

# **Workers' Productivity Analysis on Structural Construction Methods for Building Projects in West Jawa**

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**ABSTRACT :** To construct both high and medium rises building projects, we often encounter delay problems in implementation. One of the causes is a mismatch of planning methods of implementation with the number of manpower planning. In addition to the workforce is an important factor in the implementation of construction projects, the selection of right method for building structures can greatly affect the speed of the project itself.

This paper discusses case studies' productivity of construction methods for building structures analyzed and aims to determine worker productivity by using certain construction methods. The industrialization of construction method will be a challenge ahead to face the tight competition globally. This paper will show how the productivity of prefabricated construction method has less time for completion and higher productivity on worker on site.

The research was conducted in 3 building projects, namely X (1) at Bandung, Y (2) at Bekasi, Z (3) at Depok. Research is done by observing the level of worker productivity in working on different structural methods in each project.

The first research problem will identify and analyse the factors and variables of worker productivity in structural work methods for above 3 building projects using qualitative analysis on literature review for structural work methods. The second research problem will show the results of the analysis of worker productivity in the structural work method for 3 building projects mentioned above.

**KEYWORDS:** Productivity, construction methods, productivity analysis, worker productivity

## **I. INTRODUCTION**

The economic crisis that hit Indonesia has hit the construction sector to a low point. Under these conditions, the construction service company is required to raise its competitiveness in order to survive. One of these competitive advantages is the existence of workers on site. In a construction project, construction workers are an essential factor. Good worker productivity is indispensable for successful construction projects. Worker productivity will greatly affect the amount of profit or loss of a project. In Indonesia, the productivity of workers is still far behind when compared to some other countries, such as Japan and Germany which still hold the highest rank for human resources. This low productivity leads to delays in construction projects. According to SoepardiHarris<sup>[1]</sup> concluded the delay in a construction project depends on the productivity of many things, among others: 1). Human resource issues, 2) unsuitable work methodology, 3) finances, 4) technological limitations.

This research is limited to the implementation phase of a medium rise construction project on the construction of a building structure in 3 locations, namely X (1), Y (2), Z (3). Because of a wide range of discussion on low worker productivity, this study is only limited on worker productivity in relation to construction methods for structural work.

The method of construction of the execution of structural work on the building has actually been made by the contractor concerned when bidding on the job. However, often mistake to choose the method is made to make the productivity of the power becomes very low and as a result the work become delay. In other words, the construction method of the right structural work will be able to increase worker productivity and can complete the project in faster

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time. Structural work on a large scale on time or ahead schedule will make the after work relatively easier and will result in projects that are timely, of good quality and still within a measurable budget.

This study will also present case studies of structural construction methods that can be analyzed qualitatively in which productivity of workers will be compared. Productivity analysis will be made in 3 construction methods according to the work done within a certain period of time in 3 different building projects.

## Research Problems

1. What are factors and variables on construction workers in West Jawa ? (1st research problem)
2. What is the result of worker productivity analyst in structural work method for buildings in West Jawa and the comparison on each method? (2nd research problem)

## II. LITERATURE REVIEW

### Worker Productivity

Productivity is a term in production activity as a comparison between output (output) and input (input). According Aprilian<sup>[2]</sup>, productivity is a measure that states how well resources are regulated and utilized to achieve optimal results. Technically productivity is a comparison between the results achieved (output) with the overall resources needed (input). Productivity is the comparison between the results achieved with workers' achievement in certain time rate Riyanto<sup>[3]</sup>. To conclude, worker productivity is the ability of workers in production compared with inputs used, a worker can be said to be productive if he / she is able to produce goods or services in accordance with the expected in a expected time.

### Productivity Analysis

Measurement of work productivity as a means to analyse and encourage production efficiency. Another benefit is to set targets and uses, practically as a standard in the payment of workers' wages.

There are two kinds of productivity measurement tools, namely:

- a. Physical productivity, ie quantitatively such as size, length, weight, number of units, time, and worker costs.
- b. Value productivity, ie productivity measure by using the value of money expressed in rupiah, yen, dollar and so on. Raviyanto<sup>[4]</sup>.

