The Subjective Method Application to Mitigate the Construction Workers Accident

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**Abstract**. Quality, cost, and time are the primary targets of construction projects; the working-environment applying occupational safety and health is also crucial. An employer can implement occupational safety and health (OHS) by providing rules and appeals to minimize workplace accidents. Several studies found that workers' stress and fatigue caused workplace accidents. Therefore, this study aimed at identifying workers' fatigue based on subjective measurements using survey; the researchers distributed questionnaires to 30 workers multi-storey building construction projects. The analysis results revealed that workers' fatigue reached a total score of 76, which was categorized in level 3 and classified as high fatigue. The study concluded that corrective action in implementing occupational health and safety was imperative. In addition, employers need to use work-methods that can minimize workers' fatigue in construction projects. Identifying fatigue is expected to minimize work accidents in constructing multi-storey buildings.

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 [1–4]. The technology transfer affects the development process in all fields, especially construction [1,5,6]. Law no. 2 of 2017 article 59 concerning Construction Services states that in every construction service operation, service users and providers are obliged to meet Security, Safety, Health, and Sustainability Standards [7]. 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. It maintains the work environment's health and safety; it also protects colleagues, workers' families, consumers, and other people who may also be affected by work environment conditions [8–10].

Companies must perform and supervise work following existing standard operating procedures to create safe, comfortable, and productive working conditions [1,11–13]. 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, one of which is caused by stress and fatigue [14]. 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. Work facilities that are not ergonomic, a work environment that fails to meet the requirements, and unnatural work attitudes can also cause workers to lose their focus in performing their work [15]. 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 minimize the risk of work accidents; it is an effort to apply OHS 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) [16]. The construction of multi-storey buildings gives much workload, so it is essential to identify workers' errors based on subjective factors to minimize 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 measurements. It is expected that this measurement can provide positive input for project implementers and owners on applying OHS correctly. It is also beneficial for determining appropriate work methods to reduce and prevent work accidents.

1. Literature Review

## Occupational Health and Safety (OHS) and Construction Work

## These days, many organizations pay attention to Occupational Health and Safety (OHS) as it includes issues of humanity, economic costs and benefits, legal aspects, responsibility, and the organization's image [17]. The company must consider the occupational health and safety program. It is implemented to protect workers from occupational hazards and their impacts.

Work safety includes safe materials and work-processes, a safe workplace and work tools, a safe environment and work methods. Work safety aims to prevent workers from getting injured and avoid damage or loss to equipment, materials, and production. Thus, the company should consider several factors such as humans, machines, materials, work methods, and work environment [8]. These factors often influence the occurrence of accidents, so the company needs to monitor them effectively. In essence, occupational health is the harmony between work capacity, workload, and work environment. If the work environment's danger is not anticipated correctly, it will burden the workers. Occupational health is an effort and condition, enabling workers to maintain their physical, mental, and social health conditions at work. The company can apply it by setting rules and making efforts to prevent workers from conditions detrimental to health, indicated by physical, mental disorders, emotions, or pain caused by the work environment [18].

## 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 [19]. 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 [20]. One of the internal factors is a person's age, which will affect the condition, ability and capacity of the body to perform activities [8]. Work productivity will decrease with age. Work capacity, including functional, mental, and social capacity, will decline before the age of 45, which will decline by the age of 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. Complaints at work due to work-related illness indicates 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 [19].

## 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). It is a method done by distributing questionnaires measuring emotional-fatigue levels [21]. Through the questionnaire, the researchers ask the symptoms or subjective feelings of the respondent. On the IFRC scale, there are 30 fatigue symptom questions on the list. The subjective fatigue level and classification are shown in Table 1.

**Table 1.** Subjective Fatigue Classification [21]

|  |  |  |  |
| --- | --- | --- | --- |
| **Fatigue Level** | **Total Score** | **Fatigue Classification** | **Actions** |
| 1 | 30 – 52 | Low | Corrective action is not considered yet |
| 2 | 53 – 75 | Moderate | Corrective action may be required |
| 3 | 76 – 98 | High | Corrective action is required |
| 4 | 99 – 120 | Very high | Corrective action is required promptly |

1. Materials and Methods

This research employed a quantitative survey method with a descriptive analysis to describe the conditions. 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 one of the high-rise building projects in Surabaya city. The number of respondents was determined through probability sampling (the simple sampling); 30 respondents were involved in this research.

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 [21]. In this scale, there were 30 fatigue symptom questions listed. Table 2 presents the categories to prevent construction work accidents due to worker fatigue in high-rise building projects in Surabaya 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), 4 = very often (score 4).

