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Cost Estimation Analysis of Construction Projects on Simple Earthquake-Resistant Houses

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ABSTRACT

Earthquakes are natural disasters that often hit Indonesia, causing various losses in human life, including damage to homes and places to live. Therefore, the importance of building earthquake-resistant houses cannot be ignored. The research aims to obtain a comparison of the estimated cost of a simple house construction project, by considering the comparison between conventional structures and structures that are strengthened to resist earthquakes. The data used involves working drawings, Technical specifications based on practical guidelines Construction of earthquake-resistant wall houses, and work unit price analysis (AHSP) based on PUPR Ministerial Regulation No. 8 of 2023 and a list of unit prices for wages and materials for work in the Public Works and sector for the 2022 fiscal year in the city of Padang. The cost estimation results show that for a simple house with a conventional structure, the construction cost is IDR 218,913,000, while for a simple house with earthquake-resistant reinforcement, the cost reaches IDR 226,296,000. This additional cost was caused by strengthening work on foundations, columns and beams, walls, and trusses. Even though there was an increase in costs of around 3.37%, this result can be a consideration for the community. It is important to realize that with relatively small additional costs, people can increase safety and comfort in building construction. The results of this research can be a strong basis for stakeholders in the construction and policy fields to consider safety and comfort as the main factors in developing housing infrastructure.

Keywords: *Cost estimation; Cost budget plan; Earthquake resistance.*

INTRODUCTION

Earthquakes are a serious threat to many regions in Indonesia, especially in potentially earthquake areas such as Padang City, West Sumatra. Along with the experience of frequent earthquake events, these earthquakes have caused significant damage to buildings and caused loss of life[1]

The 2009 West Sumatra earthquake was a devastating event that greatly impacted several areas of West Sumatra. On September 30, 2009, this earthquake reached a magnitude of 7.6 on the Richter scale and was centered off the coast of West Sumatra about 50 km northwest of Padang City. The affected areas include Padang Pariaman Regency, Padang City, South Pesisir Regency, Pariaman City, Bukittinggi City, Padang Panjang City, Agam Regency, Solok City, and West Pasaman Regency (BPBD, Padang City, 2019).

The impact is not only felt on buildings but also inflicts significant human losses. According to Satkorlak PB data, this earthquake caused 1,117 deaths in three cities and four districts in West Sumatra. In addition, 1,214 people were seriously injured, 1,688 people suffered minor

injuries, and one person was reported missing. This disaster also damaged various levels of houses in the affected areas, with 135,448 houses severely damaged, 65,380 houses moderately damaged, and 78,604 houses damaged (BPBD, Padang City, 2019).

This event not only reflects the geographical conditions of the region in terms of seismic activity but also serves as a starting point to consider the need for increased earthquake resistance in planning and building construction in earthquake-prone areas such as West Sumatra. In this context, research and preventive efforts are becoming increasingly important to minimize similar impacts in the future.

According to the Meteorology, Climatology and Geophysics Agency (BMKG), in recent decades, Padang City has been the epicenter of several major earthquakes, including the one that triggered a potential tsunami in 2009. This statistical data shows the high risk of infrastructure damage, especially in simple house buildings [2]
The earthquake's impact on simple houses is very significant, considering that most people live in such houses. Simple houses, especially those using conventional wall materials, tend to be vulnerable to earthquake shocks, causing structural damage and accident risks for their occupants [3]

However, public awareness of the importance of building simple houses by considering earthquake resistance needs further improvement. Studies show public awareness of earthquake risk is still not optimal [4]. Therefore, efforts are needed to provide a better understanding to the community about the benefits of building simple houses by considering earthquake resistance.

Research reveals that simple houses, especially those that use reinforced concrete, still have a level of vulnerability to earthquakes [5]. This level of vulnerability can be overcome by the application of higher earthquake resistance standards in simple house construction.
Research also highlights that simple houses in Padang are vulnerable to earthquakes that need serious attention [6]. Therefore, increasing earthquake resistance in simple house construction is essential to protect residents and their property.

