Redesign of Ergonomic Worktables in Reinforced Concrete Sheet Works Reduce Ergonomic Risk Level

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Abstract: Iron work in the implementation of reinforced concrete work has ergonomic hazards or high potential hazards, including unnatural work posture (squatting, bending, turning the body repeatedly) in a relatively long time. The accumulation of unnatural work postures for a long time can cause premature fatigue, decreased work speed, level of accuracy, level of alertness, and the degree of health of workers which leads to a decrease in work productivity. Previous research showed that the analysis of work posture in reinforced concrete using the RULA method resulted in a RULA score of 7 (seven) and the Ergonomic Risk Factor measurement was 9 (nine), which means that these working conditions have a very high potential hazard that can cause skeletal muscle complaints. Musculoskeletal Disorders – MSDs) and require immediate improvement of working conditions. For this reason, research is carried out in the form of controlling potential hazards by redesigning existing tetrapods so as to reduce the score of potential ergonomic hazards and the tetrapod can be used not only for beam work but for all types of reinforced concrete work. The measurement of the potential hazard score was carried out in two ways, namely using RULA and using ergonomic risk factor assessment SNI 9011: 2021. The results showed that there was a decrease in the RULA score from 7 to 5 and a decrease in ergonomic potential hazard from a score of 9 to 4. It was concluded that the redesign of the work desk Ergonomics reduces the level of ergonomic risks factor.

1 INTRODUCTION

Industry in the field of Civil Engineering and Mechanical Engineering, including the construction world, still contributes the most to the number of fatal work accidents, not only in developing countries, but also in developed countries such as Europe. Eurostat (Jones, 2019) reported that the construction industry contributed the highest fatal accidents reaching more than 20%. Meanwhile, the ILO (ILO, 2015) also reported that construction work accidents were partly caused by a lack of training and experience on OSH. In Nairoby-County Kenya, 74% of workers injured or killed when accidents occur are under the age of 40, occurring during the busiest hours (10-11am, and 3-4pm). Falls from heights and being hit by falling objects account for about 64% of all construction site accidents. Referring to BPJS Employment data, the number of work accidents in the construction sector in Indonesia has always been in the range of 32% (Manuaba, 2006; Ministry of Manpower of the Republic of Indonesia, 2018). The ILO reports that work-related fatalities are much higher than fatal occupational accidents (ILO, 2015). Fatal work-related illnesses account for about 86% while fatal work accidents are only around 14%. The type of occupational disease with the largest cost compensation is muscle complaints or injuries (Musculoskeletal Disorders – MSDs). Previous research on ergonomic studies for reinforced concrete work shows that the work posture of reinforced concrete iron shows a RULA score of 7 which means it has a very high potential for MSDs hazards and requires immediate improvement of working conditions (Sudiajeng et al., 2018).

Based on the results of this research, ergonomics innovation has been carried out in stages to improve the working conditions of reinforced concrete work. Reinforced concrete work consists of iron work, concrete molds and casting. Ergonomics innovation begins with designing work aids for beam iron work, namely in the form of a tetrapod designed based on

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worker anthropometry. The tool is used as a workbench for reinforcing reinforced concrete beams and has been proven to improve static sitting work postures to dynamic standing work postures, reducing the risk of MSDs from the high category (Rula score 7) to the medium category (Rula score 4) and reducing the need for the number of workers from 7 (seven) people to only 2 (two) people)/beam. Iron work in building construction is very diverse, starting from beam and column work as well as foundation and floor plate work.

every worker problem needs to be intervened. Ergonomics intervention will provide an effective solution for workers as well as for company management (Bridger, 2008; International Ergonomics Association, 2020; Kroemer & Grandjean, 2009). The problem of workers is not only in work posture but also in occupational health, it is also necessary to provide a solution to the problem (Edem, Akpan, & Pepple, 2017; NIOSH, 2015; Stanford, 2016).

