Analysis of Financing for the Construction of Puzzle Houses by Polsri in an Effort to Provide Affordable Housing for Low-Income Communities (Case Study of the Construction of the Polsri Puzzle House Mockup)

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Abstract. The 1945 Constitution Article 28 paragraph (1) letter H and Law No. 1 of 2011 explicitly state that housing is a basic right of citizens, and the government guarantees and ensures that housing is decent and affordable. This is undoubtedly a challenge for the government and the people, considering Indonesia's nearly 300 million population, which is directly proportional to the need for housing. However, with a backlog of ownership reaching 12.75 million units, the substantial disparity between demand and supply becomes evident. Housing supply depends on private developers who are less interested in building houses for the MBR (Middle to Below Income) sector because the majority of them fall into the category of those who are not financially capable of transacting in the housing market. The idea is to provide affordable housing through the use of precast technology for the MBR (Middle to Below Income) sector. The goal of this research is to analyze the realization of financing for the precast puzzle house (Pracetak) to achieve efficiency using the quantitative experimental method of project-based learning. A research team from the Sriwijaya State Polytechnic delves into this gap by constructing a mock-up precast puzzle house (Pracetak) with the aim of obtaining actual costs in the construction process. This paper serves as the basis for further research regarding a comparison of the financing costs carried out by private developers and the standards set by the government..

Keywords: Puzzle House, Low income house, financing constructing.

1 Introduction

Every person has the right to have decent and affordable housing. This is clearly mandated in the 1945 Constitution Article 28 paragraph (1) letter H, which states, "every person has the right to live prosperous physically and mentally, have a place to live, and obtain a good and healthy living environment, and has the right to receive health services." This legal mandate is further elaborated in Law No. 1 of 2011 concerning Housing and Settlement Areas, which states that "housing is a basic need for every

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citizen, and the state is responsible for ensuring that every person inhabits decent and affordable housing." The second quotation from the law explicitly states that housing is a basic right of citizens, and the government guarantees and ensures that housing is decent and affordable.

The legal mandate is indeed a significant challenge for the government, given that Indonesia currently has almost 300 million inhabitants. This figure is directly proportional to the need for housing. According to data from the Ministry of Public Works and Public Housing (PUPR) in 2020, the backlog in homeownership (the gap between the number of houses built and the required amount) reached 12.75 million units. This figure indicates that many people face difficulties in accessing affordable housing [1]. The substantial disparity in the backlog underscores the gap between housing demand and supply. In practice, the supply of homes depends heavily on private developers who are often uninterested in building affordable housing for the lower-income segment, citing reasons of reduced profitability [6]. This situation is understandable since the ability of the lower-income group to transact in the housing market is limited. Only about 20% are considered capable of buying standard homes, 40% cannot afford one without government subsidies, and the remainder is categorized as poor and in need of significant government assistance to own a house [2]. The issue of limited housing availability on the market is closely related to the limited purchasing power of the lower-income group [5]. Government intervention, particularly in the form of subsidies, is essential to ensure that affordable housing is accessible and can be seen as a positive step in addressing this challenge.

The idea of affordable housing is a vision of the government in 2020 through the National Housing and Settlement Development Policy Agency (BKP4N). The concept of utilizing Precast technology in housing has proven to reduce costs by up to 6.44%, ensuring structural integrity, and enabling mass production [7]. Furthermore, in 2017, research conducted by Wasino, Suwarto, & Triwardaya aimed to analyze the financial aspects of the Precast system to determine its competitiveness in terms of investment. The study claim that Precast houses are not recommended for a 10-year term but become financially feasible for a 15-20 year horizon because the cost difference between the two methods is not significantly different [8]. Further research and a reevaluation of this concept are required to ensure that the goal of affordability can be achieved.

Of course, the question arises about the methods or approaches used to achieve this goal. In this investigation, we will attempt to utilize a cost analysis of precast house construction, as explained in the following diagram:

Fig. 1. Development financing component calculation diagram. Source: Author, 2023

This analysis involves various essential steps, and it all begins with the planning phase, including the working drawings, strength calculations, and budget planning. All of these elements play a crucial role in determining the desired end result. Cost estimation activities form the basis for cost quantities and construction implementation, which are

directly related to the future selling price of precast houses. The purpose is to predict the execution process and values for each task, and this process can be divided into conceptual and detailed cost estimation [3]. Cost estimation is closely related to the unit prices for construction activities and is a critical determinant in construction expenditure [4]. Each construction activity has its own value, which is based on the costs of materials and labor. The government, in this case, the Ministry of Public Works and Housing (Kemen PUPR), revises the Analysis of Standard Unit Prices (AHSP) each year with various versions that are commonly used in construction planning and execution. The purpose of this paper is to analyze the cost of precast house construction carried out by Polsri to determine whether it can meet the demands of the Indonesian market.

