Arranging the Work Environment Increases Productivity in Reinforced Concrete Work Practices

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Abstract. Reinforced concrete construction work, particularly in large-scale construction projects, involves a series of physical activities that demand the endurance of the worker's body, as well as a high level of concentration and skill. The quality and efficiency of work are highly dependent on the conditions of the work environment and the physical well-being of its workers. Unfortunately, although the construction sector is one of the main drivers of economic growth, it is also known to have a relatively high rate of work accidents. The causes are varied, but the factor of structuring the unergonomic work environment is one of the main causes of injuries. Poor work environment arrangements, such as imperfect body position, equipment, and materials that are located far from the job site, can lead to physical fatigue and increase the risk of long-term injury. Therefore, it is important to design and optimize the work environment with an ergonomic approach that can support worker productivity and reduce the potential for work accidents. This research aims to identify and optimize the arrangement of the work environment in the reinforced concrete construction sector, in order to increase worker productivity while reducing the risk of injury. The research methods used were field observation and interviews. Based on the results of observations on 3 work items, namely concrete decking, practical column rebar, and foot plat rebar, an average productivity increase of 18.47% was obtained.

Keywords: Concrete, Productivity, Reinforced

1 Introduction

The construction sector, especially in reinforced concrete construction work, has a very important role in the development of infrastructure and the economy of a country. However, the sector is also known for its high rate of work accidents and problems related to worker welfare. Reinforced concrete construction work often requires strenuous physical activity, such as lifting heavy materials, bending, and working in unergonomic body positions. This poses a risk of long-term injury, such as muscle and joint disorders, back complaints, and excessive fatigue. These conditions not only harm workers but also have a direct effect on productivity, efficiency, and quality of work (Yuliana & Rani, 2020). In addition, the arrangement of the work environment that

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does not pay attention to ergonomic aspects also worsens the situation. Factors such as tight workspaces, the use of tools that do not suit the physical needs of the worker, and the arrangement of the working position can lead to discomfort that reduces the focus and effectiveness of the worker. The lack of attention to the design of the work environment that supports the comfort and safety of workers makes the construction sector one of the sectors with a fairly high accident rate (Yuni et al., 2021). Given the importance of the contribution of workers to the success of construction projects (Rahadian, 2021), this study aims to identify and optimize the arrangement of the work environment with an ergonomic approach, in order to support increased productivity in reinforced concrete construction work. Produktivitas tenaga kerja dipengaruhi oleh ketersediaan alat, ketersediaan material, kondisi lapangan, dan komunikasi yang efektif (Fassa et al., 2021; Urrahmi et al., 2023). This research is expected to provide useful recommendations for construction industry players in designing a healthier, safer, and more productive work environment.

2 Methodology

This research was carried out in a concrete work practice workshop at the Department of Civil Engineering, Bali State Polytechnic. The method of data collection is through observation and the distribution of questionnaires. Observations were carried out to identify real conditions in the field, especially related to the arrangement of the workspace, the position of the workers' bodies, the use of tools, and the storage of materials. Observation was focused on students who were carrying out reinforced concrete work practices. A questionnaire was distributed to students who participated in concrete work practices to gauge their perceptions of the current state of ergonomics, as well as its impact on occupational comfort, productivity, and health. The research was carried out through 4 stages: Analyzing the conditions of the existing work environment, Calculating productivity before environmental planning, designing the environmental arrangement and using an ergonomic worktable, and calculating productivity after arranging. The structuring activities carried out are in the form of arranging the placement of materials and work tools close to the work site, and using an ergonomic workbench in assembling reinforcement (Miska, 2020). This workbench is in the form of a tapod that can be adjusted in height to suit workers and can be moved around (Sudiajeng et al., 2022).

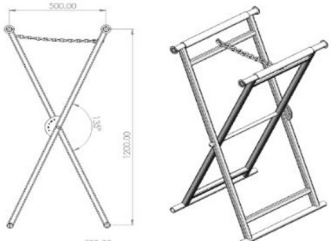

Figure 1. Ergonomic Tetrapod

Productivity measurement is carried out by comparing work outputs before and after the implementation of ergonomic design. Work output is measured in terms of task completion time and the number of work units completed in a given period. The results of this measurement are the main basis for assessing the effectiveness of the ergonomic intervention carried out. If there is an increase in productivity after environmental planning, it can be concluded that the arrangement has a positive impact. The questionnaire was given to obtain a perception of work comfort, work efficiency, and the impact of the work environment on productivity and health (Desmonda et al., 2023). A healthy workforce will work productively (Fardiansyah & Herlambang, 2022).

