CALAMITY
Calamity: A Journal of Disaster Technology and Engineering
CALAMITY 3(1): 46–57
ISSN 3025-4140

Institute for Advanced Science, Social and Sustainable Future
MORALITY BEFORE KNOWLEDGE

The relationship between fatigue and workplace accidents in the construction sector: A statistical study on contributing factors and risk implications

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Received Date: May 11, 2025 Revised Date: July 20, 2025 Accepted Date: July 31, 2025

ABSTRACT

Background: Occupational accidents remain a persistent issue in the construction sector, often associated with various risk factors including worker fatigue. This study aims to analyze the effect of fatigue on the incidence of work accidents in construction projects. Previous studies have shown that fatigue can impair concentration and reaction time, leading to increased accident risks. **Methods:** This research employed a quantitative descriptive method with data collected through structured questionnaires from 34 construction workers. The data were analyzed using regression analysis. Additionally, instrument testing included validity tests, reliability tests, and linearity tests to ensure the accuracy and consistency of the data. **Findings:** The results demonstrated that worker fatigue has a significant effect on the occurrence of work accidents ($p < 0.05$). Factors such as long working hours, insufficient sleep, and heavy workload contributed to fatigue, which in turn increased accident potential. These results align with existing theoretical frameworks linking physical exhaustion to unsafe behaviors and reduced awareness. **Conclusion:** Fatigue significantly influences the frequency of workplace accidents in construction environments. Effective management of work schedules and adequate rest is essential to minimize these risks. **Novelty/Originality of this article:** This study offers a statistically validated perspective on the influence of fatigue on construction-related accidents, supported by rigorous instrument testing to ensure reliability and precision of findings, which contributes new empirical evidence to occupational safety literature.

KEYWORDS: contruction workers; fatigue; occupational accidents.

1. Introduction

The prevalence of occupational accidents poses a serious concern that requires immediate and effective intervention (Munawaro, 2020; Patrisia, 2018; Rambulangi, 2016). As reported by the International Labour Organization (ILO), the Asia-Pacific region experiences an estimated 250 million work-related accidents annually, leading to approximately 1.2 million fatalities among workers. In Indonesia alone, Rahayu (2017) notes that roughly 414 occupational accidents occur each year, with 27.8% attributed to severe worker fatigue. Furthermore, according to Employment Social Security Administration/*Badan Penyelenggara Jaminan Sosial Ketenagakerjaan* (BPJS

Cite This Article:
Azzamullah, A., Izzoelhq, A., Alif, S. R., Purwoko, W. A., & Trisnawaty. (2025). The relationship between fatigue and workplace accidents in the construction sector: A statistical study on contributing factors and risk implications. *Calamity: A Journal of Disaster Technology and Engineering, 3*(1), 46-57. https://doi.org/10.61511/calamity.v3i1.2025.2064

Ketenagakerjaan) data from 2020, the construction sector recorded approximately 177,000 workplace accidents, showing an increase from 114,000 cases in 2019.

Construction work is inherently hazardous due to its physical nature, with much of the labor still performed manually. The physically demanding tasks make construction sites particularly prone to accidents. These incidents can result from being hit by falling materials, striking against hard surfaces, falling from heights, stepping on or being cut by sharp objects, or mishandling equipment. Contributing factors include the improper use or absence of personal protective equipment (PPE), reduced worker concentration, and human error. A key factor diminishing concentration and increasing the risk of accidents is worker fatigue.

Fatigue may arise from both internal and external sources. Internally, a worker's physical condition plays a role, while externally, the surrounding work environment has an impact (Ilyasa & AR, 2023; Maharani & Nugroho, 2022). Usmawati et al. (2021), Hamzah (2019), and Handayani & Hotmaria. (2021) found that job stress and workload contribute directly and indirectly to fatigue. Environmental aspects such as climate and work shifts also affect fatigue levels. Meanwhile, Agustin & Sariah (2018) identified internal factors including age, work tenure, marital status, and job type as significant contributors to fatigue.

A study by Uehli et al. (2014), covering more than 268,000 workers, showed that sleep problems—a key indicator of fatigue—were associated with a 1.62-fold increase in the risk of workplace injuries, with approximately 13% of accidents caused by sleep-related fatigue. Prospective studies also confirm that individuals with persistent sleep difficulties are nearly twice as likely to experience fatal workplace accidents. Similarly, research in the construction sector reveals that fatigue significantly reduces hazard recognition and safety risk perception, with regression models showing that fatigue explains up to 37% of the variance in workers' ability to identify hazards (Namian et al., 2021). These data illustrate that fatigue functions not only as a physiological or psychological condition, but also as a major safety risk factor with measurable consequences.