### Structural Construction Methods

The method of implementation of the work or commonly abbreviated as CM (Construction Method) is a sequence of logical work execution with techniques in relation to the availability of required resources and work site conditions to obtain effective and efficient way of execution. In this research, structural construction methods are construction method using different system based on the material and way of construct. They are divided into 3 construction methods in making floor structure for each building, namely

#### a. Cast-in-place Method

Based on SNI concrete, the basic structural system of lateral load restraint in general can be distinguished to be:

- Structural Resistance frame system
- Structural wall systems

The characteristic of this method is the required material delivered to the site and made almost 100% in the site of work formwork, installation of steel reinforcement up to the casting floor. Due to the 100% of work done on site, thus, this method relies heavily on work force and depends on site conditions such as weather and strict supervision.

The 1 X project at Bandung uses a cast in place system in the process. The project has 5 floors which must be completed in 9 months with total area per floor is 19,000 m<sup>2</sup>. The width of each floor is 1600 m<sup>2</sup>.

#### b. Precast Construction Method

Precast Construction is the industrialization of construction methods in which the components are manufactured massively assembled in building projects with the assistance of cranes and other lifting and handling equipment.

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Prefabricated Structural Components are constructed from concrete through precast units / precast numbers or precast elements depending on alternative use, well controlled casting is given time for hardening and reaches certain cool strengths before lifting and leading to the construction site. The construction method created using prefabricated components is collectively referred to as “*prefabricated construction* “. This trend leads to component manufacturers. In this case study the construction precast material was produced at the PT A plant in TigaraksaTangerang and sent to the Project Y ( 2 ) Bekasi.

Project 2 Y project uses a concrete precast system. This project has 5 floors which must be completed in 10 months with total area per floor is 22,200 m<sup>2</sup>. The width of each floor is an average of 3100 m<sup>2</sup>.

### c. Steel Construction Method

System construction of a building steel is a combination of structural elements in which uses a rigid steel construction (rigid). Steel construction systems use steel members as columns and beams. The steel columns are connected onto the foundation using bolt and nut joint. System connection between columns, beams and steel truss of floor can be weld or mechanically bolt and nut joint. The connection between columns and beams uses the principle of a rigid connection. Various loads and forces acting on buildings include vertical, horizontal, temperature, vibration, and so on. In a steel building, there are always elements that function to withstand the force of gravity and the lateral force.

Steel building construction systems have many advantages over buildings with concrete structures, including: 1. Steel structure work does not require scaffolding such as concrete structures. 2. Steel construction systems can be made with a relatively faster time. 3. Steel construction systems have a different kind of aesthetic and modern impression. 4. Steel construction systems have smaller dimensions than concrete construction systems.

For this research, steel work is fabricated at PT B factory in Balaraja Industrial Estate and sent to project Z ( 3 ) at Depok. Project 3 Z Project uses a steel construction system in progress. This project has 3 floors which must be completed in 4 months with total area per floor is 12,500 m<sup>2</sup>. The width of each floor is an average of 2400 m<sup>2</sup>

## III. RESEARCH METHODOLOGY

### **Method of 1st Research Problem**

The first research methodology is qualitative approach by conducting literature study. In this study will refer to the 6th edition of PMBOK and compared with some journals such as "Frame Managing Projects in Organizations how to make the best use of time techniques and people, Davidson J.<sup>[5]</sup>", and other journals.

Qualitative method used to identify and classify with objectives such as:

1. Determine the number of workers and the background to carry out the work of the floor structure of each work method.
2. Analyzing the facts and data and productivity trends of each worker's sampling for a particular construction method.
3. Determine factors and variables that affect the analysis of worker productivity on structural construction methods in building project.

### **Method of 2nd Reserach Problem**

The research conducted is qualitative, which take sample from a population and use result evaluation data schedule as main data collection tool. This research was conducted in 3 medium rise building development project. The data was collected 3 times observation in each of the above projects.