**Table 2.**Symptoms Associated with Fatigue [21]

|  |
| --- |
| **Questions** |
| **No.** | **Weakened Performance of Activities** | **No.** | **Weakened Motivation** | **No.** | **Weakened Body (Exhaustion)** |
| 1. | Head felt heavy | 11. | Thinking difficulty | 21. | Headache |
| 2. | Whole body tiredness | 12. | Too tired to speak | 22. | Stiff shoulder(s) |
| 3. | Legs felt heavy | 13. | Nervousness | 23. | Back pain |
| 4. | Yawning | 14. | Not concentrating | 24. | Breathing difficulty |
| 5. | Distracted mind | 15. | Having trouble focusing | 25. | Thirst |
| 6 | Sleepiness | 16 | Forgetting easily | 26 | Hoarseness |
| 7. | Eyes felt heavy | 17. | Decreased self-confidence | 27. | Feeling dizzy |
| 8. | Awkward and stiff body movement | 18. | Anxiety | 28. | Eyelids stiffness |
| 9. | Being unsteady while standing | 19. | Difficulty in controlling attitude | 29. | Limbs trembling |
| 10. | Wanting to lie down | 20. | Laziness in work | 30. | Feeling unwell |

1. Results and Discussion

Based on primary data from distributed questionnaires, respondents' profile is shown as in Figure 1 and Figure 2. All of 30 respondents were male and mostly young (17-35 years old). In the productive age, most of them have worked on similar projects for more than five years. When the questionnaire was distributed, they worked on wall mounting with precast concrete panels on the 4th floor. The responses were analyzed descriptively by summing up all scores and calculating the average score for each indicator. The results of the subjective fatigue level measurement are shown in Table 3.

**Figure 1.** Respondents' Profile (Age and Experience)

**Table 3.** Subjective Measurement Results

|  |  |
| --- | --- |
| **Variable** | **Total Score** |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| **Weakened performance of activities** | 22 | 25 | 21 | 27 | 28 | 22 | 23 | 26 | 21 | 25 | 27 | 25 | 23 | 30 | 22 | 21 | 24 | 28 | 27 | 24 | 22 | 25 | 26 | 28 | 31 | 23 | 25 | 22 | 24 | 27 |
| **Weakened Motivation** | 24 | 26 | 23 | 22 | 25 | 27 | 24 | 27 | 28 | 29 | 25 | 24 | 21 | 24 | 28 | 25 | 26 | 23 | 28 | 23 | 26 | 25 | 27 | 26 | 24 | 22 | 27 | 26 | 25 | 22 |
| **Weakened Body** | 26 | 30 | 27 | 26 | 21 | 25 | 27 | 22 | 23 | 25 | 23 | 29 | 30 | 28 | 24 | 27 | 29 | 30 | 21 | 28 | 26 | 29 | 30 | 25 | 21 | 23 | 26 | 27 | 29 | 27 |
| **Score** | **72** | **81** | **71** | **75** | **74** | **74** | **74** | **75** | **72** | **79** | **75** | **78** | **74** | **82** | **74** | **73** | **79** | **81** | **76** | **75** | **74** | **79** | **83** | **79** | **76** | **68** | **78** | **75** | **78** | **76** |
| **Total Score** | **2280** |
| **Average Score** | **76,00** |
| **Fatigue Classification** | **3 - High (corrective action is required)** |

The measurement results in Table 3 show that the construction workers' level of fatigue was high (level 3), with an average score of 76. Based on the classification in Table 1, corrective action is required. Some respondents were scored 30 on the Physical Weakness variable, revealing that they felt physical weakness (thirst, dizziness, feeling unwell, and pain in the back). Therefore, this subjective measurement can be used as a reference for identifying workers' fatigue and weakness. Thus, fatigue prevention measures can be determined appropriately to minimize and prevent work accidents, especially in high-rise buildings.

Fatigue can be reduced in a variety of ways aimed at the general condition and physical environment at work, for example, by regulating working hours, providing appropriate opportunities for rest [22]. Workers should avoid static work attitude and pursue dynamic work attitude to reduce the high level of fatigue [23], 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 to complete the work at the targeted time and prevent work accidents simultaneously.

1. Conclusion

The study results show that most workers experienced high levels of fatigue 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 even preventing work accidents on construction projects. Furthermore, as a positive impact, zero accidents can be achieved at the worksite. Further research related to identifying the construction workers' fatigue level using an objective method or measuring the effect of subjective and objective measurements combination is essential.

