Manual Handling Process in IBS Precast Concrete Panel Site Construction: A Case Study

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Abstract
Precast concrete panel is one of the Industrial Building System (IBS) components which is used in the modern construction industry especially in urban areas. Implementation of precast concrete panel in site creates an issue as it uses manual handling process during the construction. This study focuses in site construction using a concrete panel with 3300mm x 600mm size and compressive strength 40MPa. Consequently, issues of Musculoskeletal Disorders (MSDs) among those workers arises due to repetition of IBS workers lifting the concrete panel manually. This problem automatically reduces workers productive and giving strain for the workers when they have to spend more money and time for rehabilitation process. Aim for this is to investigate and analyze the recommended weight limit (RWL) and lifting index (LI) for those workers during the manual handling process using those precast concrete panel. The method used along this study includes; interview session, NIOSH lifting index calculation and recommended work limit calculation. The result gained at the end of this study lead to (MSDs) problem. The Recommended Weight Limit (RWL) shows the maximum or the limit of the weight that can be carried by an individual in completing the task while the Lifting Index (LI) interpret performs significant level of the risk of MSDs. This project come out with the recommend of RWL for the workers and lifting index figure thus increase the awareness among the workers and employers about the (MSDs) issues.

Keywords: musculoskeletal disorders, precast concrete panel, industrialized building system

1.0 Introduction

IBS is defined as an implementation of construction manufacturing through components prefabrication in building construction (Mohd Nawi, Othman Mydin, Abdul Nifa, Osman, & Anuar, 2015). IBS can also be defined as a construction technique in which components are manufactured in a controlled factory environment, transported within logistic area, mate and assembled into a structure with minimal supplementary site work (Oleiwi, Mustapha, & Al-Mattarneh, 2010). In order to reduce the dependency on unskilled workers from the neighboring countries, the government set up IBS Strategic Plan in 1999 to promote IBS by initially introducing the blueprints of industrialized construction of 2015, followed by the IBS Roadmap 2003-2010 and IBS Roadmap 2011-2015 (Mohd Nawi et al., 2015). However, the viewpoint for IBS execution in Malaysia still needs to be encouraged with essential initiatives from the Government by encouraging the manufacturers, contractors and suppliers to absorb the IBS system (Nurul Azam Harun, 2017). According to M.R. Yusof, Musa, Samsudin, Mohammad, & Baharuddin (2016) the construction can be

clarified based on material, process and system. M.R. Yusof et al., (2016) asserted that the weight relation of components must be used for building categorization and weight has played a significant role, impacting on the mobility and production technique of the components and their erection method on site.

As IBS become one of the construction method system, generally construction workers includes this system are always exposed to the hazard at workplace. Previous study from Zerguine et.al (2018) showed that six large construction projects in Malaysia involved 323 foreign construction workers, saying that those workers (31.5%) will have experienced falling from a great height (6 feet or more above lower level), followed by handling and lifting components (24.7%). (2018) (Zerguine, Tamrin, & Jalaludin, 2018) According to Luttmann, Matthias, Caffier, & Lieber (2003), the illness in the workplace is divided by two fragments namely in-site disease and long-term disease. The illness in-site diseases are related to pathophysiological response to internal or external factors where immediate injury is caused by 4 main factors; fallen from high level, dropped objects, tucked between objects and tripping. long-term disease is related to a disorder or disruption to a regular bodily structure and function. A syndrome is a collection of signs and symptoms associated with a specific health-related cause (Health and Safety Executive, 2017). One of the issues in construction for a long-term disease is Musculoskeletal Disorders (MSDs), caused by carrying out tasks or handling materials repeatedly beyond the limits (Adnan & Aziruddin Ressang, 2014). MSDs are injuries and disorders that affect the human body's movement or musculoskeletal system especially in joint part which occur while the workers are performing repetitive motions (Choi & Rajendran, 2014). Musculoskeletal Disorders (MSDs) are a common disease related to handling and lifting components, especially in sudden force beyond the human limitation or by repetitive work. Activities involving heavy loads can result in acute injury, but most occupation-related MSDs are from motions that are repetitive, or from maintaining a static position (Barzideh, Choobineh, & Tabatabaee, 2014). MSDs are triggered by biomechanical burden which must be applied in executing jobs, energy period, and frequency with which tasks are done. MSDs can affect joints and tendons in all parts of the body and muscles (Luttmann et al., 2003). The most effect was on different parts of the body of MSDs including the upper and lower back, neck, shoulders and extremities (arms, legs, feet, and hands) (Rwamamara, Lagerqvist, Olofsson, Johansson, & Kaminskas, 2010). According to Sang D. Choi & Lu Yuan (2016), MSDs are injuries and disorders of the certain tissue especially joints of body parts and nervous system. Examples of MSDs include epicondylitis, tendinitis, back pain, carpal tunnel syndrome, hand-arm vibration syndrome and tension neck syndrome (Lop, Kamar, Aziz, Abdullah, & Akhir, 2017).