The method used to get the research data from X project at Bandung (1), Y project at Bekasi (2), Z project at Depok (3) is direct observation on site, gather data plan vs. reality mapping casting each floor, site supervisors' interview and photo documentation. The object of research observed is the workers who do the structural work per floor on site. The data analysis used is the volume of work produced by each work group of workers and what factors influence the productivity of that working group using literature review and expert discussion.

The research on work group productivity constructing the floor of building structure consisting of placing of columns' reinforcement, installation of columns' formwork and concreting then similar activity applies to beams and slabs to form one floor structure where each project has its own working method. The stages and procedures of this study are carried out systematically. The stages and procedures of the research that will be carried out are as follows:

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1) The Preparation

At this stage, research starts to formulate the problem, the purpose of research, determining the problem boundary by exploring the literature and making questionnaires or questionnaires that will be asked in research in order to run smoothly

2) Data Collection

Searching and digging data that is required directly on site. The steps taken are:

(a) Survey on site

(b) Determining the zone to be observed (measured in m<sup>2</sup>). Determining the start of period of working time for determined group of workers (measured in days)

(c) Collecting data on the productivity of the working group

3) Research Phase

Stage of data analysis and analysis of the results.

Methods of measuring labor time (days) are established to determine productivity over outcomes achieved. Although the construction method is different from each project, the productivity of the worker will be standardized in the same unit, i.e. how many days the completion of one floor of the building structure in each project.

## IV. RESEARCH ANALYSIS

### Analysis the first research problem.

Identification of causal factors is carried out on the literature review. Gita Silvia <sup>[6]</sup> stated some factors that affected on productivity are work experience, supervision, project layout, and training / certification which have followed by workers, whereas Susianti Winoto <sup>[7]</sup> explained in her research findings on the how the productivity should be improved the need for (1) Establishing needs and schedules of material-use planning, (2) a system for storage and material access road to the project, (3) a schedule of ordering and distribution of performance / production workers and (4) factors for checking the quality of materials, had a very strong influence. However those above factors are indirectly will affect the worker productivity. To some extent, welfare factors for workers to be taken into account are (1) The Company had understood the ability of its workers to improve worker motivation, (2) If the worker registered as a non- full time employee (only guarantee of workplace accidents and deaths were applicable), (3) Proper payment schedule for the proper as well as easy administrative payment process and (4) if the wage of laborers above the regional minimum wage has a very strong influence on the welfare of labor productivity. Noor I <sup>[8]</sup> also concluded that productivity factors were expressed by seven research variables, namely site conditions and supporting facilities (X1), labor skills (X2), work experience (X3), wage conformity (X4), labor health (X5), coordination and planning (X6), and managerial (X7). Soepardi Harris [1] The factors that are affected cause the low productivity are : a. Material related delays b. Labor-related delay c. Equipment related delays d. Incorrect planning e. Less control of project timing f. Delayed Sub-contractors g. Weak Coordination h. Inadequate supervision i. Disadvantageous implementation methods j. Lack of technical personnel k. Weak communication. Based on several literature above, then the factors that affect worker productivity in this research are classified into four main factors.

The table below shows the summary of above discussion

Factors	Variables that affect productivity
Method & Technology	Engineering design, design, construction methods, work order, work measurement, availability of material around the site, supporting tools and equipment, Company's willingness to learn, consultant's approval, client knowledge on method, staff's experiences and knowledge, open mind of new technology, capital for investment, tender pricing
Site Management	Planning and scheduling, site layout, site communication, material management, equipment management, worker management, the

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	quality of project team, Project Manager's leadership, company and job site's rule and regulations, team communication
Work Environment	Work safety, weather, physical environment, job security, work training, participation, project layout, social relationship with community around the job site, security, noise control, air circulation
Human Factor	employee wage rate, job satisfaction, profit sharing, worker-worker relationship, insurance, project team relationship, leadership of worker leader, geography of workers' hometown, accomodation & transportation

