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Analysis of Partial Rehabilitation Costs Estimation of Earthquake-Resistant Simple House Structures in Bantul Regency

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ABSTRACT

The vulnerability of simple houses in earthquake-prone areas, particularly those built independently with limitations of key structural elements, demonstrates the need for a measurable and efficient partial rehabilitation approach. Although the reinforcement of earthquake-resistant buildings has been widely studied, the analysis of partial rehabilitation costs separating the calculations on each major structural element is still relatively limited. This study aims to compile an analysis of partial rehabilitation costs on column, ground beam, and ring beam elements by referring to the Unit Price Analysis and the Bantul Regency Standard Unit Price for Materials and Services in 2024. The quantitative method was applied using technical data from the results of MBKM internship activities at the Bantul Regency BPBD, which included the dimensions of structural elements, ironing details, and concrete quality. The calculation of material requirements and costs is carried out separately on each element to obtain a more measurable estimate. The results of the study showed that the cost of rehabilitating columns, ground beams, and beam rings amounted to Rp 14.676.740,54 each, Rp 14.213.412,00, and Rp 13.009.214,44. These findings confirm that differences in dimensions, element functions, and reinforcement methods have a direct effect on the amount of cost. This research contributes in the form of an approach to partial rehabilitation cost analysis that is applicable as a basis for technical decision-making in the planning of simple house reinforcement in earthquake-prone areas.

INTRODUCTION

Indonesia is at the confluence of two active earthquake tracks in the world, namely the Circum-Pacific Earthquake Belt and the Trans-Asiatic Earthquake Belt, so it has a high level of seismic vulnerability. Bantul Regency, as an area with a history of building damage due to earthquakes, is an area that requires serious attention to housing resilience, especially simple houses that are mostly occupied by middle-to-lower income people (Winarti, 2019). This condition requires a focus on improving the quality of the building structure to be able to withstand earthquake loads effectively (Fitria et al., 2024).

Type 36 houses are one of the most common forms of simple housing in Bantul. However, there are still many houses that are built without the completeness of the main structural elements, such as columns, beams, and ground beams, due to limited costs and technical knowledge (Mulyandari et al., 2024). The lack of these structural elements causes building capacity to decrease

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and is at high risk of damage during earthquakes. In this context, partial rehabilitation is a more efficient alternative to total reconstruction because it allows the reinforcement of structural elements without thorough dismantling, thus improving the structure's performance effectively and economically.

Partial rehabilitation cost analysis is an important aspect in planning the right structural intervention. Previous research, including the RISHA study, has shown that the application of earthquake-resistant construction technology can reduce costs while improving building performance (Mudawarisman et al., 2020) However, field practice still relies heavily on empirical experience, without a clear analytical framework to assess cost-effectiveness and structural performance improvement (Susanti, Susi, Adinata, 2022; Aulady & Fujimi, 2019; Hariyanto et al., 2020).

Along with developments, various studies show that the partial rehabilitation approach is getting more attention as an adaptive building resilience improvement strategy, according to local conditions, especially by utilizing materials that are easily available in the field (Brata, 2023). Several studies confirm that the addition of structural elements such as ground beams, columns, and ring beams is able to improve building performance at a relatively low additional cost. For example, partial reinforcement only adds about 3.6% of the cost of conventional development (Rahman Arifin & Jonrinaldi, 2024), while the use of local materials is considered more economical and quickly implemented (Aulady et al., 2022; Mamur Ramdani & Eldi, 2022) In Bantul Regency, the need for this approach is increasingly relevant considering that many houses are built independently without the main structural elements so that they are vulnerable to damage during earthquakes. Therefore, this study is important to obtain an accurate estimate of the cost of partial rehabilitation without total dismantling so that the repair process can be carried out efficiently and on target.

Although several studies have examined the strengthening of earthquake-resistant buildings, gaps are still visible in the study of the partial rehabilitation costs of type 36 houses specifically. Most studies have focused on structural reinforcement in general or total reconstruction, with no analysis highlighting the detailed costs of each key structural element such as ground beam, columns, and ring beam when partial work has the potential to reduce costs by up to 3–5% compared to new construction while maintaining a level of structural safety (Aulady et al., 2022; Rahman Arifin & Jonrinaldi, 2024). Studies in North Lombok and the PASIGALA area also show that partial reinforcement of core elements is effective in increasing seismic capacity in structurally deficient simple houses (Aryani et al., 2022; Asnudin et al., 2023).