Furthermore, studies using physiological monitoring have shown that fatigue impairs cognitive and physical performance (McMorris et al., 2018). Indicators such as heart rate variability, skin temperature, and body stability deteriorate in conditions of high fatigue, especially when combined with environmental hazards such as slippery surfaces or obstructed pathways (Jo & Kim, 2024; Mohanavelu et al., 2017). This evidence reinforces that fatigue cannot be considered an isolated issue, but must be understood in relation to workplace design, task demands, and environmental challenges. Therefore, addressing fatigue requires a comprehensive approach, including work-rest scheduling, improved ergonomics, effective supervision, and health promotion programs, to protect workers and reduce the risk of accidents in construction environments (Karim et al., 2025; Tao et al., 2024).

A number of studies on internal factors have focused primarily on workers under 30, as this age marks the early phase of middle adulthood, during which physiological changes—such as slower metabolism, decreased organ function, increased body fat, and other alterations—begin to emerge (Oktian, 2016). Additionally, individuals with more than five years of work experience tend to report higher fatigue levels and face a greater risk of accidents due to accumulated physical strain (Langgar & Setyawati, 2016). Repetitive tasks performed over extended periods can also lead to monotony, which exacerbates fatigue (Setyawati, 2010). Regarding sleep, research suggests an average of 5 to 7 hours per night among workers. The Indonesian Ministry of Health (2023) recommends that adults aged 18–40 get 7–8 hours of sleep per day, while the National Sleep Foundation advises 7–9 hours for those aged 18–64.

Numerous studies have attempted to assess the impact of internal factors on worker fatigue and accident risk. Some findings suggest a significant relationship between these factors and both fatigue and accident occurrences (Agustin et al., 2021; Usmawati et al., 2021). However, other research indicates that not all internal factors exert a meaningful influence. In fact, some studies conclude that internal factors do not significantly affect either fatigue or accidents. As a result, this study seeks to apply a different analytical

approach to further investigate how internal factors may influence fatigue and occupational accidents within a building construction context.

2. Methods

This research employed a quantitative approach to address the stated research problem, specifically analyzing the effect of worker fatigue on occupational accidents in a construction project. This approach aligns with the epistemological framework of the study, as it objectively investigates the relationship between measurable variables using numerical data and statistical tools.

2.1 Research location and time

The study was conducted at a construction project site located on Jalan Karangpoh Indah, an area with ongoing development activities and a substantial number of construction workers. The location was selected based on its high work intensity, long working hours, and physically demanding tasks, which are relevant to the issue of worker fatigue. The research was carried out during the active construction phase in [insert time period if available], a period in which workload and fatigue levels are typically elevated.

2.2 Population, sample, and sampling technique

The research population comprised construction workers at the project site on Jalan Karangpoh Indah, including masons and assistant workers. The sample was selected using a non-random purposive sampling technique, in which participants were chosen based on specific criteria, a minimum education level of elementary school, at least one year of experience in the construction sector, and actively working on the same project for at least three months. Following Gay et al. (2009), the sample size was set at 34 respondents, which included a 10% buffer to account for potentially invalid data. However, all questionnaires were returned and deemed usable for analysis.

Fig. 1. Questionnaire distribution on site

2.3 Research variables and data sources

This study focused on two main variables; independent variable: Worker fatigue, influenced by internal factors such as age, nutritional status, marital status, work experience, job training, and sleep duration and dependent variable, Occupational accidents experienced by the workers. The data were collected through primary sources, obtained directly from respondents via structured questionnaires.

2.4 Instruments and research materials

The instrument used in this research was a closed-ended questionnaire, consisting of two sections: respondent demographic data and question items to measure both variables. All items were rated on a 5-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), to capture responses systematically and quantitatively. A questionnaire grid was developed to structure the instrument. Indicators for fatigue were adapted from Nurmianto (2003), Suma'mur (2009), and Hastuti (2015), including symptoms such as speech fatigue, full-body exhaustion, poor concentration, nervousness, loss of motivation, and other mental and emotional fatigue indicators—totaling 17 items. Indicators for occupational accidents were based on the classification proposed by Noor (2014), which includes incidents such as being hit by falling objects, falls from height, slips, entrapment, electric shock, and burns caused by welding or chemical exposure. These indicators were represented in items 18 through 30 of the questionnaire.