Increased construction costs often follow increased levels of earthquake resistance. Applying more resilient structural designs to deal with earthquakes can impact the estimated cost of construction projects [7]. Therefore, it is necessary to analyze to understand the relationship between the applied earthquake resistance standards and the associated cost estimates.

One aspect that needs attention is the estimated cost analysis of simple earthquake-resistant house construction projects. Through an optimal understanding of the cost of building earthquake-resistant shelters, communities can make more informed decisions reduce financial uncertainty, and provide insight into the importance of cost evaluation in the context of building earthquake-resistant houses [8]. Through this knowledge, it is hoped that the community can be more involved and actively participate in construction projects that take into account earthquake resistance.

This study will attempt to fill this knowledge gap by analyzing the impact of applying earthquake resistance standards on the cost estimation of simple home construction projects. A better understanding of the balance between earthquake resistance and financial aspects is expected to provide better guidance for the community and stakeholders in deciding the desired level of earthquake resistance in the construction of simple houses.

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METHODS

The object of study of this study is the estimated cost of a simple Type 36 house construction project provided with earthquake-resistant reinforcement and this study compared the estimated cost between conventional simple houses with simple houses that were given earthquake reinforcement based on the earthquake-safe house guidebook. Literature studies are carried out by studying theories related to problems that will be discussed in the field through references to literature and theoretical studies on relevant research to support this research.

