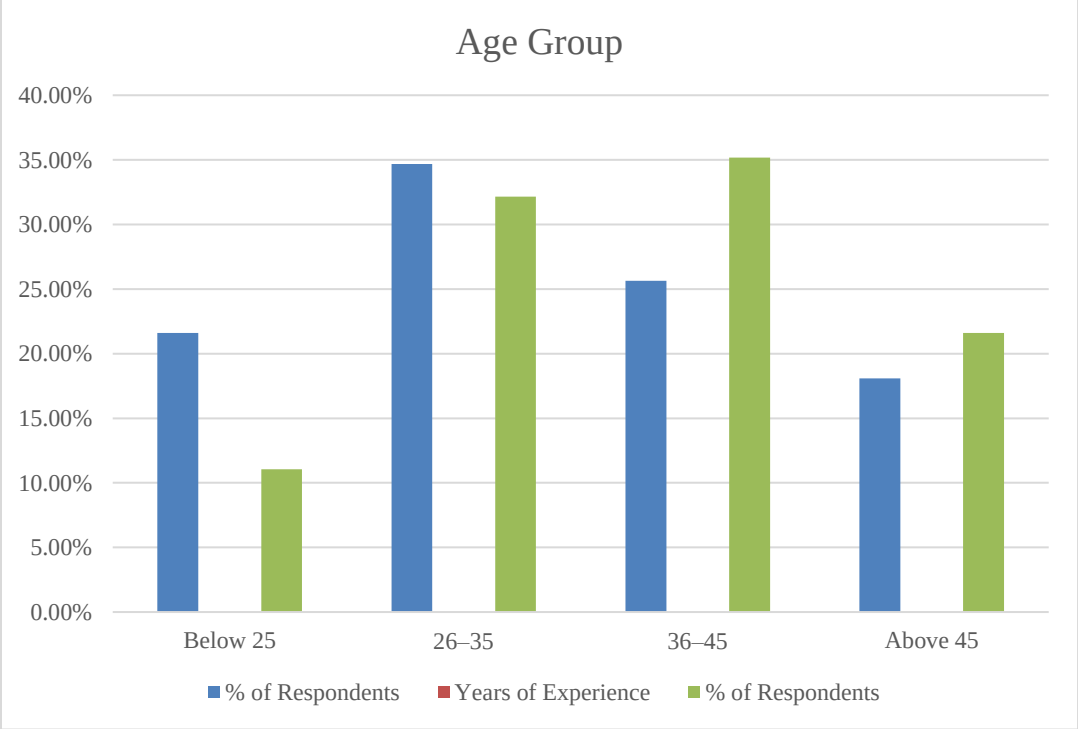
ISSN: 2320-3714
Volume:2 Issue:3
June 2025
Impact Factor:11.9
Subject: Industrial Safety Engineering

5.1 The demographics of the respondents

This table 1 outlines the age breakdown and the years of experience of the 398 construction workers interviewed in Gujarat which identifies the concentration of the mid-career labourers in the construction sector.

Table 1: Age and Experience Distribution of Respondents

Age Group	% of Respondents	Years of Experience	% of Respondents
Below 25	21.61%	Less than 1 year	11.06%
26–35	34.67%	1–5 years	32.16%
36–45	25.63%	6–10 years	35.18%
Above 45	18.09%	More than 10 years	21.61%



Airo International Journal
Peer-Reviewed
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Volume:2 Issue:3
June 2025
Impact Factor:11.9
Subject: Industrial Safety Engineering

Figure 1: Graphical Representation of Age and Experience Distribution of Respondents

The highest percentage of workers (34.67 percent) was aged between 26-35, followed by 25.63 percent aged between 36-45, which means that the workforce is fully made up of persons working at the most productive age in their careers. Likewise, a large percentage (67.34) had an experience of 1-10 years which indicates a moderate to large exposure to construction conditions. These age-experience relations indicate access to competent and experienced workforce with possible complacency or unwillingness to use new safety precaution measures and emphasize the necessity to conduct a structured training and regularly reaffirm safety training enforcement.

5.2 Trends and patterns of PPE Usage

In this table 2, the workers were asked to report the frequency of wearing Personal Protective Equipment (PPE) when working generally in the site and when handling the machine. The categorization of responses is done using a five-point likert scale of strong disagreement to strong agreement.

