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CONSTRUCTION WORKERS' SUBJECTIVE AND OBJECTIVE FATIGUE MEASUREMENT ON MULTISTOREY PROJECT

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Abstract Quality, cost, and time are the primary targets of construction projects; the working environment, occupational safety, and health are also crucial. An employer can implement occupational safety and health (OHS) by providing rules and appeals to minimise workplace accidents. Several studies found that workers' stress and fatigue caused workplace accidents. Therefore, this study aimed to investigate workers' fatigue based on subjective and objective measurements using surveys; the researchers distributed questionnaires and measured the pulse of 84 workers in multi-storey building construction projects. The subjective analysis revealed that workers' fatigue reached a total score of 77.81, categorised in level 3 and classified as high fatigue. Meanwhile, the objective analysis proves that workers' pulse rate indicates heavy load work and high fatigue levels. There is a positive but not significant correlation between subjective and objective variables from the Pearson correlation test. Thus, the study concluded that corrective action in implementing occupational health and safety was imperative. In addition, employers need to use work methods to minimise workers' fatigue in construction projects. Investigating fatigue is expected to prevent work accidents in constructing multi-storey buildings.
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Keywords Fatigue, Construction, Worker, Safety, High Building

1. Introduction

In this decade, the development in all fields has been growing, supported by increasingly modern technological developments and complex technology transfer to all sustainable development stakeholders [1, 2]. Technology transfer affects the development process in all fields, especially construction. [3, 4]. Law no. 2 of 2017 Article 59 concerning Construction Services states that service users and providers must meet Security, Safety, Health, and Sustainability Standards [5]. Thus, the implementation of construction projects must pay attention to the application of Occupational Safety and Health (also referred to as OHS) to prevent work accidents. OHS maintains the work environment's health and safety and protects colleagues, workers' families, consumers, and other people who may also be affected by work environment conditions [6, 7].

Companies must perform and supervise work following existing standard operating procedures to create safe, comfortable, and productive working conditions [8, 9]. The risk of work accidents can occur anytime and anywhere, even though nobody wants to experience it. Many workers have experienced work-cause accidents or illnesses in a construction project caused by stress and fatigue [10]. After performing activities, one might feel tired. Tiredness, sleepiness, boredom, and thirst can simultaneously occur with symptoms such as weakness, decreased motivation, and physical fatigue.

The workload on construction projects tends to cause fatigue, leading to work accidents. Unergonomic work facilities, a work environment that fails to meet the requirements, and unnatural work attitudes can also cause workers to lose their focus [9]. It can also lead to musculoskeletal system disorder, subjective complaints, and fatigue, which results in low work productivity.

Therefore, companies engaged in construction services must identify the causes of workers' fatigue to minimise the risk of work accidents; it is an effort to apply Occupational Health and Safety and zero accidents. Companies can identify workers' fatigue by using the mental workload aspect; it is done by measuring subjective feelings of fatigue, with the method issued by the International Fatigue Research Committee (IFRC) referred to as the Subjective Self Rating Test (SSRT) [10]. The construction of multi-storey buildings gives a workload, so it is essential to identify workers' errors based on subjective and objective factors to minimise workplace accidents.

Based on the description above, this study measured the extent to which the fatigue level of construction project workers of high-rise buildings using subjective and objective measurements. This measurement is expected to provide positive input for project implementers and owners on correctly applying occupational health and safety measures. It is also beneficial for determining appropriate work methods to predict, reduce and prevent work accidents.

2. Literature Review

2.1. Occupational Health and Safety (OHS) and Construction Work

These days, many organisations pay attention to Occupational Health and Safety (OHS) as it includes issues of humanity, economic costs and benefits, legal aspects, responsibility, and the organisation's image [10]. The company must consider an occupational health and safety program, which is implemented to protect workers from occupational hazards and their impacts.

Work safety includes safe materials and work processes, a safe workplace and tools, and a safe environment and methods. It aims to prevent workers from injury and avoid damage or loss to equipment, materials, and production. If the danger in the work environment is not anticipated correctly, it will burden the workers. Thus, the company should consider several factors, such as humans, machines, materials, work methods, and the environment [10].

These factors often influence the occurrence of accidents, so the company needs to monitor them effectively. Occupational health is the harmony between work capacity, workload, and work environment. Occupational health is an effort and condition that enables workers to maintain their physical, mental, and social health conditions at work. The company can apply it by setting rules and preventing workers from conditions detrimental to health, indicated by physical or mental disorders, emotions, or pain caused by the work environment [10].