In line with this, this study aims to prepare technical recommendations for partial rehabilitation of type 36 houses in Bantul Regency through strengthening the main structural elements, namely ground beam, columns, and ring beam, which are adjusted to the existing conditions of buildings in earthquake-prone areas. After the technical approach was formulated, this study also analyzed the cost components of each reinforcement work to produce a more accurate and efficient estimate of rehabilitation costs. Thus, this research is expected to be a scientific basis for policy formulation and technical decision-making that is more targeted to the target.

Based on these conditions, the urgency of the research lies in the need for a cost analysis system that can support local governments, disaster agencies, and construction practitioners in determining the priorities of structural interventions without total demolition, both before and after the disaster (Rini et al., 2016). Thus, this research is expected to provide an academic contribution as well as a practical guide in the preparation of technical guidelines for the rehabilitation of earthquake-resistant simple houses in the future.

RESEARCH METHODS

Efforts to formulate estimates of partial rehabilitation costs in earthquake-resistant simple houses require a systematic analytical approach, especially when the study is directed to

earthquake-prone areas such as Bantul Regency. To meet these needs, this study uses a quantitative approach by utilizing the building technical data obtained through the Independent Learning Independent Campus (MBKM) internship activity. The available data includes the dimensions of structural elements such as ground beams, columns, and ring beams; ironing details; and concrete quality, which is the basis for calculating material requirements and formulating the type of reinforcement work.

The characteristics of type 36 houses that are widely found in the affected areas are the main reference in this analysis. Because technical data are available from the internship, the research does not go through a specific sample selection process. All data are considered to represent the general conditions of simple house construction in the field so that the study can be focused on the analysis process without involving additional sampling procedures.

The instruments used in cost analysis are compiled based on technical standards so that the calculation results are accurate and consistent. The technical data from the MBKM internship is the main component because it contains detailed information about the dimensions of structural elements, ironing configurations, and concrete quality used as the basis for calculating the volume of work. The cost determination process is also supported by the Bantul Regency Standard Unit Prices for Materials and Services, which provides a reference for material and labor prices according to local market conditions so that the estimated budget reflects real needs in the field. In addition, the Unit Price Analysis, which refers to the Regulation of the Minister of PUPR Number 28/PRT/M/2016 and the Indonesia National Standard (2835; 2024) is applied as a guideline in calculating the cost of rehabilitation work units. The integration of the three instruments ensures that the cost estimation process is carried out in a measurable, systematic manner and in accordance with applicable technical provisions.

To provide a comprehensive overview of the flow of research implementation, a series of stages of activities are presented in the form of the following research procedures:

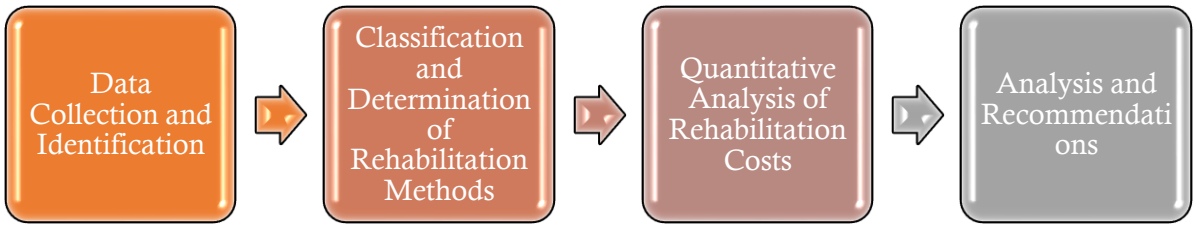

Figure 1. Research Procedure

The research procedure describes four main steps starting from the collection and identification of technical data from MBKM internships as the basis for analysis. The next stage includes the process of data classification and the determination of partial rehabilitation methods that correspond to the characteristics of the structural elements. After that, a quantitative calculation of costs is carried out through volume analysis and the preparation of cost estimates using Unit Price Analysis and Standard Unit Prices for Materials and Services to produce a Cost Estimate. The last stage includes the preparation of technical recommendations based on the results of the analysis so that an overview of the need for efficient, measurable, and applicable partial rehabilitation for type 36 simple houses in earthquake-prone areas is obtained.