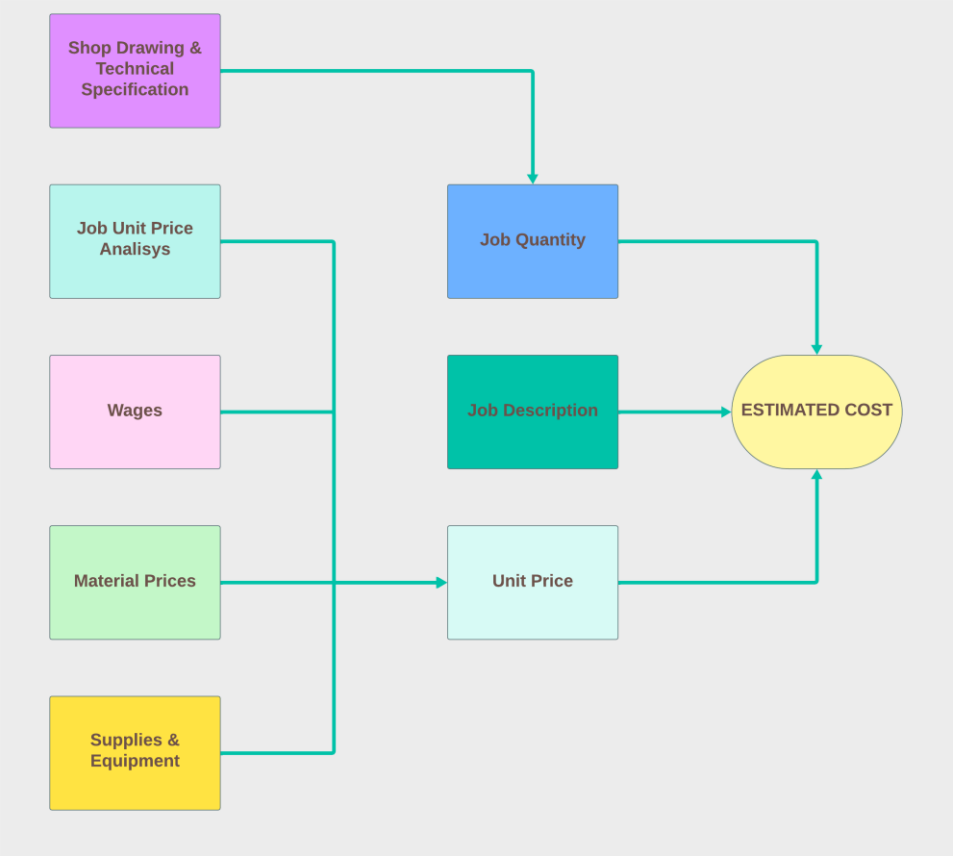

Figure 1: Stages of Cost Estimation Process

Primary data is in the form of working drawings or shop drawing images consisting of floor plans, looks, cutouts, and detailed images. Then the Technical specifications are based on practical guidelines Construction of earthquake-resistant wall houses. Analysis of Work Unit Prices (AHSP) based on the Minister of Public Works and Public Housing Regulation 8 of 2023 concerning Guidelines for Preparing Estimated Costs of Construction Work in the Field of Public Works and Public Housing. The list of unit prices of wages and materials and equipment used is based on the unit price list of work wages issued by the field to PU-an and HSBGN for fiscal year 2022 of the city of Padang.
Secondary data is data obtained based on literature, various references, books that discuss cost estimation technical information related to the construction of simple earthquake-resistant houses, online news, etc.

In data processing activities, several things related to data processing are carried out, including the following:

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1. Evaluate work drawings to find out the types of work items as well as the volume of work to be done on the construction of a simple house
2. Summarizing data or work items as well as the volume of work on the construction of simple houses based on conventional structures and earthquake-resistant reinforced structures.
3. Collect a list of unit prices of wages, materials, and tools by price standards in the city of Padang.
4. Analyze and calculate the budget plan for the construction of simple houses using conventional structures and earthquake-resistant reinforced structures.
5. Comparing the results of the recapitulation of the cost budget plan on the construction of simple houses using conventional structures and earthquake-resistant reinforced structures.
6. Make conclusions about the calculation of the budget plan about how much it will cost to make a simple house, an earthquake-resistant reinforced structure

RESULTS AND DISCUSSION

The cost estimation results show the cost difference between the two construction methods. Simple houses with conventional structures have construction costs of Rp 218,913,000, while simple houses with earthquake-resistant reinforcement have costs reaching Rp 226,296,000. The cost increase was around Rp 7,383,000 or 3.37%. This increase in results occurs because of the existence of additional earthquake-friendly work as a form of reinforcement of earthquake-resistant houses consisting of additional work of strengthening foundations, columns & beams, walls, and horses.

Table 1: Comparison of cost estimates

No	Job Description	Cost Budget Plan (Conventional)	Cost Budget Plan (Earthquake Resistant)	Additional charges	Percentage (%)
1	FOUNDATION	Rp 18,382,877.91	Rp 18,382,877.91	Rp -	0.00
2	CONCRETE/WALL	Rp 78,799,901.61	Rp 78,799,901.61	Rp -	0.00
3	HOOD/ROOFING	Rp 16,000,527.85	Rp 16,000,527.85	Rp -	0.00
4	PLASTERING	Rp 18,308,679.01	Rp 18,308,679.01	Rp -	0.00
5	CEILING	Rp 8,501,286.24	Rp 8,501,286.24	Rp -	0.00
6	CERAMIC	Rp 19,400,323.97	Rp 19,400,323.97	Rp -	0.00
7	DOOR/WINDOW	Rp 19,709,635.58	Rp 19,709,635.58	Rp -	0.00
8	PAINTING	Rp 10,247,945.44	Rp 10,247,945.44	Rp -	0.00
9	INTERNAL FITTING	Rp 21,507,046.55	Rp 21,507,046.55	Rp -	0.00
10	EXTERNAL FITTING	Rp 8,054,319.64	Rp 8,054,319.64	Rp -	0.00
11	EARTHQUAKE RESISTANT REINFORCEMENT WORK	Rp -	Rp 7,383,012.89	Rp 7,383,012.89	3.37
SUM		Rp 218,912,543.80	Rp 226,295,556.69	Rp 7,383,012.89	
ROUNDED		**Rp 218,913,000.00**	**Rp 226,296,000.00**	**Rp 7,383,000.00**	