Table 2: Regular PPE Use and Use During Machine Operation

Usage Context	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Regular use on-site	4.52%	10.55%	17.59%	44.72%	22.61%
PPE use during machine work	3.77%	9.55%	16.08%	48.24%	22.36%

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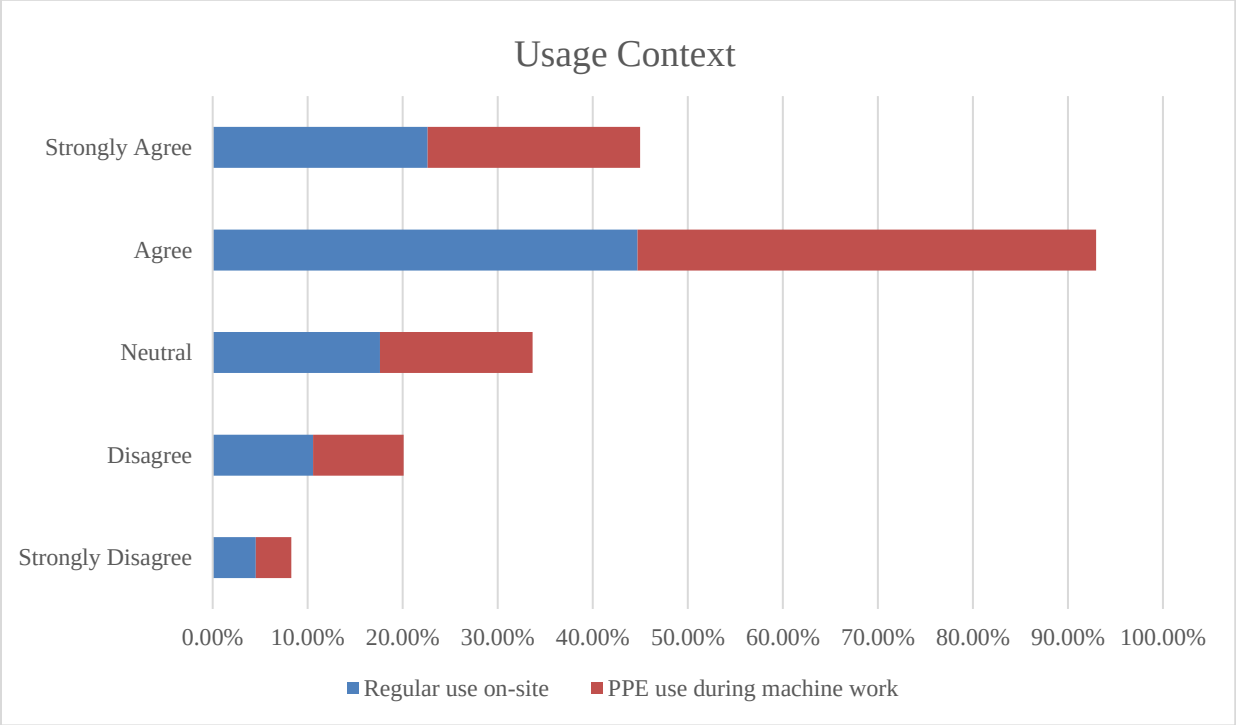

Figure 2: Graphical Representation of Regular PPE Use and Use During Machine Operation

The information shows that 67.33 percent of the respondents either do or strongly do respond to the fact that they wear protective equipment on site regularly and even more 70.6 percent responded that they adhere to using such equipment when working with the machines. But about 15 percent revealed that they do not wear PPE on a regular basis when carrying out normal work in the site and 13.32 percent of them did not wear PPE when operating the machines a task that is much riskier. Also, many of the respondents were neutral in both cases implying that they either did not behave in a certain coherent manner, or were not sure about their adherence. The current tendencies indicate a pre-existing weakness in the area of PPE compliance, especially during high-risk activities, setting the threshold of intensive safety training and the active involvement of the supervisors to control the situation.

5.3 Support of the employer and quality of equipment

Table 3 indicates the perception of the workers concerning the availability of the employer-donated PPE free of charge and general satisfaction towards the quality and adequacy of the equipment.