This research is a continuation of previous research with a focus on ergonomics innovation for plate iron work which has different characteristics from beam/column work, in terms of design, level of difficulty, and dimensions. Through this research, it is hoped that an ergonomic workbench can be created in the form of a portable, flexible, inexpensive work table, and can be used not only for beam/column work, but for all types of reinforced concrete work. One of the characteristics in the application of total ergonomics is solving multidisciplinary problems, so it requires disciplines from mechanical engineering to redesign ergonomic workbenches and civil engineering to construction work.

2 METHOD

This research was carried out with an experimental design using the Control Group Design method. Subjects consisted of 2 (two) groups, namely the control group who carried out the foundation plate ironing work with old working conditions before the ergonomic intervention was carried out (P1) and the treatment group (P2) which carried out the foundation plate ironing work with new working conditions after the intervention. ergonomics.

The ergonomic intervention carried out was to redesign the work table according to student anthropometry so that it could be used for reinforced concrete work or foundation plate reinforcement. The research sample is a student of the Department of Civil Engineering at the Bali State Polytechnic who is taking reinforced concrete reinforcement practice. The number of samples was 50 people, the P1 group was 25 students and the P2 group was 25 students. Ergonomic hazard level measurement is carried out in two ways, namely using the Rapid Upper Limb Assessment (RULA) and using the Ergonomic Risk Factor (ERF) Assessment SNI 9011 in 2021. Data analysis was carried out in a quantitative descriptive manner by comparing the RULA and ERF scores before and after repairs.

3 RESULTS AND DISCUSSION

3.1 Subject Anthropometric Analysis

The research subjects were Civil Engineering students who practiced reinforced concrete work as many as 50 students. Anthropometry of the student body is measured as the basis for redesigning the workbench on reinforced iron work. The results of student anthropometric measurements are as follows.

Table 1: Anthropometric Data of Research Subjects.

measured component	Mean	SD	percentile		
			5	50	95
Standing height	168,07	6,20	162,20	165,30	177,00
Standing elbow height	105,82	6,70	95,10	104,65	116,50
Sitting height	87,85	2,99	84,00	86,95	93,00
Sitting elbow height	24,38	2,70	19,70	24,65	28,20
Buttock-knee length	56,71	2,31	54,00	56,35	59,70
Popliteal buttock length	46,96	1,97	44,30	47,20	49,20
Knee height, sitting position	49,66	2,23	46,80	49,60	52,90
Popliteal height, sitting position	42,48	1,57	40,30	42,35	44,20
Shoulder-elbow length	35,37	2,60	31,70	35,80	38,70
Elbow to fingertip length	45,75	2,00	43,20	45,40	48,50
hand length	17,31	0,41	16,70	17,30	18,00
hand width	10,46	0,39	9,90	10,45	11,20
Reach ahead	72,06	2,36	68,50	72,65	74,30

SD: Standard Deviation

Worker anthropometry data is very important to design the tools used in work, so that the tools can be used optimally by workers if they are adjusted to the user's anthropometry (Budiyanto, Adiputra, Sutjana, & Tirtayasa, 2019; Kamat, Md Zula, Rayme, Shamsuddin, & Husain, 2017).

3.2 Work Tool Redesign

The redesign of the ergonomic workbench on the reinforced concrete slab iron work is a redesign of the previous workbench which is not in accordance with the user's anthropometric size. Redesign of work aids in the form of a tetrapod that is portable, flexible, adjustable and multi-functional, namely as a workbench for the assembly of structural beams and columns. The height of the tetrapod can be adjusted according to the user's comfort level. Aside from being a beam and column assembly workbench, in a reclining position it can also be used as a plate assembly workbench by adding a work board on it. The redesigned image of the tetrapod workbench is as follows.