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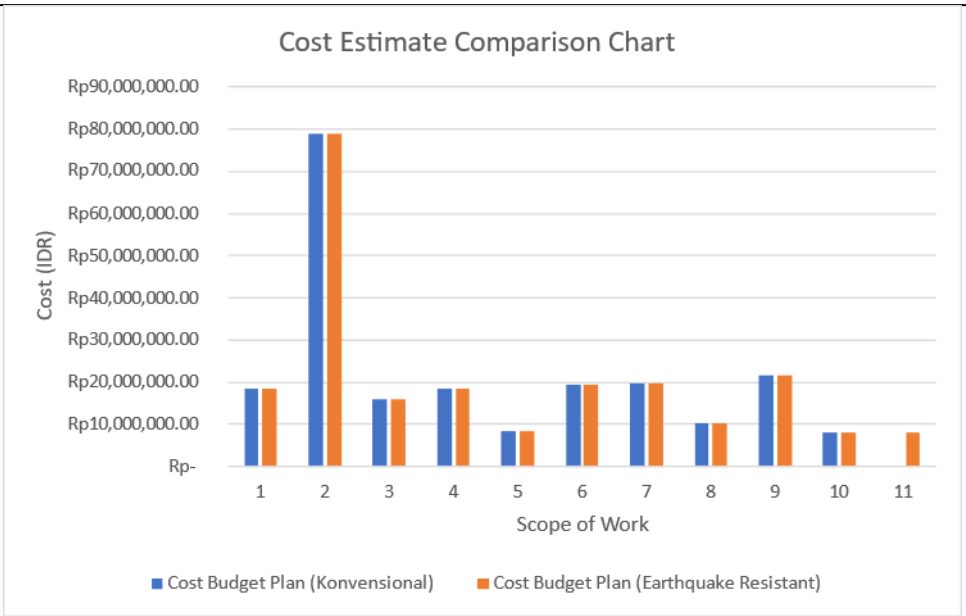

Figure 2: Cost Estimation Comparison Chart

In foundation reinforcement work, there is an additional cost of 4% due to the work of reinforcement cuttings on the foundation that uses iron every 1 m distance using iron armatures Ø10 mm. In this work, column reinforcement is passed into the slot along a pass of at least 40 D (40 cm). Then in the work of strengthening the cuttings of the Column and Beam connections, there was an additional cost of 17% due to the work of strengthening the cuttings of the connection between beams and columns using Ø10 iron. This work passes column reinforcement to the ring beam with a minimum pass length of 40 D (40 cm).
For wall reinforcement work, there is an additional cost of 16% of the total additional cost caused by brick wall installation cuttings using Ø10 iron where 40 cm > length armatures are installed every 6 layers of bricks.

In the retrofitting work of the roof easel, there was an additional cost of 63%. This is due to the work of 10 mm thick plate pairs to tie the easel, then 12 mm bolt pairs and 8/12 hook beam pairs as reinforcement.

Figure 3: Estimated cost of earthquake-resistant strengthening work

XI	EARTHQUAKE RESISTANT REINFORCEMENT WORK					
1	Foundation					
	a Reinforcement cuttings on the	Kg	11.90	25,577.75	304,477.54	
2	Columns and Beams					
	a Cuttings at the joints of columns and	Kg	47.62	25,577.75	1,217,910.14	
3	Brick Wall					
	a Stek on brick installation every 40 cm	Kg	47.62	25,577.75	1,217,910.14	
4	Easel					
	a 10mm thick plate	Kg	40.19	44,060.50	1,770,879.62	
	b builds 12mm	bh	28.00	13,500.00	378,000.00	
	c Clamping beam 8/12	M3	0.24	10,243,475.00	2,493,835.45	
					SUM	**7,383,012.89**