Airo International Journal
Peer-Reviewed
Multidisciplinary

ISSN: 2320-3714
Volume:2 Issue:3
June 2025
Impact Factor:11.9
Subject: Industrial Safety Engineering

Table 3: Availability and Quality of Employer-Provided PPE

Indicator	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Employer provides PPE at no cost	5.53%	15.08%	22.11%	39.70%	17.59%
PPE quality is satisfactory	8.04%	12.06%	19.60%	42.21%	18.09%

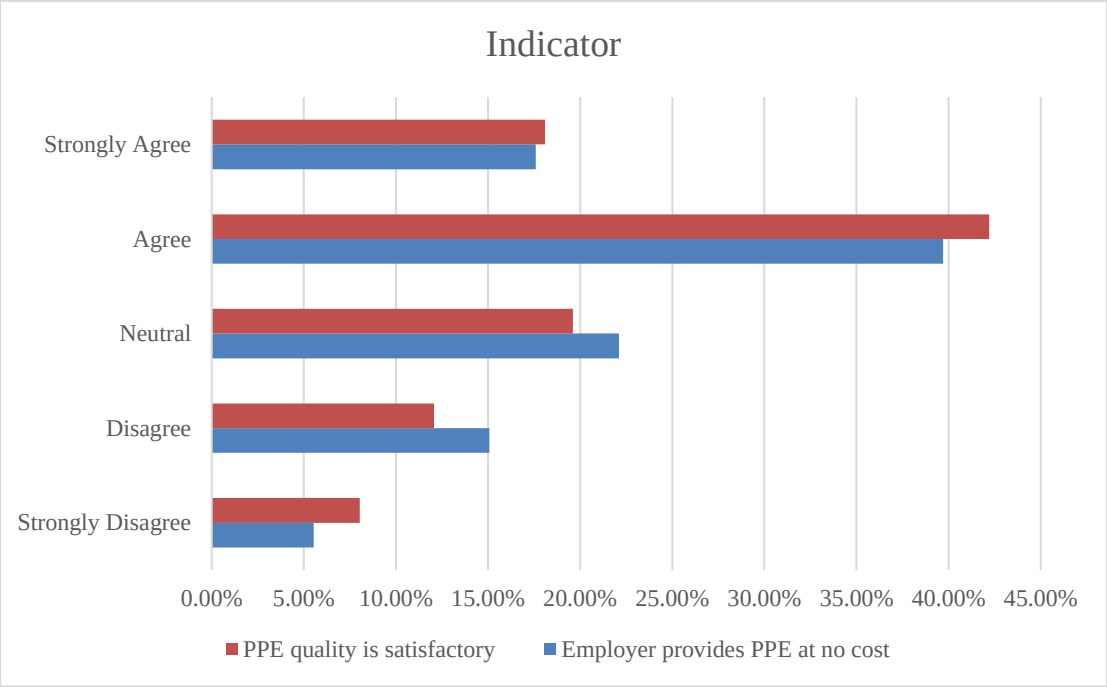

Figure 3: Graphical Representation of Availability and Quality of Employer-Provided PPE

The findings indicate that 57.29 percent of the participants felt that their employers supplied PPE at no cost which means medium organizational support. However, 20.61 percent of the workers disagreed and 22.11 percent were neutral, which means there is disparity in the provision of PPE in construction sites. As far as the quality of equipment is concerned, 60.3 percent of workers were found to be satisfied, whereas 20.1 percent were found to be dissatisfied and 19.6 had no opinion.

Airo International Journal
Peer-Reviewed
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ISSN: 2320-3714
Volume:2 Issue:3
June 2025
Impact Factor:11.9
Subject: Industrial Safety Engineering

These results indicate that the majority of the employers adhere to the requirements associated with PPE although there is a significant proportion of people who do not gain access to the proper equipment or do not consider the provided one to be of high quality. Such divide is likely to directly impact the compliance rates and employee perceptions of safety.

5.4 Attitudes of the Workers: Safety or Uncomfortableness

This table 4 shows the reaction of workers to their perception of PPE as an effective and efficient way of advancing safety with the way they regard PPE as being potentially a discomfort interest or a barrier to their performance in construction activities.