3 Result and Discussion

3.1 Result

Facility layout can shorten mobilization distance (Sidabutar et al., 2023; Yahya et al., 2023). However, observations of the existing work environment revealed two main obstacles. The first is the location of materials that are scattered and not concentrated in one place. Materials such as reinforcing iron, formwork boards, cement, sand, and work tools are often placed at various points without a clear storage system or arrangement. As a result, students have to pace back and forth to pick up materials and tools, which not only wastes time but also makes the work area more congested. This inefficient distribution of materials leads to queues in material retrieval, especially when only one tool, such as a wheelbarrow or cutter, is available. The second obstacle is that many students perform tasks in non-ergonomic positions, such as squatting or sitting on the floor while cutting iron, assembling reinforcement, or mixing concrete. Working in these positions for extended periods can cause muscle fatigue, back pain, and even minor muscle injuries. Over time, this habit can lead to poor working patterns and does not comply with construction work standards that prioritize ergonomics. The works reviewed included the manufacture of concrete decking, practical column rebar, and local foundation rebar. The results of the observation on the productivity of each job are shown in Tables 1, 2, and 3 below. Based on the table below, the work of making concrete decking, from tool preparation to cleaning, takes 3.08 hours or 185 minutes, which is done by 12 students. The working area of 0.72 m x 0.60 m x 2 units is 0.86 m^2. Thus, the working productivity is 0.86 m^2/hour (12 people x 3.08 hours) is 0.023 m^2/hour. Based on the table below, the practical column work, which spans from tool preparation to cleaning, takes 3.72 hours or 223 minutes, and is completed by 6 students. The weight of the practical column reinforcement is 11.60 kg with a length of 4 m. Thus, the working productivity is 11.60 kg / (6 people x 3.72 hours) = 0.518 kg/hour.

Table 1. Observation Results of Existing Concrete Decking Work

No.	Research time		Activity	Working time (minutes)
	Start	Finish		
1	09.00	09.19	Tool Retrieval	28
2	09.19	09.31	Job site setup	22
3	09.31	10.17	Sifting sand material	27
4	10.17	10.23	Collecting the sand sieve into a bucket	6
5	10.23	10.51	Mixing sand sieve with cement	28
6	10.51	11.02	Preparing decking concrete molds	11
7	11.02	11.41	Filling and leveling concrete in molds and installing wire	39
8	11.41	12.05	Cleaning of work tools	24
			Total	185~3.08 hours

Table 2. Observation Results of Existing Column

No.	Research time		Activity	Working time (minutes)
	Start	Finish		
1	09.00	09.11	Tool Retrieval	11
2	09.11	09.44	Iron cutting	33
3	09.44	11.58	Stirrup reinforcement fabrication	74
4	11.58	12.45	Stirrup reinforcement installation	47
5	12.45	13.05	Fastening of the Stirrup reinforcement	36
6	13.05	13.27	Cleaning of work tools	22
			Total	223~3.72 hours

Table 3. Results of Observation of Existing Foot Plat

No.	Research time		Activity	Working time (minutes)
	Start	Finish		
1	08.28	08.43	Tool Retrieval	15
2	08.43	09.04	Iron cutting	21
3	09.04	09.49	Bending of reinforcement	45
4	09.49	11.09	Arrange the reinforcement of each iron diameter according to the working drawings	80
5	11.09	12.17	Fastening reinforcement	68
6	12.17	12.31	Cleaning of work tools	14
			Total	243~4.05 hours

Based on the table above, the work of making the local foundation is calculated from the preparation of tools to cleaning, it takes 4.05 hours or 243 minutes, which is done

by 6 students. The weight of the reinforcement of the local foundation is 45.15 kg. Thus, the working productivity is 45.15kg / (6 people x 4.05 hours) = 1.857 kg/hour.

Environmental planning is focused on arranging the placement of materials and equipment close to the work site. In addition, the ergonomic tertapod is also used for reinforcement work.

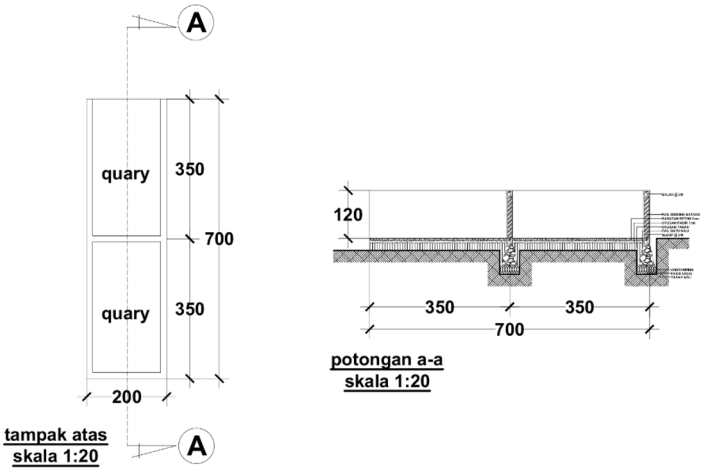

Figure 2. Arrangement of Material and Tool Placement

Observation of work productivity after the work environment arrangement was carried out, with the results as shown in Tables 4, 5, and 6 below:

Table 4. Observation Results of Concrete Decking Work After Arrangement

No.	Research time		Activity	Working Time (minutes)
	Start	Finish		
1	08.40	08.52	Tool Retrieval	12
2	08.52	09.13	Job site setup	21
3	09.13	09.38	Sifting sand material	25
4	09.38	09.56	Collecting the sand sieve into a bucket	18
5	09.56	10.23	Mixing sand sieve with cement	27
6	10.23	10.28	Preparing decking concrete molds	5
7	10.28	10.58	Filling and leveling concrete in molds and installing wire	30
8	10.58	11.17	Cleaning of work tools	19
			Total	157~2.62 hours

Based on the table above, the work of making concrete decking, from tool preparation to cleaning, takes 2.62 hours or 157 minutes, which is done by 12 students. The working

area of 0.72 m x 0.60 m x 2 units is 0.86 m^2. Thus, the working productivity is 0.86 m^2/ (12 people x 2.62 hours) is 0.028 m^2/hour.

Table 5. Observation Results of Practical Column Reinforcement Work After Arrangement

No.	Research time		Activity	Working time (minutes)
	Start	Finish		
1	08.25	08.31	Tool Retrieval	6
2	08.31	09.01	Iron cutting	30
3	09.01	10.08	Stirrup reinforcement fabrication	67
4	10.08	10.58	Stirrup reinforcement installation	50
5	10.58	11.16	Fastening of the Stirrup reinforcement	18
6	11.16	11.28	Cleaning of work tools	12
			Total	183~3.05 jam

Based on the table above, the practical column creation work, which spans from tool preparation to cleaning, takes 3.05 hours or 183 minutes and is performed by 6 students. The weight of the practical column reinforcement is 11.60 kg with a length of 4 m. Thus, the working productivity is 11.60 kg/hour (6 people x 3.05 hours) is 0.63kg/hour.

Table 6. Results of Observation of Foot Plate Reinforcement Work After Arrangement

No.	Research time		Activity	Working time (minutes)
	Start	Finish		
1	09.01	09.13	Tool Retrieval	12
2	09.13	09.32	Iron cutting	19
3	09.32	10.14	Bending of reinforcement	42
4	10.14	11.31	Arrange the reinforcement of each iron diameter according to the working drawings	77
5	11.31	12.23	Fastening reinforcement	52
6	12.23	12.31	Cleaning of work tools	8
			Total	210~3.50 hours

Based on the table above, the local foundation construction work, from tool preparation to cleaning, takes 3.50 hours (210 minutes) and is completed by 6 students. The weight of the reinforcement of the local foundation is 45.15 kg. Thus, the work productivity is 45.15kg / (6 people x 3.50 hours) = 2.149 kg/hour.

3.2 Discussion

Based on the results of the analysis, the comparison of work productivity between the existing condition and after the arrangement is presented in Table 7 below.

Table 7. Comparison of Productivity Before and After Setup

No.	Work	Productivity			Percentage
		Before	After	Unit	
1	Concrete Decking	0.023	0.028	m^2/jam	17.83%
2	Practical Column Rebar (8 cm x 8 cm)	0.518	0.632	Kg/jam	21.86%
3	Foot Plat Reinforcement (100 cm x 80 cm)	1.858	2.150	Kg/jam	15.71%
	Average				18.47%

Based on the table above, it is evident that productivity increases after the arrangement is carried out. The average increase in productivity is 18.47%.

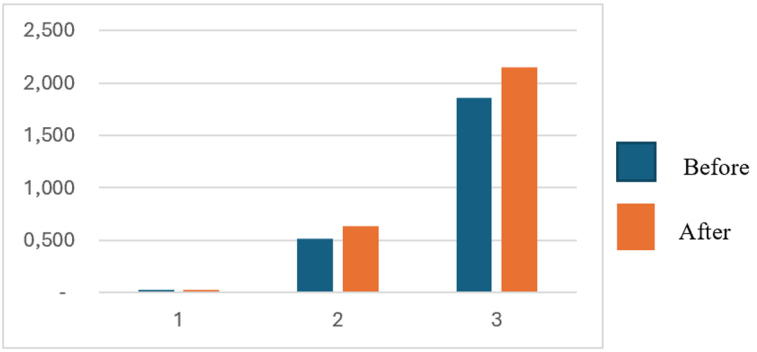

Figure 3. Productivity Graph Before and After Setup

4 Conclusion

Arranging the work environment by placing materials and tools close to the work site and using an ergonomic work desk can increase work productivity in reinforced concrete work practices by 18.47%. This research was conducted on the practice of reinforced concrete work by students who lack work experience. Further research is needed to examine the real construction work in reality.

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