2.2. Work Fatigue

Fatigue is the body's mechanism to warn that it needs rest to regain energy; it is divided into physical and mental fatigue [11]. Work fatigue factors are varied, highly complex, and interrelated, viz., intensity and duration of physical and mental work; physical problems such as responsibility, environment, health conditions, and nutrition also contribute to work fatigue.

There are internal and external factors causing work fatigue [11]. One of the internal factors is a person's age, which will affect the body's condition, ability, and capacity to perform activities [12]. Work productivity will decrease with age. Work capacity, including functional, mental, and social capacity, will decline before age 45 by age 50 and over. Another internal factor is the worker's nutritional status; all workers need nutrients from daily-consumed food.

The next factor is rooted externally. The workload is an external factor that can be differentiated quantitatively and qualitatively. A quantitative workload is working in large amounts according to the given time. A qualitative workload is working with repetitive tasks. The workforce's work pulse (heart rate) is determined by direct workload, additional workload, and work capacity. A person's workload can be categorised according to pulse frequency per minute, as shown in Table 1. Internal factors like age, gender and nutritional status also influence pulse rate. In comparison, the external factors that affect the pulse include noise, heat pressure, length of work and distance to lift the load.

Work fatigue can decrease alertness, concentration, and accuracy, causing accidents 3]. According to Christi et al. [20], work fatigue can lead to a decrease in productivity. So, work fatigue can result in decreased attention, perception barriers, slow and difficult thinking, decreased willingness or urge to work, reduced efficiency, and physical and mental activities, ultimately leading to work accidents and reduced work productivity. Complaints at work due to work-related illness indicate workers' fatigue. It is crucial to deal with any fatigue to prevent it from becoming chronic. Identifying the causes is essential to handle fatigue, which can be done by measuring it 3].

Table 1. Workload according to pulse rate per minute

Workload	Pulse Rate (per minute)	Fatigue Category	Safety Category
Very Light	Less than 75	Low	Safe
Light	75 – 100	Low	Safe
Slightly Heavy	100 – 125	Medium	Alert
Heavy	125 – 150	High	Warning
Very heavy	150 – 175	High	Warning
Incredibly Heavy	More than 175	Very High	Severe

2.3 Fatigue Level Measurement

To date, researchers have not found a way to measure fatigue levels directly. The measurements only identify the indicators showing work-caused fatigue, one of which is a subjective measurement using the Subjective Self Rating Test from the Industrial Fatigue Research Committee (IFRC) by distributing questionnaires measuring emotional fatigue levels [14]The researchers asked the respondents about their symptoms or subjective feelings through the questionnaire. The IFRC scale has 30 fatigue symptom questions.

Meanwhile, the workload is calculated by measuring the pulse, which manifests the heart's ability as an indicator of heart rate. So, the heart rate can be seen from the pulse, which propagates the heart rate. The pulse is calculated every minute with a count of repetitions (times/minute) or a maximum pulse rate of 220.

3. Materials and Methods

This research employed a quantitative survey method with a descriptive analysis to describe the conditions and correlation analysis to determine the effect of subjective and objective measurements in predicting work accidents. Therefore, primary data was used by collecting them directly from questionnaire responses. The questionnaire was arranged based on the required and relevant variables following the research objectives. The population was construction workers in 15-floor high-rise projects in Kuching city. The number of respondents was determined through probability sampling (simple sampling); 84 respondents were involved in this research. Respondents needed in this study were construction workers on multi-story building projects with several field groups. A total of 30 people installed the panel walls, 30 installed the outer wall covering, and 24 were doing concreting work.

Following the objectives, the method of measuring fatigue used the International Fatigue Research Committee (IRFC)scale, also called the Subjective Self Rating Test (SSRT), containing many questions related to fatigue symptoms [15]. On this scale, 30 fatigue symptom questions were listed. Table 3 presents symptoms associated with fatigue and the categories to prevent construction work accidents due to worker fatigue in high-rise building projects in Kuching City. The measurement scale used for each question indicator was the Likert scale, with 1 = never (score 1), 2 = sometimes (score 2), 3 = often (score 3), and 4 = very frequently (score 4).