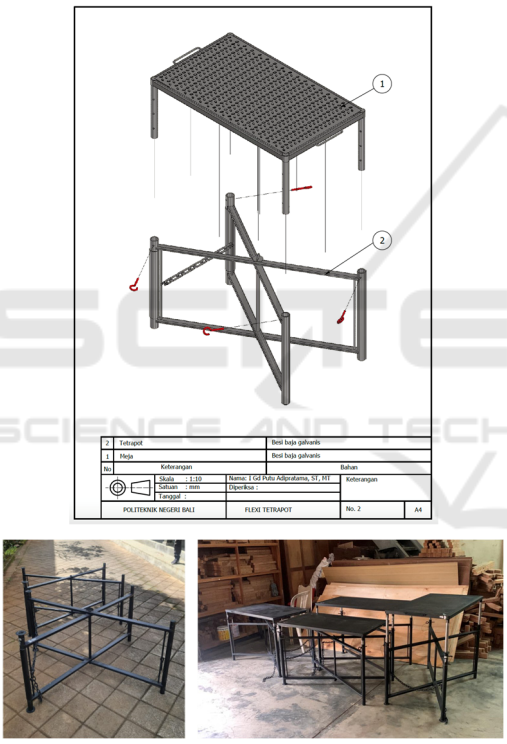

Figure 1: Tetrapod workbench design.

In accordance with the user's anthropometry, the height of the table can be adjusted between 60 - 90 cm, while the width of the table according to the reach is 60 cm and the length is 103.9 cm.

3.3 RULA Analysis

Analysis of upper body posture in workers can be measured using the RULA method. The evaluation of the RULA method is as follows.

Table 2: RULA Grand Grand Score Evaluation.

Grand Score	Score = 1 - 2	Posture Acceptable if not maintained or repeated for long periods
	Score = 3 – 4	Further investigation is need and changes may be required
	Score = 5 – 6	Investigation and changes are required soon
	Score = 7	Investigation and changes are required immediately

The results of the calculation of the RULA score are as follows.

Figure 2: Calculation of RULA Score.

Based on the results of the RULA calculation, it was obtained that before the RULA score was corrected, a grand score of 5 was obtained, this indicates that a score of 5-6 means that investigation and change are required soon, after using the redesign of the tetrapod table, the grand score decreased to 3, which means that the grand score is 3-4 further investigation is needed and change may be required.

Measurement using RULA analysis is one way to determine the level of ergonomics hazard so that it can be used in providing interventions on changes in work posture, both before and after the intervention given to workers (Yadi, Kurniawidjaja, & Susilowati, 2018; Yusuf, Adiputra, Dewa, Sutjana, & Tirtayasa, 2016).

3.4 Ergonomic Risk Factor (ERF) Analysis

Ergonomics risk level assessment is carried out using Ergonomic Risk Factor SNI 9011 Year 2021 (BSNI,

2021). Risk level assessment before redesign is as follows.

Table 3: Ergonomic Risk Factor assessment results.

	Potential Hazard Assessment Results Score			Total Assessment Results	Result Interpretation
	Upper Body	Body Back and Lower	Manual Weight Lifting		
Before Repair	7	0	2	9	Score more than 7 (dangerous)
After Repair	2	0	2	4	Score between 3-6 (needs further observation)

Based on Table 3, the ergonomic risk factor score is 9 which indicates that there is a potential hazard in reinforced concrete work, and it needs to be controlled immediately. Control is done by using a redesigned tetrapod table.

Ergonomics intervention is very necessary in order to suppress worker problems, both problems related to muscle complaints, fatigue, and increasing worker productivity (Budiyanto & Yusuf, 2020; Deouskar N, 2017; Kasper, 2014). Ergonomics approach needs to be done both in small industries and in large companies to increase work productivity (Manuaba, 2006; Sudiajeng, Adiputra, & Leibbrandt, 2012).

4 CONCLUSIONS

a. The results of the redesign of work aids in the form of a tetrapod that is protable, flexible, adjustable and multi-functional, namely as a workbench for assembling beams and structural columns. The height of the tetrapod can be adjusted according to the user's comfort level. Aside from being a beam and column assembly workbench, in a reclining position it can also be used as a plate assembly workbench by adding a workboard on it.
b. The result of measuring the RULA score before repair is 7 (Investigation and changes are ruquaired immediatelly) and after repair is 4 (Further investigation is need)
c. The result of measuring the level of ergonomic hazard risk using SNI 9011 in 2021 is that before the repair, a score of 9 (Dangerous) was obtained, while after the improvement, a score of 5 was obtained (Need further observation).

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