Acknowledgment

References

[1] Handoko F, Nursanti E, Tjahjadi M E, Hutabarat J and Mulyadi L 2018 Green Industrial System in Indonesia (Matec Web of Conferences) p 164

[2] Handoko F, Nursanti E, Harmanto D and Sutriono 2016 The role of tacit and codified knowledge within technology transfer program on technology adaptation *ARPN J. Eng. Appl. Sci.* **11** 5275–82

[3] Handoko F, Vitasari P, Hidayat S and Tjahjadi M E 2019 Technology transfer program for SMEs in Indonesia *Journal of Physics: Conference Series* vol 1375 (Institute of Physics Publishing) p 12053

[4] Hidayat S, Tjahjadi M E and Vitasari P 2018 The Triple Helix and Technology Capability and Competitiveness of SMEs in Developing Economy *Int. J. Civ. Eng. Technol.* **9** 366–78

[5] Kustamar, Wijayaningtyas M and Irfan M 2019 Value engineering: Application in avtur pipeline work at juanda international airport *Int. J. Sci. Technol. Res.*

[6] Wijayaningtyas M, Hidayat S, Halomoan Nainggolan T, Handoko F, Lukiyanto K and Ismail A 2020 Energy Efficiency of Eco-Friendly Home: Users' Perception *E3S Web of Conferences* vol 188

[7] Anon 2017 Republic of Indonesia Law Number 2 of 2017 in Construction Service

[8] Handoko F, Wijayaningtyas M, Kusuma I H A, Hidayat S, Ismail A and Abdullah Z 2020 The occupational health and safety effect on road construction worker performance *Civ. Eng. Archit.* **8** 750–9

[9] Wijayaningtyas M, Sipan I and Lukiyanto K 2017 Informal worker phenomenon in housing construction project Informal Worker Phenomenon in Housing Construction Project *AIP Conf. Proc.* **1903** 1–7

[10] Wijayaningtyas M and Lukiyanto K 2019 Informal housing construction workers' perceptions toward the improvement of effective leadership and performance *MATEC Web Conf.* **258** 02004

[11] Nursanti E, Ma'ruf A, Simatupang T and Iskandar B P 2012 Cost and availability functions using imperfect maintenance policy for a serial system *ISBEIA 2012 - IEEE Symposium on Business, Engineering and Industrial Applications* pp 386–91

[12] Nursanti E, Sibut, Hutabarat J and Septiawan A 2018 Risk management in subsea pipelines construction project using Delphi method, FMECA, and continuous improvement *ARPN J. Eng. Appl. Sci.* **13** 3834–8

[13] Laksmana D I and Wijayaningtyas M 2019 Integration facility management: Human resources *Int. J. Sci. Technol. Res.* **8** 701–5

[14] Zahra A N and Kurniawidjaja L M 2018 Construction Workers' Fatigue Conditions at PT. X Construction Contractor Apartment Development in the 2017 Work Year *KnE Life Sci.* **4** 46

[15] Zhang M, Murphy L A, Fang D and Caban-Martinez A J 2015 Influence of fatigue on construction workers' physical and cognitive function *Occup. Med. (Chic. Ill).* **65** 245–50

[16] Hapis A A 2019 Hubungan karakteristik individu beban kerja dan shift kerja terhadap kelelahan kerja pada pekerja dibagian produksi PT. Supravisi Rama Optik Karawang *Ris. Inf. Kesehat.* **8** 30

[17] Nghitanwa E M and Zungu L I 2017 Occupational health and safety provision awareness among construction workers on the construction industry of Windhoek, Namibia *Int. J. Heal.* **5** 60

[18] Mallapiang F, Santy Damayati D, Fadillah N, Kesehatan B, Kerja K, Uin F, Makassar A and Gizi B 2017 Gambaran Perilaku Tenaga Kerja Dan Pelaksa-Naan Program Kesehatan Dan Keselamatan Kerja (K3) Konstruksi Dalam Pembangunan Balai Diklat Bpk-Ri Makassar Oleh Pt. Wijaya Karya (Persero) Tbk **9** 72–84

[19] Aryal A, Ghahramani A and Becerik-Gerber B 2017 Monitoring fatigue in construction workers using physiological measurements *Autom. Constr.* **82** 154–65

[20] Andarini Y D 2017 Stres Kerja Sebagai Faktor Risiko Kelelahan Subyektif Pada Pekerja Unit Weaving Loom Pt . X Occupational Stress As Risk Factors of Subjective Fatigue for Workers in Weaving Loom Unit Pt . X *J. Ind. Hyg. Occup. Heal.* **1** 134–47

[21] Febrianti A and Khotimah A N 2020 Usulan Perbaikan Kerja Kuli Panggul Beras Menggunakan Cocorometer dan Subjective Self Rating Scale (SSRT) Serta Hubungan Parameter Stres dan Kelelahan Pada Perusahaan X Di Kota Bandung *J. Rekayasa Sist. Ind.* **9** 23–32

[22] Christi W A, Suwondo A and Setyaningsih Y 2019 Reduction of Fatigue Levels of Workers in the Construction Worker by Consuming Banana Chips with the Vacuum Frying Method *E3S Web Conf.* **125** 0–5

[23] Wahyu Adi T J and Ayu Ratnawinanda L 2017 Construction Worker Fatigue Prediction Model Based on System Dynamic *MATEC Web Conf.* **138**