Table 4: Perceived Safety and Discomfort While Using PPE

Perception	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
PPE improves personal safety	5.03%	16.33%	23.87%	39.70%	15.08%
PPE reduces work comfort and performance	2.51%	7.04%	16.08%	48.74%	25.63%

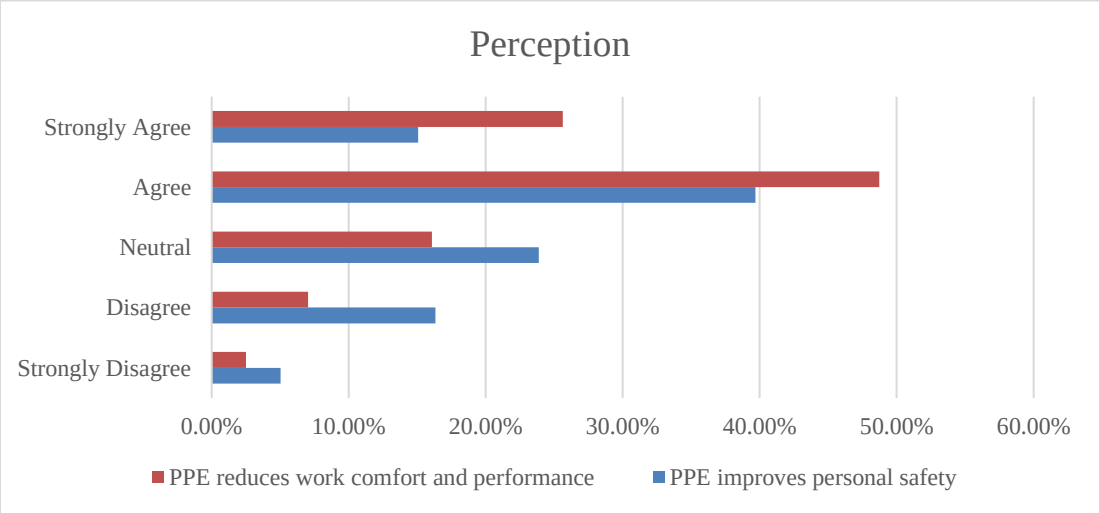

Figure 4: Graphical Representation of Perceived Safety and Discomfort While Using PPE

Airo International Journal
Peer-Reviewed
Multidisciplinary

ISSN: 2320-3714
Volume:2 Issue:3
June 2025
Impact Factor:11.9
Subject: Industrial Safety Engineering

Although a sense of optimization about PPE in terms of their safety is related by 54.78 percent of the respondents, a fairly big percentage (23.87) of the respondents were neutral to the statement, and the number that disclaimed the statement is more than 21 percent, indicating that many of the workers are not completely convinced about its protective nature. Conversely, a high 74.37 percent of employees confirmed or highly affirmed that PPE decreases comfort and has an adverse effect on the job performance. These reactions show one of the most severe behavioral barriers to PPE acceptance and its regular wear, not through ignorance but the pragmatic incomfort in taking the PPE in the first place. The results support the necessity to conduct ergonomic redesign and better fitting of PPE to provide sufficient protection without compromising its usability at the job.

5.5 Barriers of Time Pressure and Training

This table 5 shows the perception of construction workers about the effects of time pressure on PPE mandatory behaviours and perception whether the training given was adequate in respect to the correct usage of PPE.

Table 5: Impact of Time Pressure and Training Adequacy

Factor	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Time pressure reduces PPE compliance	2.01%	5.03%	14.07%	49.75%	29.15%
Training on PPE use is adequate	7.04%	8.79%	18.09%	43.22%	22.86%

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Volume:2 Issue:3
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Impact Factor:11.9
Subject: Industrial Safety Engineering