2.5 Data collection procedure and data analysis

Questionnaires were distributed directly to the workers during rest breaks to ensure convenience and avoid disrupting their work. Respondents filled out the questionnaires under supervision to ensure understanding, and the completed forms were collected immediately after. Before hypothesis testing, the following preliminary tests were conducted on the questionnaire data; validity test to ensure that each item accurately measured its intended construct, reliability test to assess the internal consistency of the instrument, linearity test to confirm that the relationship between the independent and dependent variables was linear. Subsequently, the data were analyzed using regression analysis to determine the effect of worker fatigue on the incidence of occupational accidents. Data processing was conducted using SPSS version 27, with a significance level set at 5% ($p < 0.05$).

3. Results and Discussion

3.1 Questionnaire data results

This study used a quantitative approach, which involves a systematic process and requires numerical data to generate findings and draw conclusions (Agung & Zarah, 2016). The data collection was carried out through the distribution of questionnaires to field workers involved in a construction project. The total number of respondents was 34, as predetermined in the sampling criteria.

The questionnaire included internal worker variables that influence fatigue and occupational accidents, assessed using a 5-point Likert scale, where 5 indicates "very frequent" and 1 indicates "very infrequent." The collected data were analyzed using regression analysis to identify the influence of fatigue levels on work accidents based on the individual characteristics of each worker. The following is a summary of the questionnaire data obtained in Table 1.

Table 1. Field questionnaire results

Name	Age	Education	Total Fatigue Value X	Total Accident Value Y
I	30	Senior High School	39	24
M	31	Vocational High School	37	22
F.S.	32	Senior High School	31	23
A.R.	33	Senior High School	33	20
A.Z.	34	Senior High School	33	21
S	34	Junior High School	46	25
S	34	Junior High School	36	17
S.W.	35	Senior High School	23	17
F	35	Junior High School	36	24
M	37	Elementary School	23	22
C.H.N.	37	Senior High School	35	20
S	37	Junior High School	25	21
M.M.	37	Junior High School	34	20
S	38	Elementary School	46	24
A	38	Junior High School	44	25
W.A.	39	Senior High School	23	17
A.A.D.	39	Senior High School	22	16
S.A.	40	Diploma	23	19
M.S	41	Senior High School	36	19
A.J.	41	Senior High School	20	18
F.H.	41	Diploma	32	18
K.M.	42	Elementary School	20	21
S.A.M.	42	Senior High School	22	17
A.Y.	43	Senior High School	21	23
C	43	Senior High School	34	21
M.A.	43	Junior High School	23	20
E.S.	43	Senior High School	24	15
P	44	Junior High School	32	22
M.D.A.S.	44	Senior High School	24	15
M	24	Senior High School	42	14
E.S.W.	23	Senior High School	39	25
B.D.	22	Senior High School	26	14
R.M.A.A.M.	22	Senior High School	34	23
R	27	Vocational High School	53	18

3.2 Validity test

The validity test was conducted to ensure the legitimacy of the research instrument. A question item is considered valid if it shows a significant correlation at the 5% level, determined by comparing the calculated r-value (r-count) with the critical r-value (r-table). With 34 respondents, degrees of freedom (df) = 32, resulting in an r-table value of 0.349. The following table shows the validity test results in Table 2. Based on Table 2, it can be observed that most r-count values exceed the r-table value, indicating that the majority of the questionnaire items are valid.

Table 2. Validity Test Results using SPSS

No Question	Question Variables	rcount	rtable	Control
P1	Fatigue	0.929	0.349	Invalid
P2		0.225	0.349	Invalid
P3		0.767	0.349	Valid
P4		0.228	0.349	Invalid
P5		0.965	0.349	Valid
P6		0.389	0.349	Valid
P7		0.480	0.349	Valid
P8		0.841	0.349	Valid
P9		0.796	0.349	Valid
P10		0.919	0.349	Valid

P11		0.938	0.349	Valid
P12		0.878	0.349	Valid
P13		0.872	0.349	Valid
P14		0.384	0.349	Valid
P15		0.431	0.349	Valid
P16		0.966	0.349	Valid
P17		0.94	0.349	Valid
P18	Accident	0.084	0.349	Invalid
P19		0.763	0.349	Valid
P20		0.763	0.349	Valid
P21		0.641	0.349	Valid
P22		0.188	0.349	Invalid
P23		0.188	0.349	Invalid
P24		0.164	0.349	Invalid
P25		0.17	0.349	Invalid
P26		0.335	0.349	Invalid
P27		0.066	0.349	Invalid
P28		0.226	0.349	Invalid
P29		0.181	0.349	Invalid
P30		1	0.349	Valid