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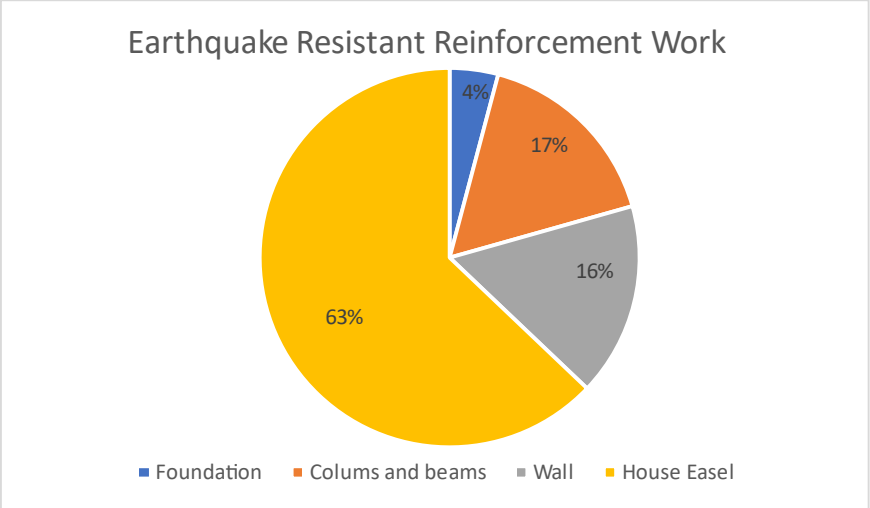

Figure 4: Earthquake Resistant Strengthening Job Detail

It is important to note that this relatively small increase in cost provides great advantages in terms of safety and convenience. With earthquake-resistant reinforcement, homes become better able to withstand earthquakes, reducing the risk of damage and providing greater protection for human life.

This cost addition is not only an investment in structural security but also an investment in the peace of mind and comfort of the home's occupants. People need to realize that with additional affordable investment, they can build homes that are not only aesthetically pleasing but also earthquake-resistant. The research was carried out in compliance with the engineer's code of ethics, illustrating the ethical responsibility attached to engineering practice. The engineer's code of ethics emphasizes the importance of integrity, safety, and public well-being, values that align with the study's objectives.

In the context of natural disasters such as earthquakes, where damage to homes can significantly impact human life, the engineer's code of ethics mandates engineers to prioritize public safety. This study, which focused on comparing cost estimates of simple home construction projects with and without earthquake-resistant reinforcement, reflects a commitment to these values.
The use of data from working drawings, technical specifications, unit price analysis of work (AHSP), and unit price lists of wages and fieldwork materials to PU-an and HSBGN, provides a solid basis for accurate and transparent calculations. Thus, the results of this study can be considered by the standards of integrity and accountability mandated by the engineer's code of ethics.

The importance of increasing the level of safety and comfort in building construction, as indicated by the results of the study, reflects the ethical principles of engineers who demand concern for the welfare of society. The results of this research can provide a strong foundation for stakeholders in the field of construction and policy to take steps that support the ethical values of engineers in building safer and more sustainable housing infrastructure.

CONCLUSION

Based on the results of the analysis that has been done, several conclusions can be drawn, as follows:

1. The cost estimation results show that for simple houses with conventional structures, the construction cost value is IDR 218,913,000, while for simple houses with earthquake-

resistant reinforcement, the cost reaches IDR 226,296,000.
2. From the comparison made, the increase in costs in simple houses with earthquake-resistant reinforcement obtained a value of IDR 7,383,000 which is 3.37%.
3. This additional cost is due to additional reinforcement work consisting of foundation reinforcement work, columns and beams, walls, and easel.

Based on the calculations that have been done, it can be suggested that it is important to realize that with the addition of relatively small costs, the community can increase the level of safety and comfort in building construction. The results of this study can be a strong foundation for stakeholders in the field of construction and policy to consider safety and comfort as major factors in the development of housing infrastructure.

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