Based on the results of data collection, initial data was obtained, which was then used as a basis to produce accurate information through the process of processing and analyzing data. In this study, data processing is carried out through several stages as follows:

1. Identification and Classification of Quantitative Data

   This stage includes the grouping of data of structural elements, such as columns, ground beams, and ring beams, along with their technical characteristics, to

systematically organize the data as the basis for volume calculation and cost estimation.

2. Work Volume Analysis

   At this stage, the classified dimensional data is used to quantify the volume of work and is applied specifically to the ground beam, column, and ring beam element so that the material requirements for each element can be precisely determined. Volume calculation is done using the formula:

   $$V = L \; x \; W \; x \; H \quad (1)$$

3. Preparation and Analysis of Rehabilitation Costs

   The entire volume of work is combined with the unit price based on Unit Price Analysis and Standard Unit Prices for Materials and Services to produce an estimated rehabilitation cost. The calculation of the unit cost uses the formula:

   $$\text{UPA} = \textit{(Material Coefficient x Unit of Material) + (Wage Coefficient x Unit Price of Wages) + (Equipment Coefficient x Unit Price of Tools)} \quad (2)$$

   With the estimated cost calculated by the formula:

   $$\textit{Cost estimate} = \textit{Volume x Unit Price Analysis} \quad (3)$$

The results of the analysis are presented descriptively to show the contribution of the cost of each structural element to the total rehabilitation needs, as well as the basis for technical recommendations for increasing the resilience of simple houses to earthquakes in Bantul Regency.

RESULTS AND DISCUSSION

The results and discussion in this study are compiled to provide a comprehensive overview of the main findings obtained from the analysis process. This section explains how data is processed, interpreted, and connected to the technical context in the field so as to produce information relevant to the research objectives. The following description is presented systematically through several sub-sections so that the process of identification, calculation, and evaluation of structural elements can be understood more clearly and in a more directed manner.

Rehabilitation Methods

After determining the structural elements that require addition or strengthening, the rehabilitation method for each element is arranged with different stages of work according to the needs of each section. Illustrations of the rehabilitation stages are shown in Figure 2, Figure 3, and Figure 4.

Figure 2. Column Structure Rehabilitation Method

The process of rehabilitating the columns in Figure 2 begins with the partial dismantling of the walls to open up the workspace and ensure that the area is ready to receive reinforcement elements. Furthermore, reinforcement is installed according to dimensions and technical

specifications, where the accuracy of the configuration has been proven to affect the effectiveness of structural capacity building (Prasetiawan & Makrifa, 2022) The final stage is the installation of formwork as a casting mold to maintain the position of the reinforcement during concretization, in line with the findings (Natalia et al., 2024) regarding the importance of formwork control in the successful rehabilitation of structural elements.

The ground beam rehabilitation process in Figure 3 begins with opening the work area through the partial dismantling of the walls and the installation of wooden supports to prevent wall shifts during construction activities. This step is important to maintain the stability of the existing structure before the reinforcement work is carried out. After the workspace is secure, a series of ground beam reinforcements are assembled according to technical specifications, where the accuracy of repetition is a key factor in increasing the capacity of the building's lower elements (Prasetiawan & Makrifa, 2022). The next stage is the installation of formwork that functions to control the shape of the casting and maintain the position of the reinforcement, as recommended by (Natalia et al., 2024) in concrete rehabilitation practices. Through this procedure, the process of strengthening the ground beam can be carried out in a directed manner and contributes significantly to increasing the strength of the structure.

