Conference Paper

Construction Workers' Fatigue Conditions at PT. X Construction Contractor Apartment Development in the 2017 Work Year

Azyyati Nabiilah Zahra and L. Meily Kurniawidjaja

Occupational Health and Safety Department, Faculty of Public Health, Universitas Indonesia, Jl. Margonda Raya, Beji, Pondok Cina, Kota Depok, Jawa Barat 16424, Indonesia

Abstract

Fatigue is one of the main factors of workers' accidents in construction. This study aimed to find out the fatigue conditions of PT. X construction workers. Using cross-sectional design and Industrial Fatigue Research Committee Questionnaire, it was found that 100 percent of workers experience fatigue before and after work, with the prevalence of fatigue above low increased after working from 52.5 to 69.3 percent, meaning that further assessment and improvement were needed. The study found, working time (p = 0.02) and water consumption (p = 0.05) are risk factors that have significant correlation with worker's fatigue. Control measures that had been done were limiting the overtime hours, providing temporary shelter, and regular exercise. It was suggested to tighten the policy of working hours, promote healthy lifestyle, and control working environment factors.

Keywords: fatigue, construction worker, IFRC, occupational health

Corresponding Author:
L. Meily Kurniawidjaja
meily@ui.ac.id

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1. Introduction

International Labour Organization estimates that every year, there are at least 60,000 fatal accidents at construction sites around the world [1]. In Indonesia, in 2010, PT Jamsostek and Kemenaker Indonesia recorded that the construction sector contributed to 31.9 percent of all occupational accidents in various industrial sectors, ranking in first place [2]. In Indonesia, work fatigue is one of the three main causes of injuries and accidents in the construction field [2]. In May 2017, a pre-survey of construction workers at PT. X identified several factors that pose a potential risk of fatigue in the workplace, such as long working hours. From the results of a pre-survey interview with 20 construction workers, 90 percent of the workers stated that they had worked overtime in the past week, 72.2 percent of whom (13 people) had an average working time of approximately 13 hours a day or 91 hours a week. Moreover, 80 percent of the

workers reported that they often felt tired or sore throughout their whole body, and 60 percent of the workers reported often feeling drowsy. Fatigue level or conditions will increase if they are continuously ignored and will often result in health problems and/or accidents. This study aims to describe construction workers' fatigue conditions at a PT. X construction contractor apartment development in the 2017 work year.

2. Methods

This research used a cross-sectional study design and a semi-quantitative method. The research was conducted by assessing the level, type and risk factor of fatigue on construction labours at PT. X apartment development in May–June 2017, using an industrial Fatigue Research Committee Questionnaire questionnaire (with 30 items assessing symptoms of subjective fatigue). The population included all construction labourers at PT. X during 2017 (N = 150). The research sample was calculated using a sample formula from a descriptive study ($\alpha = 0.05$; $P = 0.45$; $d = 0.05$) [3, 4] and was taken through proportional sampling. However, after workers who did not meet the inclusion criteria, such as workers who were sick, *off,* or not coming to work and workers who refused to participate in this research, were excluded from the study, the sample size was reduced to 101 individuals (39 metal workers, 40 form workers, 6 foundry workers, 4 MEP (Mechanical-Electrical-Plumbing) workers, and 12 daily workers).

For the hypothesis, a chi-square test was used for two categorical independent variables, and a linear regression test was used for more than two categorical independent variables. Fatigue was categorised into two levels (a mild and moderate level and a high and very high level) to test this hypothesis.

3. Results

According to the results, all the construction workers experienced fatigue before and after work, and their fatigue level increased after working from 52.5 percent (40.6% reported moderate fatigue; 11.9% reported severe fatigue) to 69.3 percent (60.4%, 7.9 percent and 1 percent reported moderate, severe and very severe fatigue, respectively). When grouped according to their work activities, such as metal, form, foundry, MEP, and daily workers, it was found that before work, there were already severely fatigued workers in all working groups (except for the foundry workers), especially mechanical-electrical-plumbing (MEP) workers. After work, the MEP group had the highest proportion of workers with severe and very severe fatigue (Table 1).