Precast concrete panel which is categorized as a light and medium weight panel or heavy weight panel has been prefabricated in factory and is still using manpower during its installation process (Shapie et al., 2018). Consumption of precast panel in construction industry focused due to the most popular IBS components application among the IBS industry players.

The issues occur in ergonomic term when the workers at construction site do the lifting process manually using totally abundant human energy which develops serious injuries to the muscles, tendons, ligaments and joints and in turn, reduces the productivity (Azman, Ahamad, Majid, & Shah, 2012). The current technique is unhealthy and dangerous when being performed repeatedly by workers. Due to this issue, the objectives of this study are to analyze the recommended weight limit (RWL), lifting index (LI) and physiological experience among workers while lifting precast concrete panel with 3300mm x 600mm size.

The sizes of precast concrete panel depend on certain models produced by manufacturer, and this study focused on a model produced by Yang Sulong (M) Sdn. Bhd. in Melaka. The specifications of precast concrete were 100mm thick, 600mm width and 3300mm length with weight distribution of 135 kg/m^2. The range mass of precast concrete was between 240 kg to 260 kg with compressive strength of 40 MPa. Generally, this precast concrete comes in bulk of 5 units for each pallet in a horizontal position of y.

2.0 Methodology

This study focuses on the construction site which using manual handling process to lift the concrete panel by using an ergonomic approach. Two construction site were involved in this study which are Perumahan Penjawat Awam 1 Malaysia, (PPA1M) at Jasin, Melaka and a construction for a bungalow around Baru Berendam, Melaka. The analyses involve the recommended weight limit (RWL) calculation, NIOSH lifting index (LI) calculation and physiological experience by using Nordic Questionnaire among workers while lifting precast concrete panel with 3300mm x 600mm size.

2.1 Recommended work limit (Rwl) and lifting index (Li)

Parameters such as weight of concrete panel, horizontal location(H), vertical location (V), vertical travel distance (D), asymmetry angle (A), frequency rate (F), lifting duration, and coupling component (C) were measured for every worker. Horizontal multiplier (HM), vertical multiplier (VM), distance multiplier (DM), asymmetry multiplier (AM), coupling multiplier (CM), and load constant (LC) were calculated based on measurement of each of workers involved. The data for RWL calculation were collected from 3 different types of Body Mass Index (BMI); underweight, normal and overweight. Then, these RWL results were analyzed using LI equation according to (below than 1.0) *nominal* or (more than 1.0) *high risk* (Middlesworth, 2011).

2.2 Nordic musculoskeletal questionnaire

In this study the information on psychological perception contribute to the significant problem is assessed by using the questionnaire survey. The signification between LI and MSDs by using Nordic Musculoskeletal Questionnaire (NMQ)(Kuorinka et al., 1987) were analyzed . Nordic Questionnaire was designed as a standardized questionnaire allowing the evaluation of neck, low back, shoulder and general complaints for epidemiological research use. The purpose of this survey was to identify and investigate the MSDs problem among workers due to the repeatedly lifted concrete panel activity in the workplace. This NMQ can be distributed as a

survey through structured interview or questionnaire. This questionnaire includes the general information about respondents and the significant problems regarding muscle fatigue.

Determining reliability for this study ensuring the data collection instrument used is consistent or will affect the results of the study. Internal consistency method used was translated into the *Alpha - Cronbach* score. (Taber, 2018) Six workers have been participated and data interpreted the *Alpha - Cronbach* validity test score representing each category. Based on the results, the developed questionnaire had a good reliability based on the score of 0.86 and the instrument was deemed fit for the survey. This score became an induction for the correlation stage for each item submitted in the questionnaire. 19 respondents were involved in this study who were divided into 3 categories according to weight; (6) underweight, (7) normal and (6) overweight. From Taber (2018), the validity of Cronbach Alpha interpretation is good and acceptable (0.86).

3.0 Results and discussion

The results were beneficial to improve the manual handling process of the concrete panel lifting in the IBS system. This study focused on the psychophysical (i.e., horizontal distance, vertical travel distance, precast concrete panel size, etc.) and biomechanical ergonomics factor in the form of the recommended assisting devices and appropriate body posture.