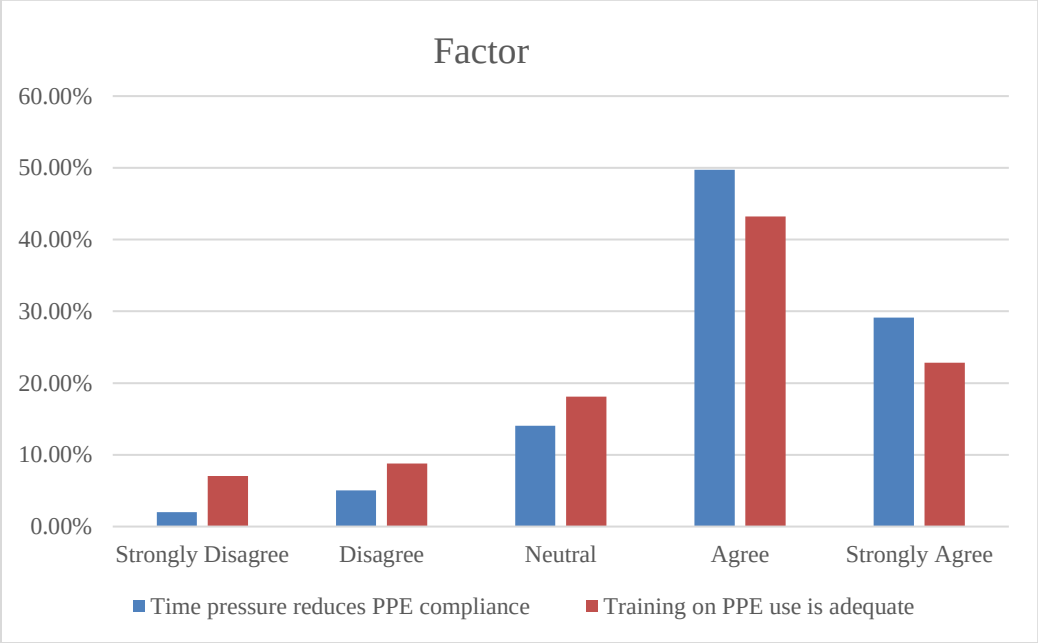

Figure 5: Graphical Representation of Impact of Time Pressure and Training Adequacy

Seventy-eight-point nine percent of the respondents strongly agreed or agreed that the limitation of time at work can easily amount to the exclusion of PPE use indicating that when the expected productivity is at stake, safety may become a victim. This brings out a major operating deterrent in which compliance orientation is outbalanced by job requirements. Conversely, 66.08 per cent of the workers indicated that they were satisfied with the training given on the use of PPE. But on the other side, 15.83 percent disagreed with that, and 18.09 percent were indifferents showing that the quality of training programs will be variable among the sites. The results portray a twofold problem of adhering to PPE in time-limited working environments and making sure the training process is unified, applicable and available to many.

5.6 Social Orientation to Rule and Awareness Programs

In this table 6, the views of the workers on the significance of improving PPE awareness schemes and the need to impose harsher penalties to effect compliance to the safety codes has been provided.

Airo International Journal
Peer-Reviewed
Multidisciplinary

ISSN: 2320-3714
Volume:2 Issue:3
June 2025
Impact Factor:11.9
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Table 6: Support for Awareness and Rule Enforcement

Measure	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Need for increased PPE awareness	7.54%	12.56%	21.61%	41.21%	17.09%
Support for stricter PPE rule penalties	3.02%	6.03%	16.08%	47.23%	27.64%