From the interview results, some of the fatigue symptoms that respondents complained about the most before and after work were thirst (83.2%), stiffness throughout the body (68.3%), back (waist) pain (60.4%), leg pain (49.5%), shoulder stiffness (47.5%) and feeling ill (47.5%).

Table 1: Level and types of fatigue.

Variables	MetalWorkers (n = 39)	Formwork (n = 40)	Foundry (n = 6)	MEP* (n = 4)	Daily Workers (n = 12)	Total Respondents
Fatigue Level (%)						
Before Work						
Mild	53.8	50	50	0	33.3	47.5
Moderate	43.6	32.5	50	25	58.3	40.6
Severe	2.6	17.5	0	75	8.3	11.9
After Work						
Mild	35.9	35	16.7	0	16.7	30.7
Moderate	61.5	55	66.7	50	75	60.4
Severe	2.6	10	16.7	25	8.3	7.9
Severe	0	0	0	25	0	1
Fatigue Type	Physically Demanding	Physically Demanding	General	General	Physically Demanding	–
Note: * = Mechanical-Electrical-Plumbing.						

Table 2: Work-related risk factors.

Work-related Risk Factors	Frequency		Mild Fatigue (%)		Moderate Fatigue (%)		Severe Fatigue (%)		Very Severe Fatigue (%)		P-Value	
	n	%	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Overtime*											0.454	0.523
Appropriate	4	4	25	50	75	50	0	0	0	0		
Inappropriate	97	**96.0**	48.5	29.9	39.2	**60.8**	**12.4**	8.2	0	**1.0**		
$\overline{X}$/day = 5.32 hours												
Min–Max/day = 0–16.7 hours												
$\overline{X}$/week = 31.92 jam												
Min–Max/week = 0–59.5 hours												
Shift											0.709	0.492
Morning shift	95	94.1	49.5	32.6	38.9	58.9	11.6	7.4	0	1.1		
Night shift	6	**5.9**	16.7	0	66.7	83.3	**16.7**	**16.7**	0	0		

Work-related Risk Factors	Frequency		Mild Fatigue (%)		Moderate Fatigue (%)		Severe Fatigue (%)		Very Severe Fatigue (%)		P-Value	
Work time**											**0.020***	0.096
Appropriate	8	7.9	25	0	37.5	75	37.5	25	0	0		
Inappropriate	93	**92.1**	49.5	33.3	40.9	59.1	**9.7**	6.5	0	1.1		
$\overline{X}$/day = 6.85 hours												
Min–Max/day = 4–9 hours												
$\overline{X}$/week = 46.44 hours												
Min–Max/week = 14–63 hours												
Years of service (months)												
< 1	10	9.9	50	20	20	80	**30.0**	0	0	0	0.282	0.977
1 – 3	62	61.4	45.2	30.6	41.9	58.1	**12.9**	9.7	0	**1.6**		
> 3 – 6	25	24.8	52	24	44	68	4	8	0	0		
> 6	4	**4**	50	**100**	50	0	0	0	0	0		
Workload												
Light	3	3	33.3	66.7	66.7	33.3	0	0	0	0	0.254	0.626
Moderate	17	16.8	52.9	29.4	41.2	58.8	5.9	11.8	0	0		
Heavy	66	**65.3**	43.9	28.8	43.9	**62.1**	**12.1**	**7.6**	0	**1.5**		
Very heavy	15	14.9	60	33.3	20	60	**20.0**	6.7	0	0		
Work climate												
Not hot at all	2	2	50	0	0	100	50	0	0	0	0.071	0.263
Slightly hot	20	19.8	50	35	50	50	0	15	0	0		
Warm	42	**41.6**	52.4	33.3	38.1	59.5	9.5	7.1	0	0		
Overheated	24	23.8	41.7	29.2	45.8	66.7	12.5	0	0	**4.2**		
Very overheated	13	12.9	38.5	23.1	30.8	61.5	**30.8**	**15.4**	0	0		
Lighting												
Too bright	4	4	0	25	100	75	0	0	0	0	0.999	0.924
Slightly glare	18	**17.8**	38.9	27.8	50	55.6	**11.1**	**11.1**	0	5.6		
Bright enough	68	67.3	47.1	29.4	39.7	61.8	13.2	8.8	0	0		
Dark	9	8.9	77.8	22.2	11.1	55.6	**11.1**	0	0	0		
	2	2	100	50	0	50	0	0	0	0		
Too dark												
Noise level												
Quiet	10	9.9	50	30	30	50	20	20	0	0	0.291	0.469
Rather noisy	27	26.7	48.1	33.3	44.4	63	7.4	3.7	0	0		
Noisy	45	**44.6**	42.2	33.3	46.7	55.6	11.1	8.9	0	**2.2**		