3.1 Samples

19 male participants completed the study. The distribution is summarized in Table 1.

Table 1: Personal Characteristics.

Percentages of participants (%)		
Experience		
>10 years	**5 years – 9 years**	**< 2 years**
		21
37	37	5
Percentage of BMI index respondent		
Less than 18.5 (Underweight)	**18.5 – 24.99 (Normal)**	**25- 29.99 (Over weight)**
21	32	47

Table 1 shows details of the respondents' work experience and distribution of BMI Index.

The majority of subjects (37 %) have working experience of more than 5 years. These working experiences findings showed higher result might be affected by the high salary from the employers and employers tend to keep those workers whom already have high skill for this job. 21% of respondents were underweight according to the Body Mass Index (BMI) while 32% and 47% of respondents belong to the normal and overweight category respectively.

3.2 Recommended work limit (Rwl) and lifting index (Li) and physiological experience among workers

From observation and results revealed that workers fully experience prolonged standing, manual lifting, pushing and pulling respectively. Workers never exposed to the knowledge or training about ergonomics or ergonomic studies. Level of pain and discomfort is a qualitative measure and empirical studies testing for psycho-physical are well-known methods for screening the musculoskeletal disorders (Jagannath & Adalarasu, n.d.). The outcomes from the study can best be described in Table 2. The interpretation of the mean value reflects the high level, medium level and low level involving the use of Likert scale. Estimated mean value can best be described based on Landell (1997). As illustrated in Figure 1, different body parts are related to work discomfort or pain.

Table 2: Work related discomfort/ pain perceived in different parts of body.

Characteristic	Mean
Neck	2.55
Shoulder	3.45
Upper back	3.75
Lower back	3.90
Upper arm	3.30
Lower arm	3.25
Hand	3.77
Thigh	3.55
Calf	2.45
Feet	2.35

1.00 - 2.49- Strongly disagree ; 2.50 – 3.49 - Medium3.50 – 5.00 Strongly agree (Landell,1997)

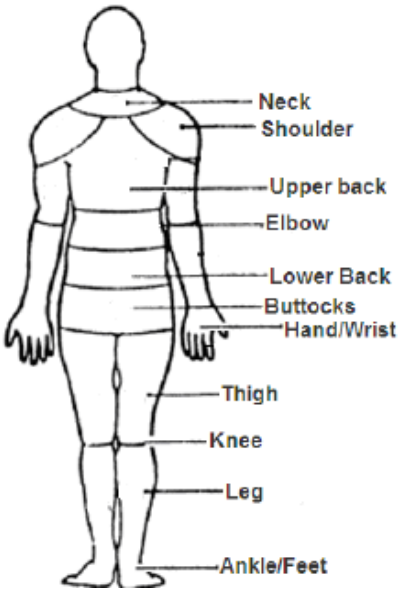

Figure 1: Work related discomfort/ pain perceived in different parts of body. (Jagannath & Adalarasu, 2011)

The findings revealed that respondents were strongly agreed that they experienced discomfort or pain in the upper back, lower back, hand and thigh with mean of 3.75, 3.90, 3.77 and 3.55 respectively. Meanwhile, respondents showed a moderate level for pain or discomfort in the shoulder, neck, upper arm and lower arm. For calf and feet parts, respondents strongly disagreed with the statement. In determining the RWL from the NIOSH lifting equation of the task conditions manipulated in the psychophysical and biomechanical experiments, the six multipliers must be calculated first. The measurements and data needed are shown in Figure 2. In general, all the respondents were classified to three groups based on the Body Mass Index (BMI) namely Normal, Underweight and Overweight.

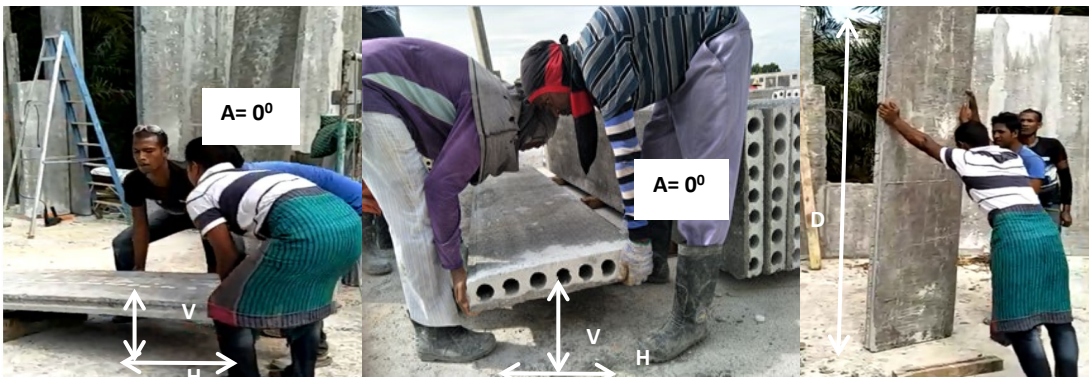

Figure 2: Psychophysical and biomechanical determination of respondents.