Objectively, the observed and measured data can be obtained using the five senses by measuring the pulse of workers at work. Worker fatigue is known by measuring the worker's pulse at work. The worker's pulse rate is estimated to produce an average. All workers in the study are in good health, as known by the workers who come to work, which describes their good condition. Pulse rate measurements are carried out every working day, starting in the morning before and after work, in the afternoon before and after rest, and in the afternoon before and after work. Measurements were taken six times a day and carried out for three days.

4. Results and Discussion

Based on primary data from distributed questionnaires, respondents' profiles of workers' ages and experiences are shown in Figures 1(a) and (b). All 84 respondents were male and mostly young (17-35). Most have worked on similar projects in the productive age for over five years. When the questionnaire was distributed, the first group installed the panel walls on the 4th-7th floor, the second group installed the outer wall covering, and the third group did concrete work on the 9^{th}-10^{th} floor.

The measurement results indicated that the construction workers' level of fatigue was high (level 3), with an average score of 77.81. Some respondents from the first and third groups scored 30 on the Physical Weakness variable, revealing that workers, when installing the panel walls and concreting work, mostly felt physical weakness (thirst, dizziness, feeling unwell, and pain in the back). Meanwhile, most workers in the second group scored 30 on the motivation weakness. This condition reveals that workers in the second group felt challenged to think, nervous, had difficulty concentrating, had difficulty focusing, had reduced self-confidence and anxiety, and had trouble controlling their attitude when installing the outer wall covering. Therefore, this subjective measurement can identify workers' fatigue and weakness. Thus, fatigue prevention measures can be determined appropriately to minimise and prevent work accidents, especially in high-rise buildings.

The objective measurement was collected using pulse rate measurement for each worker. Each respondent's pulse rate was measured six times daily for three days of observation. A person's workload can be categorised according to pulse frequency per minute. The average pulse rate obtained for the first respondent is 126.5 bits/minute, and included in the load are heavy work, high fatigue and warning safety categories. The same activities were also applied to other respondents and groups.

The Pareto diagram shows that as many as 70% of workers in group one who were working on installing the panel walls, based on observations for three days, experienced a high level of fatigue with a pulse measurement range between 124.8 – 130.2 bits/minute. The measurement results in group one are almost the same as most workers in group 3, who do concrete work. As many as 70% of workers experience high-category fatigue with an average pulse of 125.5-130 bits/minute. Meanwhile, in group 2, which did wall covering, the results of measuring the pulse of workers categorised as high fatigue with a range of 125.4-131.2 bits/minute were 77% of the total respondents. Compared to the average pulse rate of the three groups, group two has the highest average. All three groups fall into the heavy workload and security categories that require a warning.

Furthermore, the normality test was carried out on the research variables, namely subjective and objective fatigue. The normality test results on the research variables obtained a significance value of the aim fatigue variable of 0.759 and the subjective fatigue variable of 0.615. The test results indicate that the two variables are normally distributed. Meanwhile, the Pearson correlation test measures the relationship between workers' subjective and objective fatigue variables. The results of the Pearson correlation test between objective fatigue and subjective fatigue obtained a correlation coefficient of 0.111 and a significance of 0.860 ($p > 0.05$). These two values indicate a positive but insignificant correlation between objective fatigue and subjective fatigue, meaning that the higher objective fatigue will not significantly affect the higher subjective fatigue.

The analysis results above show that the measurement results of the two measurement variables prove and can predict the occurrence of work accidents. The measurement results subjectively prove that workers divided into three majority groups are included in the category of high fatigue, and urgent corrective action is needed. The results of objective measurements taken from pulse results for three days and six times/day of observation also show that the work carried out by workers in the three groups is included in the heavy workload and high fatigue category, so immediate warning actions are needed to prevent work accidents. Therefore, the possibility of work accidents in the case of high-rise building projects is included in the high category.

Fatigue can be reduced in various ways aimed at the general condition and physical environment at work, for example, by regulating working hours and providing appropriate opportunities for rest [16]. Workers should avoid a static work attitude and pursue a dynamic one to reduce the high level of fatigue [17], which can circulate blood and oxygen to the body better. Therefore, the company must provide dynamic work methods, provide drinking water at specific points, and allow workers to rest at intervals. The supervisor determines the workers' schedule so that they can complete the work at the targeted time and prevent work accidents simultaneously.

