

Towards Green Building with Prefabricated Systems on Flat Development in Indonesia

Hary Agus Rahardjo, Priyasambada, and Dwi Dinariana

Abstract—The increase of population in major cities led to the rise in housing need. In line with the growth of the city, the available land in urban areas increasingly limited and expensive. Construction of flats is one solution to meet the housing needs. In practice, many conventional construction methods require lumber for formwork and scaffolding. Excessive consumption of wood has shown to reduce forest cover and damage the environment, which is negatively affecting human life. This paper examines the precast method as an alternative system that can be used. Object of research is done on the construction of flats in the city of Batam, Bantul and Bandung. Result of the discussion suggests that the prefabricated system can save the use of wood, reduce the cost of construction, maintain the environment and also contribute to the green building.

Index Terms—Development, flat, green building, prefabricated.

I. INTRODUCTION

A. Background

The population of large cities increased from year to year. This happens in several major cities in Asia such as Tokyo, New Delhi, Beijing, Manila, Bangkok, Jakarta, Singapore, and Kuala Lumpur as shown in the Fig. 1 below [1].

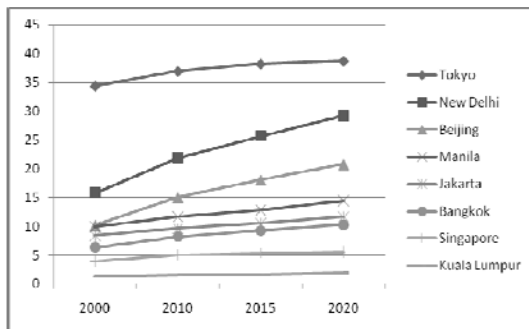


Fig. 1. Population growth in Asia major cities.

The population increase is partly due to the arrival of residents from areas outside the major cities due to various reasons, such as to obtain a higher income, better education, and better health facilities, up to complete existing entertainment facilities as well as the ease live. In line with national economic progress, then other cities such as Bantul, Batam and Bandung are also experiencing growth and therefore the population of those cities is also increasing due to several factors similar to those that occurred in the major

cities [2]-[5]. The population growth in Batam, Bantul and Bandung is pointed out in Fig. 2 as follow. This has led to an increased need for shelter for its residents.

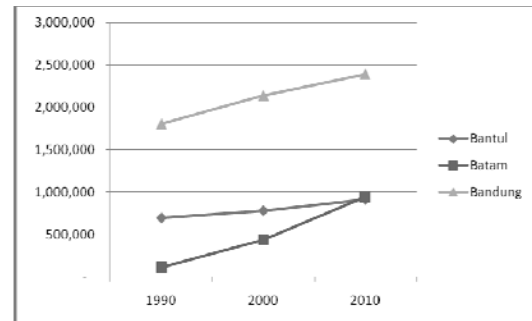


Fig. 2. Population growth in Batam, Bantul and Bandung city.

With the passage of time, the development of the city has resulted in limited land for settlement. Increasing land prices restrict citizens to build the settlements horizontally or in the form of landed houses. To meet the needs of residential facilities for its residents, the construction of flats is a solution, because it can utilize a smaller area but can accommodate a lot more number of people to live.

The construction of high-rise building in general and flats in particular, especially in Indonesia, is still frequently used formwork and scaffolding wood to make concrete construction. Fig. 3 below shows construction method using wood as formwork and scaffolding which is known as Conventional System.



Fig. 3. Conventional system using wood for formwork and scaffolding.

The use of wood in large quantities from time to time has reduced timber forest cover in Indonesia. Reduction of forest area is often not accompanied by conservation efforts, such as reforestation. This resulted in significant environmental damage, and can even lead to natural disasters such as floods and landslides during the rainy season.