2 Method

This research employs a Quantitative method sourced from the project experiment of building the Puzzle House at Polsri in 2022. In other words, Project-Based Learning is the source used to calculate the research needs, including one of the aspects related to the value or amount of funding for the construction of the Polsri Puzzle House. This method is expected to provide insights into the realization of project financing for house construction with an advantage in terms of efficiency in its financing. There were three sample houses built. As not all of these buildings were completed, the calculations were based on the house with the most comprehensive condition for each component. These three houses were located on the campus of Politeknik Negeri Sriwijaya, both on the Bukit Besar and Musi II campuses.

Fig. 2. Puzzle House in Bukit Campuses Polsri. Source: Author, 2023

Data Collection. Primary data comprises records of expenditures for financing the construction of the Polsri Puzzle House, including expenses for purchasing materials and payments for labor in executing the construction of the sample house. For identical items with differing prices at various stores, the highest price will be taken as the base price for materials. In addition, field data is collected to determine the volume of precast concrete printing for each building component. As for secondary data, the financing calculations use standard calculation methods derived from developed theories,

including calculating equipment depreciation and considering material compositions in the implementation of precast concrete work based on certain standards.

Data Analysis. The analysis model employed is quantitative descriptive, with the goal of calculating the actual financing required for the construction of the Polsri Puzzle House. Project financing calculations are conducted systematically according to the sequence in construction financing calculations. In data analysis, the financing is categorized based on the order in construction and the architectural building elements. Furthermore, project financing calculations are performed using tabular systems to determine the overall cost.

3 Result and Discussion

Polsri Puzzle House Mockup. The sample houses constructed under the Matching Fund 2022 project amounted to 3 (three) units. 2 (two) units are located on the Polsri Bukit Besar campus in Palembang, and 1 (one) unit is located on the Polsri Musi 2 campus. The house built on the Musi 2 campus has the most complete structural and architectural building components. Therefore, this building serves as the reference object for the overall cost calculations of this affordable housing project. The initial stage in the financing calculation involves identifying the work required for the sample houses.

Fig. 3. Puzzle House in Musi II Campuses Polsri. Source: Author, 2023

In terms of its anatomy, this building consists of two major parts: the building body and the building roof. The design of this building does not include a foundation, as it is intended to be flexible and adaptable to various types of land conditions. Therefore, each user who wishes to construct it must prepare the land and a pedestal for the building to stand on. From a spatial design perspective, this building has an area of 36 square meters and includes 2 (two) bedrooms, 1 (one) bathroom/toilet, and 1 (one) multipurpose main room inside.

The building body consists of the following components: (1) Precast columns with concrete quality K300 (normal concrete), comprising three types with a total of 12 columns, including seven columns of type 1, four columns of type 2, and one column of type 3; (2) Precast beams with concrete quality K300 (normal concrete), totaling 30 beams with three types of beams, including 18 beams of type 1, six beams of type 2,

and six beams of type 3; (3) Precast panels using lightweight concrete material, totaling 87 panels with four types of panels, including 54 panels of type 1, 21 panels of type 2, 9 panels of type 3, and 3 panels of type 4; (4) Doors and windows, consisting of 4 aluminum and 9mm plywood panel doors, 2 aluminum and glass windows, and 1 double-hung window; (5) Floor work, using plain white 30x30 cm ceramic tiles for the main area, and textured brown 30x30 ceramic tiles for the bathroom; (6) Sanitary work, including the provision of faucets, floor drains, and squat toilets; (7) Electrical work; and (8) Finishing work, which involves plastering the walls and painting the wooden doors.

The roof of the building consists of the following components: (1) Roof framework and roof cover with an area of 64 square meters, using metal roof covering and lightweight steel roof framework; (2) Sunshade work with an area of 10 square meters, using calsiboard GRC material with a galvanized hollow framework; and (3) Ceiling work with an area of approximately 36 square meters, using PVC material to cover the ceiling and a galvanized hollow framework. Each of these works was identified, and the unit prices for the materials used were determined.