Mean for Recommended Weight Limit (WRL) by the BMI group is illustrated in Table 3. In addition, Lifting Index (LI), calculated using NIOSH lifting equation, can be observed in Figure 6 for each group.

Table 3: The Mean of Recommended Work Limit of the BMI groups.

	BMI		
	Less than 18.5 (Underweight)	**18.5 – 24.99 (Normal)**	**25- 29.99 (Over weight)**
Average Concrete panel per person (kg) (MAWL)	83	83	83
RWL (kg)	26.81 kg	27.91 kg	28.96kg

Note: MAWL – Maximum Acceptable Weight of Limit, RWL – Recommended Weight Limit

The results on the maximum safe weight for lifting concrete panel revealed that the RWL for Overweight BMI group was the highest with only 3.8% more than the Normal group and 8% for Underweight group. The RWL figures of these groups showed only a slight difference. Mass load in this study was 250kg which was divided to 3 or 4 workers whom responsible for lifting activities, was more than the "Load constant" itself which was 23kg. Based on NIOSH Guidelines, a load is considered in ideal and safe with maximum acceptable weight includes 75% for females and 90% for males. Surprisingly, the results show a clear trend that the RWL for each group of BMI is more than the baseline weight or load constant (LC), strongly support the idea in contrived high risk for workers for experience back injuries later.

These RWL results firmly propose that employers should consider a possible solution in depleting the risk injury factors in workplace.

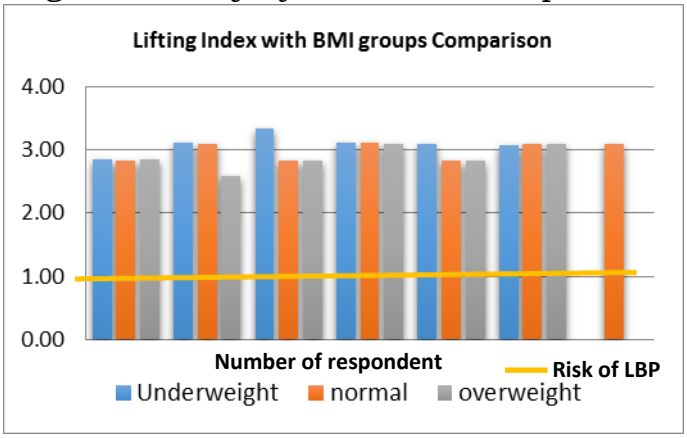

Figure 3: Lifting index for each BMI group.

Apparently, Figure 3 shows that the LI analysis demonstrated that all groups of respondents scored more than 1; ranging between 2.80 and 3.10; an overall mean of 3.10 for Underweight group, 2.98 for the Normal group and 2.88 for the Underweight group. Most of the LI values were greater than 2, describing potential high risk for the respondents whom performing such tasks for experiencing Low Back Pain (LBP). A further analysis was carried out with LI values were more than the baseline 1, added with RWL values which exceeded the baseline of LC consent the facts that workers were really imposed a higher risk of LBP.

4.0 Conclusion

In summary, the results of the Recommended Weight Limit (RWL), Lifting Index (LI) and physiological experience among workers when lifting the precast concrete panel with 3300mm x 600mm sizes yield that IBS workers have been exposed with a higher risk of LBP and will eventually suffer MSDs especially in the spine and waist. All results and analysis gained in this study lead to MSDs problem. Taken together from the RWL which is about the maximum or the limit of the weight that can be carried by an individual to complete task and the LI about the significant level of the risk would seem to suggest a lot of improvement and recommendation must be considered in terms of appropriate techniques assisted by the right design equipment or machine in elevating workers' productivity during lifting the precast concrete panel and still achieve the best health during and after performing the tasks. This scenario needs an action to be taken by multiple parties such as a government in terms of constructing a safety and healthy realms in terms of ergonomic courses or legislation for the site workers, developer as employer, union, NGOs and workers themselves in raising an awareness mutually along with an educational effort. This study revealed a figure of Recommended Weight Limit and Lifting Index that can be used by employees for increase the awareness among the workers on the (MSDs) issue as well.

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