5. Conclusion

The study results show that most workers experienced high fatigue levels and needed corrective action. The construction project implementer should change the work method to be dynamic and provide breaks for workers outside of lunchtime to drink. This study is expected to be useful for construction project implementers by identifying the level and type of labour fatigue to become a reference for mitigating and even preventing work accidents on construction projects. Furthermore, as a positive impact, zero accidents can be achieved at the worksite. Further research on predicting construction workers' accidents should measure fatigue levels by combining subjective and objective methods with worker internal factors such as age, weight, height, and nutritional status.

REFERENCES

1. Handoko F, Paula C, Hidayat S, Rastini EK, Wijayaningtyas M, Vitasari P. A green-based manufacturing system to solve pallet shortage problems. Heliyon [Internet]. 2021 Apr 1 [cited 2021 Apr 17];7(4):e06823. Available from: https://doi.org/10.1016/j.heliyon.2021.e06823

2. Wijayaningtyas M, Lukiyanto K. Home occupants awareness toward Green building : Greenship rating index application. In: AIP Conference Proceedings 2447. 2021. p. 1–6.

3. Kustamar, Wijayaningtyas M, Irfan M. Value engineering: Application in avtur pipeline work at juanda international airport. Int J Sci Technol Res [Internet]. 2019;8(10):1092–6. Available from: http://www.scopus.com/inward/record.url?eid=2-s2.0-85073977031&partnerID=MN8TOARS

4. Wijayaningtyas M, Redjo RESM, Handoko F, Lukiyanto K, Jiram WRA. The Millennials ' Energy Efficiency Behaviour towards Eco-friendly Home. Civ Eng Archit [Internet]. 2021 [cited 2021 Apr 17];9(2):394–403. Available from: http://www.hrpub.org

5. Wijayaningtyas M, Sipan I, Lukiyanto K. Informal worker phenomenon in the housing construction project. In: AIP Conference Proceedings. 2017.

6. Wijayaningtyas M, Lukiyanto K. Informal housing construction workers' perceptions toward the improvement of effective leadership and performance. MATEC Web Conf. 2019;258:02004.

7. Handoko F, Wijayaningtyas M, Kusuma IHA, Hidayat S, Ismail A, Abdullah Z. The occupational health and safety effect on road construction worker performance. Civ Eng Archit. 2020;8(5):750–9.

8. Nursanti E, Sibut, Hutabarat J, Septiawan A. Risk management in subsea pipelines construction project using Delphi method, FMECA, and continuous improvement. ARPN J Eng Appl Sci.

2018;13(11):3834–8.

9. Laksmana DI, Wijayaningtyas M. Integration facility management: Human resources. Int J Sci Technol Res. 2019;8(12):701–5.

10. Zahra AN, Kurniawidjaja LM. Construction Workers' Fatigue Conditions at PT. X Construction Contractor Apartment Development in the 2017 Work Year. KnE Life Sci. 2018;4(5):46.

11. Zhang M, Murphy LA, Fang D, Caban-Martinez AJ. Influence of fatigue on construction workers' physical and cognitive function. Occup Med (Chic Ill). 2015;65(3):245–50.

12. Nghitanwa EM, Zungu LI. Occupational health and safety provision awareness among construction workers on the construction industry of Windhoek, Namibia. Int J Heal. 2017;5(1):60.

13. Aryal A, Ghahramani A, Becerik-Gerber B. Monitoring fatigue in construction workers using physiological measurements. Autom Constr [Internet]. 2017;82(December):154–65. Available from:http://dx.doi.org/10.1016/j.autcon.2017.03.003

14. Andarini YD. Occupational Stress As Risk Factors of Subjective Fatigue for Workers in Weaving Loom Unit Pt . X. J Ind Hyg Occup Heal. 2017;1(2):134–47.

15. Christi WA, Suwondo A, Setyaningsih Y. Reduction of Fatigue Levels of Workers in the Construction Worker by Consuming Banana Chips with the Vacuum Frying Method. E3S Web Conf. 2019;125(201 9):0–5.

16. Wahyu Adi TJ, Ayu Ratnawinanda L. Construction Worker Fatigue Prediction Model Based on System Dynamic. MATEC Web Conf. 2017;138.

17. Didik Wargiono, Julianus Hutabarat, Dimas Indra Laksmana. Analysis Of Musculosckeletal Complaints Disordered With Reba Method And Rula Method, Journal of Sustainable Technology and Applied Science, 2021, 2(1), 9-16, https://doi.org/10.36040/jstas.v2i1.3578