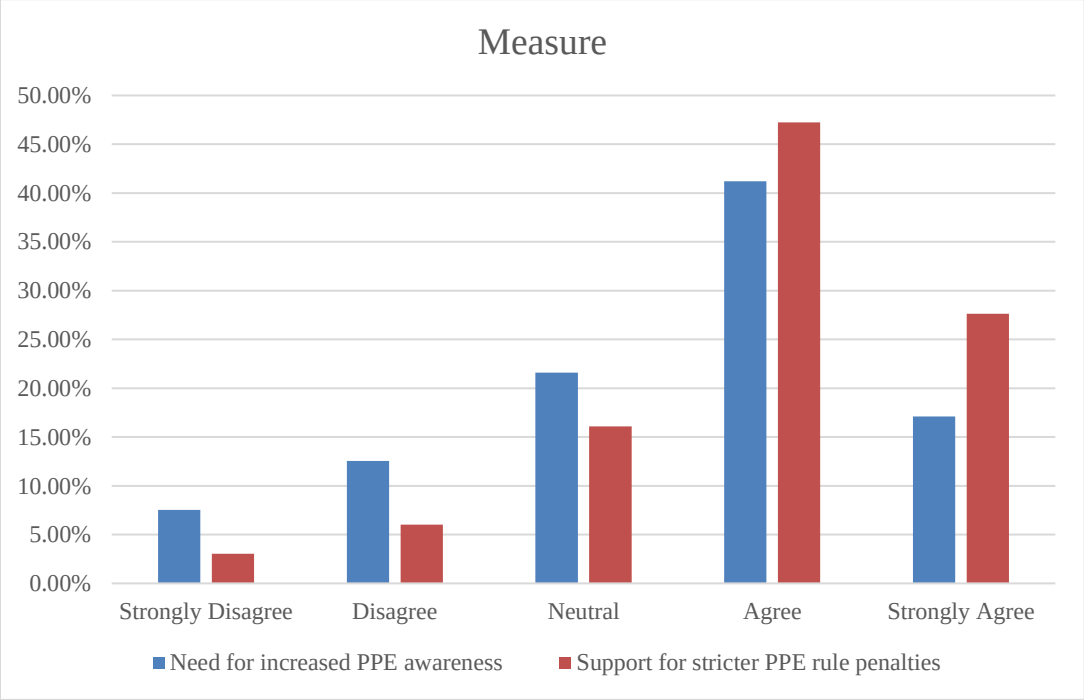

Figure 6: Graphical Representation of Support for Awareness and Rule Enforcement

An aggregate 74.87 percent of the respondents either agreed or strongly agreed that more severe over punishment can only enhance the use of PPE. It shows that the workers are very much in favor of strict control of safety. Provision of more educational and awareness campaigns about PPE was supported by 58.3 percent of the respondents in terms of awareness. Although a larger percentage was neither in favor of (21.61%) nor against (20.10%) the enhancement of safety

ISSN: 2320-3714
Volume:2 Issue:3
June 2025
Impact Factor:11.9
Subject: Industrial Safety Engineering

culture, the general picture displays the openness of the workforce towards the issue. These findings imply that construction workers understand the drawbacks of voluntary compliance and would be ready to use institutional actions to strengthen PPE use and decrease occupational risks.

5. CONCLUSION AND RECOMMENDATIONS

The Research has investigated the effectiveness of Personal Protective Equipment (PPE) in improving the safety of construction workers in Gujarat through sample of 398 across the job positions and construction sites. The results bring out developments and unresolved issues in PPE use and safety culture. Demographic survey also showed that most construction workers are between the period of 26 to 45 years and that they have an average to extensive experience (1-10 years) most of whom are well-positioned to learn and comply with safety measures. There were however contradictions in the use of PPE. Although more than two-thirds of the workers cited frequent use of PPE, about 15 per cent did not adhere to its use, even during risky acts like use of machinery. It is a dangerous practice gap. Employer support was of moderate nature, as 57.29 percent of the employees stated that no fee was paid to access PPE. But approximately twenty percent of them were not satisfied enough or did not know how good or poor PPEs are, the unsymmetrical supply and low-quality supply recognized. Further, although more than half of the workforce recognized the protective advantages of the PPE, many of them said they were uncomfortable, and their ability to perform their jobs was hindered because of the poor design or improper fit, so usability is a critical discouraging factor in their persistent practice. Time pressure was also seen as a big hindrance, with 78.9 percent of workers reporting to have missed PPE very frequently due to productivity pressure. Although the training was mostly rated positively, it was not with consistency. A large number of the workers either said that they were not satisfied or remained neutral on the issue of whether they felt that training was sufficient. Positively, most of the workers agreed on increased sensitization and more focused approach on PPE standards implementation, demonstrating an increasing culture of institutionalizing safety. These results suggest that the comprehensive strategy that would include equipment design, training, enforcement, and change of behavior are all crucial.

ISSN: 2320-3714
Volume:2 Issue:3
June 2025
Impact Factor:11.9
Subject: Industrial Safety Engineering

Based on the conclusions drawn from the data analysis, the following recommendations are proposed to improve PPE effectiveness and safety compliance in Gujarat's construction sector:

- **Use Ergonomically Designed PPE:** To overcome the discomfort and performance challenges, employers are encouraged to work together with manufacturers to supply PPE which are lightweight, breathable, and designed to fit India climatic conditions. An improvement in the design should be done based on the regular feedback of workers.
- **Uniformity and broadening of PPE Training Programs:** training must become standardized, realistic, and adjusted to the literacy levels. The module need not only deal with proper use but also risk understanding with refresher sessions planned at the site level on regular basis.
- **Enhance Supervisory Oversight and Enforcement of the Rule:** Supervisory oversight must be strengthened in construction firms with the monitoring carried out with strict rules. This must involve check offs, use record and some form of penalizing or disciplinary action when they do not comply.
- **To initiate specific awareness and motivation activities:** Safety awareness activities using visuals, different languages and peer-to-peer must be run on a regular basis. Peers and accountability can also be created through reward-based systems (i.e. Safe Worker of the Month).

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