### Analysis the second research problem

#### 1st sampling

Project	At	Method Used	A	B	C	B / (A x C)
			Amount of Workers (men)	Total Floor to be cast (m2)	Total days to finish 1 Floor ( days )	Productivity Value
X	Bandung	Cast in place	80	1600	14	1,429
Y	Bekasi	Precast	26	3100	16	7,452
Z	Depok	Steel	34	2400	10	7,059

#### 2nd sampling

Project	At	Method Used	A	B	C	B / (A x C)
			Amount of Workers (men)	Total Floor to be cast (m2)	Total days to finish 1 Floor ( days )	Productivity Value
X	Bandung	Cast in place	73	1600	12	1,826
Y	Bekasi	Precast	31	3100	16	6,250
Z	Depok	Steel	33	2400	12	6,061

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### 3rd sampling

Project	At	Method Used	A	B	C	B / (A x C)
			Amount of Workers (men)	Total Floor to be cast (m2)	Total days to finish 1 Floor (days)	Productivity Value
X	Bandung	Cast in place	60	1600	12	2,222
Y	Bekasi	Precast	28	3100	17	6,513
Z	Depok	Steel	34	2400	10	7,059

The overall productivity value is used to calculate the worker productivity performance. The total amount of worker at the column A in the table is counted and determined for the job stated at Column B. Calculated in one working day = 10-12 hours including overtime, then, the number of days start to be noted each day until completion of casting the next upper floor. Having obtained the datas of number of day ( column C ), to find the productivity value, the total large of floor in m2 is divided the number of worker times required days to complete in men days.

$$\text{Productivity Value} = \frac{\text{Total large area of floor ( m2)}}{\text{Amount of workers} \times \text{Total days to finish( men - days )}}$$

The smaller Production Value shows the lower the productivity of work gained, on the other hand, the bigger the Productivity Value means the higher the productivity of work acquired.

From above data, the average of each Productivity Value is as follows, **Project X (1) = 1,825, Project Y (2) = 7,738, Project Z (3) = 6,726**. It is clearly shown that Project X (1) using the cast in place method has a very low Value Productivity value compared to two (2) and (3) projects that have not much different value.

## V. CONCLUSIONS

- 1) There are four main factors affecting the analysis of worker productivity, namely: **1. Methods and technology**, **2. Site management**, **3. Work environment**, **4. Human factors**. Each factor of the above factors has the following variables: 1. Methods and technologies, consisting of factors: engineering design, construction methods, work order, work measurement. 2. Site management, consisting of factors: planning and scheduling, Site layout, Site communication, material management, equipment management, worker management. 3. Work environment, consisting of factors: work safety, weather, physical environment, quality of supervision, job security, work training, participation. 4. Human factors, employee wage rate, job satisfaction, profit sharing, worker-worker relationship.

This research found the Method and Technology is the most dominant factor caused the productivity in construction workers. The further research should be conducted to find the most relevants and dominant factors and variables affecting the productivity of workers and its correlation.

- 2) From the data collection and analysis, the research concluded that :
  - a. The smallest Productivity Value is Project X (1) reveals that work on site has more difficulty to handle the 4 factors mentioned above. Cast-in-place method need more planning and accurate material arrival on site, scheduling is also strongly influenced by the rainy season, the presence of workers also shows a large

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variation where frequently the number of workers needed is frequently not match with real condition on site. It caused the productivity becomes very low.

- b. The 2 - X and Y projects have almost the same value because this method only accepts structural members from the factory and only install them on site. Workers are not as many as the cast in place method so that workers' " up and down " in number is relatively more controlled. Weather has little effect on productivity because work was carried out maximally before raining comes.
- c. This research finds that off site work / fabricated at the factory will make productivity much higher and industrialize components structures creates a more controlled environment. It can provide the benefit of speed and timely completion of the project. Further research should study more detail about cost and quality using offsite method and developed for trades / other construction activities such as wall work, facade, staircases, etc. so that overall work can be done more measurable and faster.

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