Figure 3. Ground Beam Structure Rehabilitation Methods

Figure 4. Ring Beam Structure Rehabilitation Method

The ring beam rehabilitation process in Figure 4 begins with the installation of scaffolding along the roof stalwarts to ensure a safe and stable workspace, as recommended in existing building rehabilitation practices (Firmansyah et al., 2023). Once the support structure is in place, part of the wall and roof elements are removed to provide access to the new fastening area. The next stage is to assemble the ring beam reinforcement according to the reinforcement specifications, which plays a role in increasing the continuity of the upper element and the lateral load distribution of the building (Prasetiawan & Makrifa, 2022). This process is then continued with the installation of formwork as a casting mold to maintain the position of the reinforcement and the quality of the concrete during hardening, following the general principles of rehabilitation of reinforced concrete structures (Natalia et al., 2024). The series ensures the effective reinforcement of the installed ring beam and supports the overall increase in the building's earthquake resistance capacity.

Quantitative Analysis of Rehabilitation Work

In order to obtain a systematic picture of the need for structural rehabilitation, the analysis of the volume of work is carried out with reference to the actual dimensions of the elements and

the reinforcement methods applied to the simple house. The volume calculation is structured in a measured manner so that the material requirements of elements such as walls, columns, ground beams, and ring beams can be clearly identified according to the characteristics of each component. This stage is an important foundation in determining the amount of rehabilitation work while ensuring that reinforcement needs can be calculated consistently and can be accounted for technically.

After the volume needs of each element are obtained, the next step is to translate these results into cost estimates using the Bantul 2024 Standard Unit Prices for Materials and the Unit Price Analysis. This process is carried out by matching the material needs and stages of work that have been calculated with the official unit price of the region so that each rehabilitation item has a measurable and standardized cost value. This integration of volume quantification and cost analysis results in a more comprehensive picture of the need for partial rehabilitation, while ensuring that the cost plan is aligned with local technical and regulatory conditions.

Cost Estimate

To obtain the value of the cost estimate, the calculation is carried out by multiplying the volume of work on each item by the unit price analysis. For example, the calculation of the cost estimate for wall demolition work.

Volume $= L \; x \; W \; x \; H$

$= 32{,}00 \text{ x } 0{,}12 \text{ x } 0{,}4$

$= 1{,}536 \text{ m}^3$

Unit Price analysis $= \text{Rp } 532.114{,}34 \text{ m}^3$

Cost Estimate $= V \; x \; Unit \; Price \; analysis$

$= 1{,}536 \text{ x Rp } 532.114{,}34$

$= \text{Rp } 690.550{,}53$

Based on the results of the calculation above, it is known that the Cost Estimate (CE) for wall demolition work is Rp 690,550.53. For other activities, it can be seen in Table 4 in the form of Cost Estimate for all partial rehabilitation work of type 36 simple house structures based on the results of the analysis.

Table 4. Cost Estimate for Partial Structural Rehabilitation

No	Job Description	Volume	Unit	Unit Price	Total Price
Cost Esitimate for Colomn Structural Rehabilitation					
A	Preparation and Demolition Works				
1	Scaffolding installation	2,00	Set	Rp 62.000,00	Rp 124.000,00
2	Demolition of 20-cm masonry wall	1,320	m^3	Rp 532.144,34	Rp 690.550,53
3	Demolition of 15-cm masonry wall	0,223	m^3	Rp 532.144,34	Rp 116.530,40
B	Concrete Works				
1	Structural Column 20 × 20 cm				
	D10 longitudinal bars	118,40	kg	Rp 14.409,92	Rp 1.706.135,48
	D8 confinement bars	68,650	kg	Rp 14.409,92	Rp 989.225,97
	Formwork	26,40	m^2	Rp 254.359,09	Rp 6.715.079,98
	fc 21 MPa (K-250) concrete	1,320	m^3	Rp 1.164.983,48	Rp 1.537.778,20
2	15 × 15 cm Practical Column				
	D10 longitudinal reinforcement	35,520	kg	Rp 14.409,92	Rp 551.840,64
	D8 confinement bar	15,380	kg	Rp 14.409,92	Rp 221.643,43
	Formwork	6,930	m^2	Rp 254.359,09	Rp 1.762.708,49
	Plastering and Finishing Works	0,22	m^3	Rp 1.164.983,48	Rp 259.500,07