Work-related Risk Factors	Frequency		Mild Fatigue (%)		Moderate Fatigue (%)		Severe Fatigue (%)		Very Severe Fatigue (%)		P-Value	
Too noisy	9	8.9	55.6	22.2	33.3	77.8	**11.1**	0	0	0		
Extremely noisy	10	9.9	60	20	20	70	**20.0**	**10.0**	0	0		
Note: * Appropriate = ≤ 3 hours per day & 14 hours per week (UU RI No. 13/2003);												
** Appropriate = ≤ 7 hours/day and 40 hours/week (6 working days /week) or 8 hours/day and 40 hours/week (5 working days/week) (UU RI No. 13/2003)												

Table 3: Non-work-related risk factors.

Non-work-related Risk Factors	Frequency		Mild Fatigue (%)		Moderate Fatigue (%)		Severe Fatigue (%)		Very Severe Fatigue (%)		P-Value	
	n	%	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Age (years)											0.744	0.781
	38	37.6	47.4	21.1	42.1	71.1	10.5	7.9	0	0		
≤ 25												
	63	**62.4**	47.6	36.5	39.7	54	**12.7**	7.9	0	**1.6**		
>25												
$\overline{X}$ = 31.37; Min–Max = 19–65												
Health status											0.402	0.166
No risk to fatigue	84	83.2	46.4	32.1	40.5	60.7	13.1	6	0	1.2		
More risk of fatigue	17	**16.8**	52.9	23.5	41.2	58.8	5.9	**17.6**	0	0		
Smoking											0.635	0.885
Not a smoker	6	5.9	33.3	50	66.7	50	0	0	0	0		
Ever smoke	12	11.9	50	33.3	41.7	58.3	8.3	8.3	0	0		
Smoker	83	**82.2**	48.2	28.9	38.6	61.4	**13.3**	**8.4**	0	**1.2**		
Caffeinated drinks consumption (cups)												
Not at all												
1 – 2	15	14.9	40	20	53.3	73.3	6.7	6.7	0	0	0.571	0.571
> 2 – 5	26	25.7	69.2	42.3	19.2	50	11.5	7.7	0	0		
> 5	53	**52.5**	41.5	30.2	45.3	60.4	13.2	7.5	0	**1.9**		
$\overline{X}$ = 2.64	7	**6.9**	28.6	14.3	57.1	71.4	**14.3**	**14.3**	0	0		
Min-Max = 0 – 8												
Water consumption (Litres)	5	**5**	40	0	60	80	0	**20**	0	0		
< 1	32	**31.7**	40.6	21.9	46.9	65.6	12.5	12.5	0	0		