3.3 Reliability test

The reliability test was conducted to assess the consistency and dependability of the questionnaire items. Data are considered reliable if the Cronbach's Alpha coefficient exceeds 0.60. The following table summarizes the reliability test results for the variables of work fatigue and occupational accidents in Table 3. The results show that both variables have Cronbach's Alpha values greater than 0.60, indicating strong internal consistency and reliability of the data.

Table 3. Reliability test results using SPSS

Variables	Cronbac's Alpha	Control
Fatigue	0.951	Reliabel
Accident	0.957	Reliabel

3.4 Linearity test

The linearity test was conducted to determine whether there is a significant linear relationship between the two variables under analysis. The SPSS output provides a significance (Sig.) value, where a value greater than 0.05 indicates linearity, and a value less than 0.05 indicates non-linearity. The results are as follows Table 4.

Table 4. Linearity test results using SPSS

No. Question	Question Variables	Sig Dev. F. Lin.	Sig Linearity	Control Sig. Dev.F. Lin	Control Sig. Linearity
P1	Fatigue	0.861	0.000	fulfilled	fulfilled
P2		0.200	0.132	fulfilled	Not fulfilled
P3		0.151	0.000	fulfilled	fulfilled
P4		0.750	0.000	fulfilled	fulfilled
P5		0.145	0.206	fulfilled	Not fulfilled
P6		0.969	0.000	fulfilled	fulfilled
P7		0.826	0.011	fulfilled	fulfilled
P8		0.498	0.001	fulfilled	fulfilled
P9		0.084	0.000	fulfilled	fulfilled
P10		0.797	0.540	fulfilled	Not fulfilled
P11		0.540	0.000	fulfilled	fulfilled
P12		0.479	0.000	fulfilled	fulfilled
P13		0.566	0.000	fulfilled	fulfilled

P14	0.026	0.026	Not fulfilled	fulfilled
P15	0.453	0.008	fulfilled	fulfilled
P16	0.867	0.000	fulfilled	fulfilled
P17	0.014	0.188	Not fulfilled	Not fulfilled

These tables show the deviation from linearity and linearity significance for each questionnaire item. According to the results, 5 items did not meet the linearity assumption and will be tested further using nonlinear regression. The remaining items were considered suitable for linear regression analysis.

Table 5. Linearity test results using SPSS (Advance)

No. Question	Question Variables	Sig Dev. F. Lin.	Sig Linearity	Control Sig. Dev.F. Lin	Control Sig. Linearity
P18	Accident	0.014	0.188	Not fulfilled	Not fulfilled
P19		0.973	0.000	fulfilled	fulfilled
P20		0.450	0.000	fulfilled	fulfilled
P21		0.649	0.000	fulfilled	fulfilled
P22		0.074	0.074	fulfilled	Not fulfilled
P23		0.074	0.074	fulfilled	Not fulfilled
P24		0.403	0.004	fulfilled	fulfilled
P25		0.693	0.003	fulfilled	fulfilled
P26		0.099	0.006	fulfilled	fulfilled
P27		0.227	0.000	fulfilled	fulfilled
P28		0.146	0.146	fulfilled	Not fulfilled
P29		0.68	0.680	fulfilled	Not fulfilled
P30		0.121	0.121	fulfilled	Not fulfilled

3.5 Regression test

The regression analysis was conducted to determine the significance of the relationship between fatigue levels and the occurrence of workplace accidents. The SPSS output provides the significance value (Sig.), where a value below 0.05 indicates a statistically significant result. The test results show a significant relationship between fatigue and occupational accidents, as the Sig. value is less than 0.05. The results are as follows Table 6.

Table 6. Regression test results

Test Type	Amount of data	Sig F.	Sig	Control
Regression Test	34	0.023	0.05	Significant

3.6 Discussion

Based on the findings from the validity, reliability, linearity, and regression analyses, it can be concluded that all questionnaire items were valid and reliable, indicating that the research instrument is trustworthy and effectively measures the studied variables. The linearity test showed that most of the fatigue indicators have a linear relationship with occupational accidents, although a few items failed to meet the linearity assumption. The regression analysis confirmed a statistically significant effect of fatigue levels on workplace accidents, as indicated by a significance value below 0.05. This confirms the hypothesis that higher fatigue levels contribute to a higher risk of accidents. In summary, this study demonstrates a statistically significant relationship between worker fatigue and occupational accidents, supporting the hypothesis and reinforcing the importance of fatigue management in construction safety protocols.