B. Problem Statement

Environmental degradation, especially forest areas need to be stopped. Settlement construction should pay attention to environmental aspects. To get to the green building it is necessary to look for alternative construction methods that

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The authors are with the University of Persada Indonesia (e-mail: rahardjo30@yahoo.com, priyasambada@yahoo.com, dwidinariana@yahoo.com).

can reduce the volume of wood used in construction work. One way of reducing the use of wood in building construction is the application of precast system. The question is whether the application of precast system can save the use of wood in building materials compared to conventional structural system implementation. How big savings are to be gained. Are there incentives that can be given to developers as the party that undertakes the construction of flats by applying precast structural system? In addition, we examine the contribution of precast structural system to be able to meet the criteria of green building.

C. Purpose of the Study

This study is intended to demonstrate that the use of precast systems can reduce the use of wood materials in building construction, compared with conventional systems. In addition, the decrease in the use of the wood will be studied more about saving costs and also assessed the effectiveness of the precast system in supporting the achievement of green building.

D. Research Method

This study uses the method of Comparative Quantitative research. The study is based on the philosophy of positivism which emphasizes phenomena objectively and quantitatively assessed. Maximizing the objectivity of the research design was conducted using the figures, as well as processing the figures. Comparative research directed to find out whether there are differences between the two groups in the variables studied. This paper will examine the differences in the amount of wood used for the formwork in a project that uses conventional system and the amount of wood used for the formwork when the project is done with precast system. Precast system used is the PSA system. The research sample included a five-story building, typical building affordable for the people in Indonesia. Sample locations are in the city of Bandung, Batam and Bantul.

II. LITERATURE REVIEW

A. Reduction of Forest Area in Indonesia

Indonesia is a country with the third largest tropical forest in the world after Brazil and Zaire, which is an area of 133.7 million hectares. The vast covering 10% of the total tropical forest in the world. Indonesia's forest area covering 60% of the entire territory of Indonesia. Indonesia's forests have an important role. Not only as the lungs of the world, has the source of life and economic development, but also as a counterweight evened global climate [6]. Indonesia experienced a loss of forests or deforestation area of 15.8 million hectares (ha) between 2000 and 2012. Therefore, be the fifth largest country in terms of forest loss as indicated in Fig. 4 below [7].

B. Flats Development in Indonesia

Flat development in Indonesia is carried out with regard to the arrangement of the urban areas and also to meet the needs of the home for its residents. Rental flats is allocated for the students, police officers, military members, workers, and boarding pupils. In 2011, rental flats built as many as 100

buildings and in 2012 increased to 126 buildings [8]. The shape of rental flats with affordable rental rates can be seen in Fig. 5 as follows.

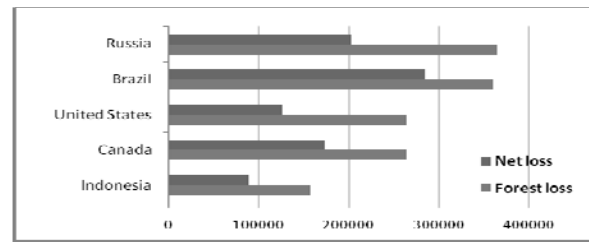


Fig. 4. Forest loss and net loss in the world.



Fig. 5. Affordable rental flat in Indonesia.

C. Prefabricated Method with PSA System

PSA precast system is an open system framework structure (open frame) which has a unique connection to the location of the component beams and columns in the column above the rallying point. This system can be used for low-rise buildings to high-rise buildings [9].

PSA precast system consists of three components, namely: column components, beam components and slab components. Overall PSA system precast components can be assembled in fabric or in the field (the project site) as shown in the following Fig. 6.



Fig. 6. Prefabricated concrete.

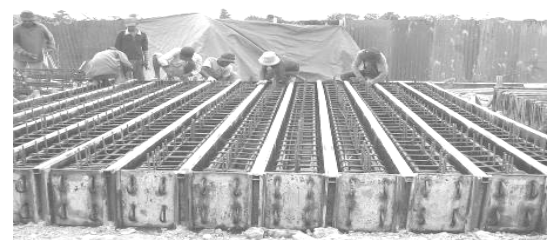


Fig. 7. Molding component of PSA system.