Non-work-related Risk Factors	Frequency		Mild Fatigue (%)		Moderate Fatigue (%)		Severe Fatigue (%)		Very Severe Fatigue (%)		P-Value	
1 – < 2	62	61.4	51.6	37.1	35.5	58.1	12.9	3.2	0	1.6	0.999	**0.050***
2 – 5	2	**2**	50	50	50	0	0	50	0	0		
> 5 – 8	0	0	0	0	0	0	0	0	0	0		
> 8												
$\overline{X}$ = 2.24												
Min-Max = 0.24 – 7												
Sleep quantity	54	53.5	48.1	27.8	40.7	59.3	11.1	11.1	0	1.9	0.798	0.125
Appropriate (≥ 7 hours/day)	47	**46.5**	46.8	34	40.4	61.7	**12.8**	4.3	0	0		
Inappropriate (<7 hours/day)												
$\overline{X}$ = 6.79 hours												
Min–Max = 3 – 10 hours												
Body Mass Index (BMI)											0.822	0.671
Normal	70	69.3	41.4	30	45.7	60	12.9	8.6	0	1.4		
Abnormal	31	**30.7**	61.3	32.3	29	**61.3**	9.7	6.5	0	0		
Commuting time											0.712	0.753
	100	99	47	30	41	61	12	8	0	1		
≤ 30 minutes												
	1	**1**	100	100	0	0	0	0	0	0		
> 30 minutes												
Second job											0.565	0.372
No second job	96	95	47.9	31.3	40.6	60.4	11.5	7.3	0	1		
Have second job	5	**5**	40	20	40	60	**20**	**20**	0	0		
Social responsibilities											0.221	0.297
No social responsibilities	91	90.1	45.1	27.5	41.8	62.6	13.2	8.8	0	1.1		
Have social responsibilities	10	**9.9**	70	60	30	40	0	0	0	0		
Family responsibilities											0.234	0.523
Single	33	32.7	40.6	25	53.1	68.8	6.3	6.3	0	0		
Married	68	**67.3**	50.7	33.3	34.8	56.5	**14.5**	8.7	0	1.4		

The distribution of work-related fatigue risk factors is listed in Table 2. It was found that before work, there was a significant correlation between working time (p = 0.02) and worker fatigue. Most respondents worked (without including overtime) more than

7–8 hours per day or 40 hours per week (92.1%), with an average working time of 46.44 hours per week; some were found to work up to 63 hours per week. Meanwhile, almost all the respondents worked overtime for more than 3 hours per day or 14 hours per week (96%), with an average of 5.32 hours of overtime per day and 31.92 overtime hours per week. A heavy and very heavy workload in construction work was reported by 65.3 percent and 14.9 percent of the respondents, respectively. It was found that 16.7 percent of workers on the night shift (start work at night) experienced severe fatigue before and after work. The highest proportion of severe fatigue was found among workers with an overheated work climate (15.4%), and very severe fatigue after work was found among workers in a very overheated climate.

The distribution of unrelated fatigue risk factors is shown in Table 3. It was found that 16.8 percent of workers had a health status that put them at greater risk of fatigue. The majority of respondents were smokers (82.2%). More than half of the respondents consumed > 2–5 cups a day of caffeinated drinks (52.5%), while 6.9 percent consumed > 5 cups a day, and some (1%) even consumed more than 8 cups a day.

A significant correlation was found between water drinking behaviour (p = 0.05) and worker fatigue after work. About 31.7 percent of workers still drank from 1 to 2 or more litres of water a day; 5 percent of workers only drank less than 1 litre of water a day, but others (1%) only drank 0.24 litres a day. In terms of the quantity of sleep, 46.5 percent of the respondents had less than 7 hours per day, while other workers (4%) only slept 3 hours per day. It was also found that 59.4 percent of workers had sleep disorders (i.e., insomnia).

4. Discussion

4.1. Work fatigue

All the construction workers in this study were found to experience a moderate and high level of fatigue both before and after work, with the majority of them experiencing increased fatigue (a very high level of exhaustion) after work. Construction work involves high-risk activities and requires physical and mental alertness among workers at all times [5]. In this study, the workers who felt fatigue tended to have complaints of physical and cognitive malfunctions [6]. Fatigue experienced by construction workers can be very dangerous because it can result in effects such as reduced concentration, poor decision making, failure in using work equipment and compromises on safety

regulations; based on previous research, these effects are some of the determining factors and conditions (*shaping factors*) of workplace accidents [7, 8].