No	Job Description	Volume	Unit	Unit Price	Total Price
C	Plastering and Finishing Works				
1	Structural column plastering work (1PC:4PP mix, 20 mm thickness)	1,320	m^2	Rp 70.835,52	Rp 93.502,89
2	Practical column plastering work (1PC:4PP mix, 20-mm thickness)	0,220	m^2	Rp 70.835,52	Rp 15.778,61
3	Finishing/rendering work	1,540	m^2	Rp 31.739,60	Rp 48.996,27
				Total	Rp 14.676.740,5
Cost Estimate for Ground Beam Structural Rehabilitation					
A	Preparation and Demolition Works				
1	Demolition work for 40-cm-high wall section	1,536	m^3	Rp 532.114,34	Rp 690.550,53
2	Timber bracing	4,00	trunk	Rp 93.694,80	Rp 374.779,20
B	Concrete Works				
1	Ground beam 15 × 20 cm				
	D10 longitudinal bars	292,05	kg	Rp 14.409,92	Rp 4.208.467,51
	D8 confinement bars	167,89	kg	Rp 14.409,92	Rp 2.419.294,34
	Formwork	15,200	m^2	Rp 254.359,09	Rp 1.231.548,99
	fc 21 MPa (K-250) concrete	1,140	m^3	Rp 1.164.983,48	Rp 1.328.081,71
C	Wall Construction Works				
1	Reinstallation of ½ brick masonry wall (1PC:4PP mortar mix)	7,800	m^2	Rp 227.881,80	Rp 1.778.389,57
D	Plastering and Finishing Works				
1	Wall plastering work (1PC:4PP mix, 20 mm thickness)	15,610	m^2	Rp 70.835,52	Rp 1.105.600,80
2	Ground beam plastering work (1PC:4PP mix, 20-mm thickness)	15,200	m^2	Rp 70.835,52	Rp 1.076.699,90
3	Finishing/rendering work	30,810	m^2	Rp 31.739,60	Rp 977.833,60
				Total	Rp 14.213.412,0
Cost Estimate for Ring Beam Structural Rehabilitation					
A	Preparation and Demolition Works				
1	Scaffolding installation	12,00	Set	Rp 523.144,34	Rp 401.774,85
2	Demolition work for 20 cm high wall section	0,768	m^3	Rp 113.792,84	Rp 1.365.514,08
B	Concrete Works				
1	Ring beam (15 × 20 cm)				
	D10 longitudinal bars	292,05	kg	Rp 14.409,93	Rp 4.208,467,51
	D8 confinement bars	167,89	kg	Rp 14.409,93	Rp 2.419.294,34
	Formwork	15,200	m^2	Rp 254.359,09	Rp 1.231.548,99
	fc 21 MPa (K-250) concrete	1,140	m^3	Rp 1.164.983,48	Rp 1.328.081,17
C	Plastering and Finishing Works				
1	Ring beam plastering work (1PC:4PP mix, 20 mm thickness)	15,200	m^2	Rp 70.835,52	Rp 1.076.699,90
2	Finishing/rendering work	30,810	m^2	Rp 31.739,60	Rp 977.833,60
				Total	Rp 13.009.214,4

Source : Processed Researcher, 2025

In this study, the price component per m² is not included because the area calculation used refers to the area of structural elements, namely columns, ground beams, and beam rings, not the area of the building as a whole. In partial rehabilitation, each element has different dimensional characteristics, material requirements, and reinforcement methods, so the cost approach cannot be simplified into units per m² as in new construction work. Cost estimates are more accurately presented through the calculation of element volume and combined with Unit Price Analysis and Standard Unit Prices for Materials and Services so that the value obtained reflects the actual cost based on specific work items. Although in general, structural rehabilitation is often in the range of

Rp1,500,000 to Rp2,000,000 per m², the results of this study show that when the cost is divided by the area of the building, a value of Rp407,687.24 is obtained for columns, Rp394,817.00 for ground beams, and Rp361,367.07 for ring beams. Thus that the rehabilitation cost approach produced in this study is still in the normal and reasonable price for structural element strengthening work.