PSA precast system uses molds made of steel plates that can be used over and over again with a high level of repetitions. The repetition rate will have an impact on the cost of production, where the higher repetition rate will be the lower cost of production [10]. Mold component is a series of elements that can be mounted and opened easily. Molding components can be seen in the Fig. 7 below.

D. Green Building in Indonesia

One sector that has a significant contribution in energy consumption, water consumption, and land use, is the building sector [11]. Therefore it is necessary to apply a new paradigm in building construction that is the concept of green buildings.

In the application of the concept of green building, we need a measurable and objective guideline, adapted to the existing environment, and there is regular evaluation to the implementation.

It's all to meet Greenship rating issued by GBCI (Green Building Council of Indonesia), which can meet the existing regulations, among others, saving energy, conserving resources, reducing the burden on the city's infrastructure, and recognition of green building commitment [12]. One of the main aspects that must be considered in building a green building is the use of the material. If we are using materials from nature, then the material must meet the following requirements [13]:

- 1) Impact to the environment should be a source of renewable energy and sustainable manner.
- 2) Economic impact, the material must be obtained from local sources/around the project, to reduce transportation costs
- 3) Social Impact, material containing recycling system to reduce waste products, but still well tested material.

III. RESULT AND DISCUSSION

The following are the results of calculations for the use of timber formwork in Batam city, Bantul and Bandung. The data used comes from Flats Development Project conducted by the Directorate General of Human Settlements, Ministry of Public Works, Strategic Urban Settlements Development Unit, 2012-2013 fiscal years. The data obtained were taken from three locations that use a PSA precast system.

A. Location: Batam City

Construction of flats in the city of Batam is located in the Top 100 Tembesi, consisting of 2 twin blocks, where each block is a twin five-level building, with four levels of occupancy from the 2nd floor to the 5th floor, while the first floor is used as a public facility area.

Execution time was 270 calendar days, the work schedule of the structure completed in 17 weeks.

The wood needs distribution with conventional systems for each building component in Batam location is as shown in the following Fig. 8. In the conventional system shows that the demand for wood for formwork plate is more than 50% of the total wood, as many as 209.384 m³ (57%) of the total 368.55 m³. Meanwhile, the need of wood requirement in the PSA system is as illustrated in the Fig. 9. The total

requirement of wood by using precast PSA system compared with conventional methods only by 4.7% (17:32 m³/368.55 m³). Comparison of wood needs on location in Batam, for some parts of the building can be seen in Fig. 10.

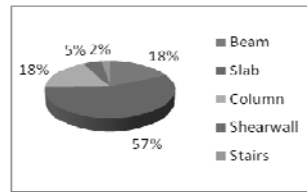


Fig. 8. Conventional system.

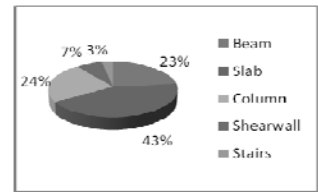


Fig. 9. PSA system.

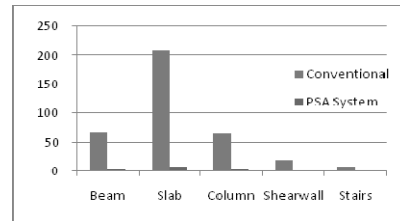


Fig. 10. Comparison of wood needs.

B. Location: Bantul City

Construction of flats in the city of Bantul is located in Kota Gede, consisting of 1 twin blocks, where each block is a twin five-level building, with four levels of occupancy from the 2nd floor to the 5th floor, while the first floor is used as a public facility area.

Execution time was 210 calendar days, the work schedule of the structure completed in 17 weeks.