Based on the categorisation of fatigue symptoms experienced by construction workers in Saito's study [9], the most serious symptoms of fatigue that found on this study were drowsiness, slackness of capabilities to work and specific feelings resulting from body malfunction. To reduce these complaints, workers can practice warming up regularly before work and stretching at set intervals between working hours. However, further research is needed regarding the workplace design and other ergonomic factors to address the underlying causes of fatigue.

In the current research, the working group that had the highest proportion of workers with severe and very severe fatigue was the MEP group. MEP work is related to the construction of sanitary and electricity infrastructure and facilities in a structure being built [10]. In this study, it was found that 50 percent of the workers had heavy workloads, worked on the *night shift*, and had long working hours (10.06 hours per day and 66.75 per week). Another factor that might have been influential was the small number of workers during the time of the research – for example, only 8 people worked out of the 15 people supposed to be working because the 7 others were *off* (i.e., *taking a leave*) – so the workload was almost twice as heavy as usual.

4.2. Work-related risk factors

As mentioned in the results section, a significant correlation was observed between working time (p = 0.02) and worker fatigue before work. The average duration of total working time (normal + overtime) of the respondents was 12.17 hours per day and 78.36 hours per week, and a longer working time was found among several individuals. This is in line with a study on worker fatigue, which showed that the risk of incidents or injury and occupational diseases was doubled among workers who worked more than 12 hours per day and 60 hours per week compared with those working 8 hours per day [11]. Other studies have also found that the culture *of long working hours* among construction workers who do not take a break (in a day) or holidays (in a week), reaching a limit of ≥50 hours per week, can result in conditions of fatigue that double the risk of injury compared with normal working hours [7]. According to a Centers for Diseases Control and Prevention (CDC) report, the 9th and 12th hours are a critical time in which workers experience a decline in awareness, an increase in fatigue, and a decrease in cognitive function [12].

Construction work activities require substantial physical effort. This demand for physical effort is a potential cause of increased risk of fatigue among construction workers [13]. If this type of work is coupled with a heavy workload, the excessive energy demand on workers will lead to fatigue, lowering job performance by reducing the speed of work and increasing the risk of *error* while working [14, 15].

In this study, 51 percent of the workers, who were on the morning shift, complained that the most tiring phase of their shift was during the afternoon. Explanations for this include the hot environmental conditions, heavier workload, time limitations (i.e., the need to rush) and the condition of the workers' bodies as they began to get tired. In contrast, the *night shift* workers in this study experienced a high level of fatigue both before and after work. Working on the *night shift* can disrupt the body's circadian rhythms, which can affect the quality (such as sleep disorders) and quantity of sleep and work performance, as well as causing a metabolic imbalance in the body [11]. In addition, *night shift* workers tend to have a low level of alertness in the span from 3 a.m. to 5 a.m. in the morning, which can increase the risk of occupational accidents [16].

The majority of respondents in this study felt that the climate at their current workplace was hot. Many workers complained about the natural weather conditions, such as the heat from concrete vapour and the open structure of the building site, allowing the sun to shine on them directly. When the air in an environment is hot, the body requires sufficient rest to minimise its metabolism rate [17]. Moreover, a hot climate can reduce the body's fluid level through sweating, triggering a state of exhaustion [17].

4.3. Non-work-related risk factors

Although most workers did not have a high-risk health status, some of the participants had diseases or conditions that could trigger or exacerbate fatigue, such as anaemia, hypotension, kidney disease, asthma and dizziness [11, 13]. Meanwhile, other health conditions were observed that could have been triggered by fatigue or excessive work load, including ulcers and waist pain [18]. Other health conditions that could harm the safety and health of the workers during construction projects were identified among the workers, such as hearing loss and asthma.