Unit prices. The unit prices used are the labor and material unit prices based on the construction of the Polsri Puzzle House. Unit prices consist of the basic labor rates and material prices. The Palembang City Government has issued a unit price list for Palembang, but these prices are not used as a reference due to the differences in pricing compared to the actual costs in the field.

The base prices for labor are differentiated based on daily wages for craftsmen and workers, as well as contract rates based on the skills of craftsmen, such as tiling contracts, door and window work contracts, ceiling work contracts, and roof work contracts. The base wage for craftsmen is Rp. 140,000 per day, and for workers, it's Rp. 110,000 per day. The base material prices are sourced from several stores where materials for the construction of the Polsri Puzzle House were purchased. For the same materials with different prices due to differences between stores, the highest price is used in the calculation of the project's actual costs. This is taken as the maximum and safe value for realizing the work. The base material prices are categorized based on the groups of materials that were identified earlier, which include: (1) the door and window material group, (2) the material group related to wood, (3) the electrical material group, (4) the material group with stone and cement as the base, (5) the plumbing or sanitary material group, (6) the flooring material group, (7) the base iron material group, (8) the roof work material group, (9) the painting material group, and (10) other supporting disposable material group.

Unit Price Analysis. The unit price analysis for the construction of the Polsri Puzzle House is conducted for the production of precast components such as Columns, Beams, and Wall Panels. This is done to determine the value or price of each component for each type. For other work like the roof and ceiling, only the used materials and the contract labor cost are calculated according to the realization. The unit price analysis for each component is derived from the calculation of craftsmen and worker wages for one cycle of component production, the material used based on the volume of molds and material per component, and the depreciation value of the equipment or molds used.

Unit Price Analysis for Wall Panel Components. Wall panels are made of lightweight concrete material. In this unit price analysis, the calculation considers one cycle of the panel casting process, resulting in panels ready for installation. There are 4 (four) types of wall panels used, each of which has one mold capable of producing 3 components in each casting cycle. Therefore, the total number of panels that can be produced in one casting cycle is 12 panels.

Fig. 4. Mold for the wall panel components of the Puzzle Polsri house. Source: Author, 2023

The wall panel casting process is conducted over 2 days to obtain the finished components, which are then dried through air-drying methods. On the first day, the mold is prepared by applying oil to its surface, the panel's reinforcement using wire mesh is prepared, and casting is performed in all the molds. On the second day, the molds are disassembled to separate the previous day's castings and prepare for the next casting. Therefore, one production cycle is calculated over 2 working days and requires 1 carpenter and 1 laborer. The lightweight concrete volume needed for a single casting is 0.54 m³, which is rounded up to 0.6 m³ in the calculation because the casting is done in collaboration with lightweight brick manufacturers, who require us to purchase according to their production units. In more detail, you can refer to the following table:

Table 1. Unit Price Analysis and Wall Panel Components

Job Description			Unit (Rp)	Wages (Rp)	Material (Rp)	Amount (Rp)
One Cycle of The Panel Casting Process						
Wages						
2,0000	OH	Craftsman	140.000	280.000		
2,0000	OH	Prentice	110.000	220.000		
Materials (for 12 Panel / 4 Casting)						
0,6000	M3	Lightweight Concrete	800.000		480.000	
1,0000	Ltr	Used Oil	5.000		5.000	
1,0000	Kpg	Wiremesh 5 mm	310.000		310.000	
				500.000	795.000	1.295.000
Price for One Panel						107.916,67

From the calculation above, the production cost for 1 panel wall is Rp. 107,916.67. This price needs to be added to the calculation of the depreciation of the mold equipment

used to produce the wall panel. The depreciation is calculated using the unit production method, where the formula used in the calculation is as follows:

(*Acquisition Price - Residual Price*) X (*Usage: Maximum Capacity*) = *Cutback*

With an acquisition value of Rp. 23,040,000, a residual value of 95% per year, and an annual usage of 144 times or 3 productions per week, and a maximum production capacity over 10 years, the depreciation per mold is Rp. 115,200. This value is then divided by 3 (the number of panels produced per mold), resulting in Rp. 38,400 as an additional production cost. From this analysis, the production cost for 1 wall panel unit is Rp. 146,317.00.