The wood needs distribution with conventional systems for each building component in Bantul location is as shown in the following Fig. 11. In the conventional system shows that the demand for wood for formwork plate is more than 50% of the total wood, as many as 209.384 m³ (56%) of the total 372.59 m³. Meanwhile, the need of wood requirement in the PSA system is as illustrated in Fig. 12 below. The total requirement of wood by using precast PSA system compared with conventional methods only by 5.18% (19:31 m³/372.59 m³). Comparison of wood needs on location in Bantul, for some parts of the building can be seen in the following Fig. 13.

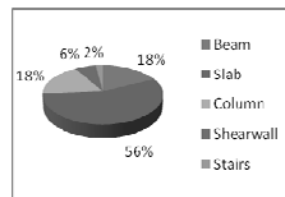


Fig. 11. Conventional system.

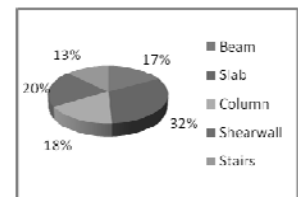


Fig. 12. PSA system.

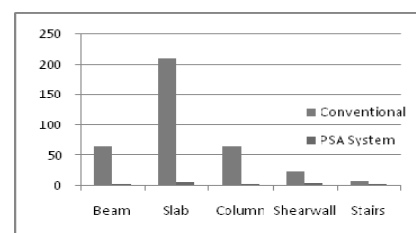


Fig. 13. Comparison of wood needs.

C. Location: Bandung City

Construction of flats in the city of Bandung is located in

Rancaekkek, consisting of 1 twin blocks, where each block is a twin five-level building, with four levels of occupancy from the 2nd floor to the 5th floor, while the first floor is used as a public facility area.

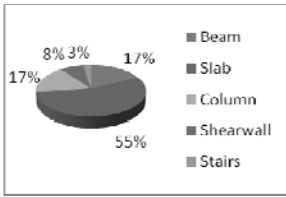


Fig. 14. Conventional system.

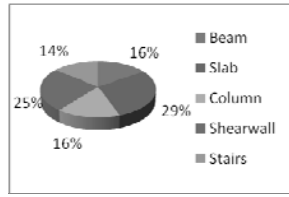


Fig. 15. PSA system.

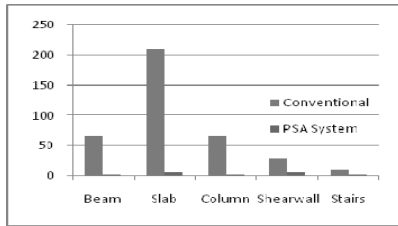


Fig. 16. Comparison of wood needs.

TABLE I: THE AVERAGE AND TOTAL VOLUME OF FORMWORK ON CONVENTIONAL SYSTEM

No	Location	Volume of wood (m ³)					TOTAL
		Beam	Slab	Column	Shearwall	Stairs	
1	Batam	66.157	209.384	65.591	19.744	7.675	
2	Bantul	66.157	209.384	65.591	23.785	7.675	
3	Bandung	66.157	209.384	65.591	28.927	9.510	
	TOTAL	198.470	628.152	196.774	72.455	24.859	
	AVERAGE	66.157	209.384	65.591	24.152	8.286	373.57

TABLE II: THE AVERAGE AND TOTAL VOLUME OF FORMWORK ON PSA SYSTEM

No	Location	Volume of wood (m ³)					TOTAL
		Beam	Slab	Column	Shearwall	Stairs	
1	Batam	4.028	7.414	4.108	1.237	0.531	
2	Bantul	3.331	6.131	3.397	3.957	2.499	
3	Bandung	3.405	6.267	3.472	5.429	3.122	
	TOTAL	10.764	19.812	10.977	10.623	6.152	
	AVERAGE	3.588	6.604	3.659	3.541	2.051	19.443

TABLE III: THE COST COMPARISON OF WOOD MATERIALS USED

	System	Volume m ³	Unit Price US\$	Total US\$
1	Conventional	373.57	290	108,335
2	PSA System	19.44	290	5,637

Execution time was 210 calendar days, the work schedule of the structure completed in 17 weeks.