Based on the results, this study shows that the partial rehabilitation of type 36 houses in Bantul Regency is carried out through the application of rehabilitation methods that are tailored for each structural element, such as columns, ground beam, and ring beam, so that each element can be strengthened in a directional manner according to technical needs, the calculation of the volume of work is carried out systematically using a basic formula to ensure accurate estimation of material needs, while the unit price of goods refers to the Bantul Regent Regulation Number 64 of 2024 so that the estimated cost reflects local market conditions; These results provide a solid quantitative picture of the cost and volume of rehabilitation, as well as a basis for comparison with previous studies.

Understanding the need for structural reinforcement in simple homes is very important to assess the effectiveness of partial rehabilitation. The findings of this study show that reinforcement of ground beams, columns, and ring beams can significantly increase the durability of the structure, although the cost requirements are different for each element. This variation confirms that the reinforcement approach must be tailored to the structural characteristics of each element to maximize the cost efficiency and seismic performance of the building. These results are in line with previous research that confirms that the repair of some structural elements can improve seismic performance without causing a significant increase in costs (Rahman Arifin & Jonrinaldi, 2024; Aulady et al., 2022). The views of (Habieb et al., 2023) which emphasize the use of simple methods and easily accessible local materials, and (Firmansyah et al., 2023) which emphasize the importance of alignment between scientific evidence and local needs in building rehabilitation, also reinforce the relevance of the partial approach as a practical strategy in the field.

In addition, this study confirms that the integration of volume calculations, the Unit Price Analysis, and Cost Estimation allows for more accurate and measurable rehabilitation cost estimation. This approach provides a solid foundation for disaster agencies, such as BPBD, to prioritize structural interventions in earthquake-prone areas. This is in line with findings (Agisna et al., 2022) that emphasize the importance of evaluating structural suitability before intervention, as well as (Hamid et al., 2021; Natalia et al., 2024) and (Prasetiawan & Makrifa, 2022) which shows the effectiveness of partial reinforcement through the use of columns, beams, and simple bonding methods in increasing earthquake resistance.

In assessing the achievements of this research, it is important to understand the scope and limitations that accompany the analysis process. The research is still limited to 36 simple type houses in Bantul Regency and only includes three main structural elements, namely ground beam, columns, and ring beam, so the findings cannot be generalized to the variety of buildings with different dimensions and structural configurations. Other elements such as walls, roofs, and non-structural components have not been included in the evaluation, while the technical data used is sourced from a case study at BPBD Bantul, so that the condition of buildings in other areas with different characteristics and reinforcement needs has not been accommodated. In addition, the rehabilitation method applied is general, and the cost estimate referring to SNI and Standard Unit Prices for Materials and Services for the current year makes the results of the analysis greatly influenced by fluctuations in material prices and wages. The effectiveness of strengthening is only assessed in terms of cost without verifying the performance of the post-rehabilitation structure.

CONCLUSION

Understanding the need to strengthen structures is an important foundation in assessing the effectiveness of partial rehabilitation in simple houses. Based on the results, the application of rehabilitation methods on columns, ground beams, and ring beams, through the selective opening of work areas, the installation of new reinforcement, and the use of formwork as a casting quality control. This shows that each element requires a different reinforcement approach according to its

structural characteristics. The calculation of the volume of work carried out in a measured manner results in varying material needs, which are then processed through the Unit Price Analysis and the Standard Unit Prices for Materials and Services to obtain an accurate rehabilitation cost estimate. The series of analyses showed that the total cost of column rehabilitation reached Rp 14,676,740.54, ground beam Rp 14,213,412.00, and ring beam Rp 13,009,214.44. This difference in value confirms that variations in volume, element function, and reinforcement method are the main factors that affect the total cost.

Based on the results of the research that has been conducted, further research is recommended to not only focus on the technical aspects of the structure but also consider the availability of materials and the dynamics of construction costs at the local level. In addition, it is necessary to evaluate the performance of post-rehabilitation buildings as well as assess other structural and non-structural elements to support the development of a simple house-strengthening strategy that is more adaptive and improves building safety in earthquake-prone areas.

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