Next, calculations were made for the unit price analysis of the column and beam components of the Puzzle House. Columns and beams share the same forming material, which is concrete with a quality of K300. In the casting process, the material requirements have been formulated according to the standard material composition (Job Mix Formula) for 1 cubic meter of K300 concrete, which is 1,277.14 kg of split gravel, 448.73 kg of sand, 379.63 kg of cement, and 0.25 liters of concrete admixture. The column dimensions are relatively the same, measuring 15 cm in length x 15 cm in width x 300 cm in height. The differences in each column are found in the number and position of the grooves for each column type. For the beams, the difference lies in the length of the beams: 3 m for beam type 1; 2 m for beam type 2; and 1 m for beam type 3. The thickness dimension is the same, measuring 5 cm, with a height of 30 cm.

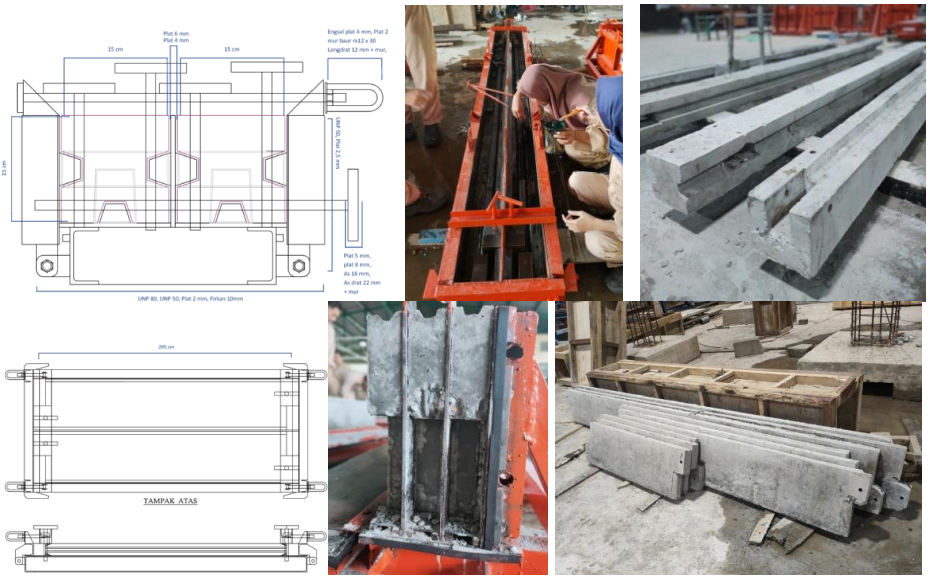

Fig. 5. Mold for the column dan beam of the Puzzle Polsri house. Source: Author, 2023

In one casting cycle for the column and beam components, the volume is calculated based on the available molds. There are 3 types of column molds, each of which can produce 2 columns, and 3 types of beam molds, each of which can produce 3 beams. Since each column and beam has different shapes and sizes, the total concrete volume for one production cycle is approximately 0.6221 m3. The labor cost for both the worker and the mason is calculated for a 2-day cycle, reflecting the same pattern as the panel production, which starts with mold preparation, reinforcement, and casting on the first day and continues with mold opening and preparation for the next casting on the second day. In detail it can be explained in the following table:

Tabl. 2. Unit Price Analysis column dab beam components.

Job Description			Unit (Rp)	Wages (Rp)	Material (Rp)	Amount (Rp)
One Casting Cycle for Column and Beam Components						
Wages						
2,0000	OH	Craftsman	140.000	280.000		
2,0000	OH	Prentice	110.000	220.000		
Material: 1 M3 Concrete K 300						
1.277,1	Kg	Coral 1/1 cm	307		392.602	
448,73	Kg	Sand	183		81.942	
379,63	Kg	Cement	1.340		508.704	
0,2500	Ltr	DamDex (Hardener)	75.000		18.750	
2,0000	Ltr	Used Oil	5.000		10.000	
					1.011.998	
Material (for 6 Column; 3 molds and 9 Beam; 3 molds)						
0,6221		Concrete K 300		500.000	629.590	1.129.590

From the calculations above, the price of K300 concrete for one production cycle is approximately Rp. 1,129,590. Since the column and beam components have different sizes, this value is then divided based on the dimensions of each component to obtain the concrete cost for each component type.

Table 3. Calculation of concrete prices per type of column and beam.