The wood needs distribution with conventional systems for each building component in Bantul location is as shown in the following Fig. 14. In the conventional system shows that the demand for wood for formwork plate is more than 50% of the total wood, as many as 209.384 m³ (55%) of the total 379.57 m³. Meanwhile, the need of wood requirement in the PSA system is as illustrated in Fig. 15 below. The total requirement of wood by using precast PSA system compared with conventional methods only by 5.72% (21:70 m³/379.57 m³). Comparison of wood needs on location in Bantul, for some parts of the building can be seen in the following Fig.

16.

D. Cost Saving Analysis of the Usage of Wood Formwork

From the calculation of the material needs of the wood on the location in Batam, Bantul and Bandung for both systems, the conventional system and the PSA system, it can be calculated on the average usage at each location. Then on the basis of the average consumption, we calculated the total use of wood materials in building the towers.

Table I and Table II below indicated the average and total volume of formwork on conventional system and PSA system.

Table III above [14] shows that the cost of wood materials used to build flats with PSA System is only for 5.2% of the cost of the use of wood in conventional system.

IV. CONCLUSION

Precast structural system proved more efficient in the use of wood materials for formwork system compared with a conventional structure. Average use of wood for the conventional system is 373.57 m³ compared with PSA System precast systems which requires only as much as 19.44 m³ of wood, or of only 5.20% compared with conventional methods.

By using precast structures that system, the overall cost of housing construction will be cheaper. By taking the average price of lumber grade II US\$290 per m³, then the conventional system would require a fee of US\$108,335 while the PSA System precast structural system costs only US\$5,637. There was a decrease in the cost of Rp. 1.239445 billion, - or US\$103,287. The total cost of the work for 1 twin block structure is Rp. 3.945575 billion,- or US\$328,797 so that there is an impairment charge of 31.41%. Thus, the cost efficiency at the same time is an incentive that can be given to developers of flats building.

Application of PSA System in the public housing development also contributed a sizable number of buildings in the criteria that apply green building. As per the existing criteria, the minimum number that can be achieved is 5 points (from MRC items 5 i.e. fabrication material usage by 3 points and from MRC 6 i.e. items of local material usage, by 2 points) and a maximum of 7 points if the item is added to the material MRC 4 i.e. wood certified usage by 2 points. It is a fairly large number of green building in contributing scores.

Meanwhile GreenShip for the building of a new book by GBCI, according to MRC criteria 4, certified wood to get the maximum value of 2, according to MRC criteria 5 Materials Prefabricated get maximum value 3, and according to the criteria of the MCR 6 to get the maximum value of 2.

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Hary Agus Rahardjo was born in Tegal, Indonesia in 1959. He got his Ph.D. degree in civil engineering from Colorado State University, USA in 2002.

He is a lecturer in the field of civil engineering and the vice rector at the University of Persada Indonesia, Jakarta. His research area is about Construction and Infrastructure Project Management.

Dr. Rahardjo has publication in *Procedia Social and Behavioral Sciences* 46 (2012), pp 5497 – 5501,

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Prijasambada was born in Jakarta, Indonesia in 1963. He got his master of management in Jakarta and also master of civil engineering in Jakarta, Indonesia.

He is a lecturer in the field of civil engineering and the director of the engineering consultant with the expertise in structural engineering design. He had designed structural aspect of many high rises building built in Indonesia.

Prijasambada has many patents; one of them is PSA system, a system of structural component prefabricated.



Dwi Dinariana was born in Madiun, Indonesia in 1969. She got her doctorate degree in environmental and natural resources management from IPB, Indonesia in 2011.

She is a lecturer in the field of civil engineering and the head of Department of Civil Engineering Master Program at the University of Persada Indonesia, Jakarta. Her research area is about housing and construction management.