As mentioned earlier, 82.2 percent of the respondents were smokers. Smoking is a lifestyle choice that causes fatigue indirectly because nicotine in cigarettes can reduce the flow of oxygen in lung and blood tissue, which inhibits the process of energy

production [11]. Smoking can stimulate the nervous system and affect the quality of sleep [11], which can also be exacerbated by the consumption of caffeinated beverages. Consuming caffeinated beverages within six hours before bedtime can contribute to a lack of sleep, and caffeine can only provide a temporary energy boost to the body; once this energy boost is depleted, it will trigger fatigue [11]. In addition, the consumption of over six such *caffeinated* beverages per day makes one vulnerable to anxiety, irritability and decreased performance [11]. The study results showed that some workers drank up to eight caffeinated beverages per day (as aforementioned), and most of the workers consumed coffee within six hours before bedtime.

Other important risk factors for fatigue among the workers in this study were water consumption and quantity of sleep. A significant correlation was found between water consumption (p = 0.05) and worker fatigue after work. The average consumption of water among workers in this study is lower from construction workers' water consumption standard. Some of the workers in the current study complained that the quantity of water supplied by the foremen in their divisions was insufficient. Some work crews on the same floor were only provided one gallon of water per day, which had to be shared among the 15–20 members of the crew. The location of the water was also a barrier to adequate water consumption. Most of workers deliberately ignored their thirst while working because they felt too tired to go down 5 or 6 floors and go back up within a short time just to get a drink. Not drinking enough fluid can lead to dehydration, causing the body to function less efficiently; this behaviour increases the risk of and exacerbates fatigue [11]. Construction crews working in a hot, humid environment, in addition to a heavy physical workload, tend to be vulnerable against dehydration and heat stress [19].

Regarding the quantity of sleep, the average amount of sleep required for adults is 7–8 hours [20, 21]. Continual sleep deprivation will lead to an accumulated *sleep debt* and increase fatigue-related risks [11, 22]. Furthermore, a lack of sleep at night can increase an individual's blood alcohol concentration to 0.05 percent and 0.1 percent, respectively, if that individual is awake for 17 and 20 hours, causing his or her work capability and performance to decrease; that individual will experience a loss of concentration and an increase of exhaustion [16].

5. Conclusions

All construction workers in this study experienced fatigue before and after work, with the majority of the workers experiencing an increased fatigue level after work. Fatigue

due to physical workload was experienced by metal, formwork, and daily workers. Meanwhile, the foundry and MEP workers experienced general fatigue. In a construction work context, a high level of fatigue was estimated to be linked to the following factors: the work culture of *long working hours*, a heavy workload, the night shift, a hot work climate, extreme or insufficient lighting (too light/too dark) at work, a high level of noise, and a working period classified as new *workers* (working period less than 3 month). Fatigue was found to be exacerbated by non-work-related conditions, such as the following: water consumption below two litres a day, smoking, the consumption of over five caffeinated beverages a day, insufficient quantity and quality of sleep, risky health statuses, abnormal BMI, family obligations, age (above 25 years) and an additional job (among a fraction of workers). The results showed that working time (p = 0.02) and water consumption (p = 0.05) were significantly correlated with worker fatigue before and after work, respectively.

6. Recommendations

Controlled measures have been taken to reduce the risk of fatigue among the construction crew, such as preventing workers who have worked overtime until 04:00 a.m. on one shift from coming to work before 04:00 p.m. the following day. Workers were provided with a dorm, and regular gymnastic activities have been introduced. Further attempts that can be made include tightening the maximum working time restrictions under national law (Act No. 13/2003) and increasing the number of field workers. Construction crews could be given time off work (especially after the 9th working hour) and offered a *break time* during *shift*. Pre-work training could be conducted for new workers, and workers could be educated about acceptable working hours, the risks of work-related fatigue and the importance of *healthy lifestyles*. Drinking water facilities should be provided for workers on each floor or on every two floors, and the condition of *the dorm* could be improved to make it more comfortable for the workers to rest. Furthermore, healthy and nutritious food could be offered at affordable prices in the workers' cafeteria. Pre-work or routine health screening could be conducted to detect diseases and conditions that are harmful for workers on a construction project.

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