Concrete Volume		Component Type	Production Price (Rp)	Unit Price (Rp)
0,0591	M3	COLUMN TYPE 1	1.129.590	107.240
0,0619	M3	COLUMN TYPE 2	1.129.590	112.346
0,0619	M3	COLUMN TYPE 3	1.129.590	112.346
0,0653	M3	BEAM TYPE 1	1.129.590	78.983
0,0428	M3	BEAM TYPE 2	1.129.590	51.747
0,0203	M3	BEAM TYPE 3	1.129.590	24.512

From the calculations, the cost of adding reinforcement to the concrete for each type of column and beam in the Puzzle House Polsri was determined. The calculations revealed different requirements for each component type, including Rp. 76,800 for Column Type 1, Rp. 78,933 for Column Type 2 and Type 3, Rp. 55,111 for Beam Type 1, Rp. 36,667 for Beam Type 2, and Rp. 18,667 for Beam Type 3. Like the panels, columns, and beams are also subjected to depreciation calculations for the molds used. With different acquisition values for each type of column and beam mold, different results were obtained for each type of column and beam as an addition to their production value. Depreciation calculations for the equipment also followed the unit production method, where the acquisition prices for each type were Rp. 23,330,000 for each type of column mold; Rp. 20,410,000 for beam mold Type 1, Rp. 18,840,000 for beam mold Type 2, and Rp. 15,110,000 for beam mold Type 3; the residual value was calculated at 95% per year, with 144 uses per year or 3 production cycles per week, and a maximum production capacity for 10 years. The calculation involved summing to determine the price of each component with each type using the formula:

Unit Price = Concrete Price (Wages + Materials) + Reinforcement Price + Loss Value of Mold Tools

The formula resulted in the required financing for producing each unit of column and beam components for each respective type. This information is illustrated in the following table:

Table 4. Calculation of financing per unit of column and beam components of the Polsri Puzzle house.

Component	Wages and Concrete Materials (Rp)	Reinforcing (Rp)	Loss Value of Mold Tools (Rp)	TOTAL (Rp)
COLUMN TYPE 1	107.240	76.800	58.325	242.365
COLUMN TYPE 2	112.346	78.933	58.325	249.604
COLUMN TYPE 3	112.346	78.933	58.325	249.604
BEAM TYPE 1	78.983	55.111	34.017	168.111
BEAM TYPE 2	51.747	36.667	31.400	119.814
BEAM TYPE 3	24.512	18.667	25.183	68.362

The calculation of construction costs begins with the identification of each task, measuring the volume of activities, determining the required material volumes, and identifying the unit prices for labor and materials used. In the calculation of the actual financing for the construction of the Puzzle Polsri house, grouping is done based on the stages of activities, namely: (1) Preparation work, (2) Main building work, (3) Roof work, (4) Flooring work, (5) Door and window work, (6) Ceiling work, (7) Electrical installation work, (8) Sanitary work, and (9) Finishing work. The overall cost calculation can be seen in the following table:

Table 5. Recapitulation of Financing Calculations for The Construction of Polsri Puzzle House.

No	Job Description	Wages (Rp)	Materials (Rp)	Amount (Rp)
1	PREPARATION WORK	500.000,00	357.500,00	857.500,00
2	MAIN BUILDING WORK	2.500.000,00	21.611.168,92	24.111.168,92
3	ROOF WORK	2.600.000,00	7.901.000,00	10.501.000,0
4	FLOORING WORK	1.580.000,00	3.757.000,00	5.337.000,00
5	DOOR AND WINDOW WORK	1.800.000,00	5.899.000,00	7.699.000,00
6	CELING WORK	1.080.000,00	3.249.000,00	4.329.000,00
7	ELECTRICAL INSTALATION WORK	1.120.000,00	3.211.000,00	4.331.000,00
8	SANITARY WORK	150.000,00	293.500,00	443.500,00
9	FINISHING WORK	500.000,00	525.000,00	1.025.000,00
	TOTAL COST	**11.830.000,0**	**46.804.168,92**	**58.634.168,92**

From the calculations above, it can be determined that the construction cost required for building one unit of the Polsri Puzzle House is Rp. 58.634.168,92, with a total labor cost of Rp. 11,830,000,00 and a total material cost of Rp. 46.804.168,92.

4 Conclusion

The real cost calculations required for the construction of the Polsri Puzzle House are presented based on the sequence of construction and anatomical building elements. The financing is explained using a tabular system to provide a comprehensive breakdown of the costs. The total cost for one unit of the Polsri Puzzle House is Rp. 55,939,199.30. The research on the financing of Polsri Puzzle House construction should be continued to make a comparison with houses or housing projects built by private companies or the government. This comparative analysis will help draw conclusions regarding the cost efficiency of the Polsri Puzzle House construction.Top of Form.

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