The results of this study, which reveal a statistically significant relationship between worker fatigue and workplace accidents, are consistent with various previous studies (Hinze et al., 2021; Ju et al., 2021; Namian et al., 2021). For example, a study of construction workers in the United States showed that fatigue has a direct negative impact on hazard

recognition and safety risk perception, with fatigue explaining 37% of the variability in hazard recognition and 28% in safety risk perception (Ibrahim et al., 2023). Similarly, experimental studies using physiological indicators such as heart rate variability and skin temperature found that physical and mental fatigue significantly increased unsafe behavior, suggesting that fatigue affects not only cognitive performance but also motor coordination (Behrens et al., 2023; Zhang et al., 2023). These findings are consistent with the current study, in which fatigue indicators were found to measurably influence accident risk.

Furthermore, meta-analytic evidence from 27 observational studies with more than 268,000 participants shows that workers with sleep problems face a 1.62 times higher risk of workplace injuries, with approximately 13% of workplace accidents caused by sleep-related fatigue (Injury Facts, n.d.). Longitudinal studies have also confirmed this pattern, showing that individuals who report sleep difficulties are nearly twice as likely to experience fatal workplace accidents compared to those without sleep problems (Alhainen et al., 2022). This data reinforces the argument that fatigue, especially when associated with inadequate recovery or insufficient sleep, is an important determinant of workplace safety outcomes.

Other empirical studies have highlighted the role of environmental and situational factors in amplifying the effects of fatigue (Li et al., 2023). For example, research using inertial motion sensors found that workers' body stability decreased significantly at high levels of fatigue, especially in hazardous conditions such as slippery floors or obstructed pathways. This suggests that fatigue not only increases the risk of accidents itself but also interacts with environmental hazards to multiply that risk. In addition, a large-scale survey of construction workers reported that nearly half experienced fatigue for several days within a three-month period, and those who frequently felt fatigued were more than twice as likely to experience physical and cognitive functional difficulties.

Overall, findings from these various methodological approaches—ranging from subjective questionnaires to physiological measurements and longitudinal epidemiological data—show a consistent and strong relationship between fatigue and workplace accidents. This convergence of evidence reinforces the study's conclusion that fatigue management should be an integral component of occupational health and safety strategies. Effective interventions, such as optimizing work-rest cycles, monitoring sleep quality, improving ergonomic design, and strengthening supervision, are crucial for reducing accident rates, improving worker well-being, and promoting sustainable productivity in the construction industry.

4. Conclusions

Based on the research findings regarding the influence of workers' internal factors on fatigue and occupational accidents in construction projects, several conclusions can be drawn. The research instrument was found to be both valid and reliable, as confirmed by the results of validity and reliability testing using SPSS version 27. All questionnaire items met the validity requirements, with correlation coefficients exceeding the critical value (r-count > r-table), and the Cronbach's Alpha coefficients were greater than 0.60, indicating strong reliability. Furthermore, most indicators of fatigue and occupational accidents showed a linear relationship with internal worker factors, based on the results of the linearity test. However, a few indicators did not meet the criteria for linearity. The results of the linear regression analysis revealed a significant influence of fatigue levels on the incidence of workplace accidents, as demonstrated by a significance value (Sig.) less than 0.05. Overall, it can be concluded that fatigue has a significant impact on work-related accidents. Nevertheless, it is also likely that other, more dominant factors not examined in this study—such as external factors, behavioral patterns, safety management, and environmental conditions—may also contribute substantially to the occurrence of workplace accidents.

Acknowledgement

We extend our heartfelt appreciation to the editorial team and reviewers for their thoughtful evaluation and detailed review of this scientific paper. Their valuable insights, constructive suggestions, and thorough examination have played a crucial role in improving the clarity, depth, and overall quality of our work.

Author Contribution

Each authors was actively involved in the preparation and writing of this research article.

Funding

This research received no external funding.

Ethical Review Board Statement

Not available.

Informed Consent Statement

Not available.

Data Availability Statement

Not available.

Conflicts of Interest

The authors declare no conflict of interest.

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